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Accessibility Factors and Conservation Forest Designation Affecting Rattan Cane Harvesting in Lambusango Forest, Buton, Indonesia

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Abstract Rattan cane is an important non-timber forest product (NTFP) harvested from Indonesian tropical forests. However, the extraction of NTFPs such as rattan cane may conflict with forest conservation efforts. A better understanding of harvesting practices can help assess the extent of this conflict and guide forest management decisions. This study assesses the accessibility factors that influence rattan cane harvesting levels in Lambusango Forest, Buton Island, Indonesia, and whether the harvesting of rattan cane is affected by the designation of conservation areas. To this end, the analysis adopts participatory mapping, Geographic Information Systems and a questionnaire survey and employs multiple regressions and analysis of covariance. The results show that accessibility, particularly slope and distance, can play a role in the quantity of rattan canes harvested. The presence of conservation forest does not significantly affect rattan cane harvesting levels. This could be due to limited awareness of the harvesters going to the vicinity of the designated conservation areas and mixed sentiments towards conservation efforts due to the long tradition of forest dwelling and harvesting activities. The study concludes that the successful establishment and management of conservation areas require consideration of the specificity of the local context such as the abundance of forest resources, accessibility and historical forest-people interactions, in addition to biological factors.

Keywords NTFP · Rattan cane harvesting · Accessibility · Conservation forest · Buton Island

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Introduction

Non-Timber Forest Products (NTFPs)

In a developing country such as Indonesia, various forest uses, including the extraction of Non-Timber Forest Products (NTFPs), are long-established and important livelihood sources for local people living in and around the forest. The attraction of NTFPs lies in the fact that they are often regarded as free goods (Ambrose-Oji 2003). Forests are repositories of village food and wealth and buffers during times of crisis (Rigg 2009), and as such NTFPs may be harvested for both subsistence and commercial purposes (Ambrose-Oji 2003; Ndangalasi *et al*. 2007). In some areas (such as rural Laos) they may contribute as much as 46% to the household economy (NBSAP 2004). With growing concern about deforestation and forest encroachment, and the maintenance of forest ecosystem services, NTFP extraction has been conceived as a means to balance forest conservation with the needs of local economies (Kusters *et al*. 2006). Consideration has been given to how NTFP extraction can maintain the structure and cover of the forest and provide incentives for local people to preserve the forest (Peters *et al.* 1989; Arnold and Ruiz Perez 2001). However, ecological and economic sustainability perspectives bring quite different and sometimes conflicting dimensions to the debate (Arnold and Ruiz Perez 2001).

Extraction of forest products is commonly conducted by the poorer members of society, who are not able to apply intensive farming and who have few alternative livelihood sources. As NTFPs require minimal capital and skill for their utilisation, they can play a key role as an immediate cash source for forest dwelling people even where they are not fully commercialised.

NTFP Extraction and Accessibility in the Forest

NTFPs are mostly extracted as wild products and the nature of extraction is manual and small-scale. There have been only a few discussions on accessibility factors that could affect NTFP extractions (Kaimowitz and Angelsen 1998; Shaanker *et al.* 2003). Among them, Siebert (2001) indicated that the extent of rattan cane extraction was limited by distance. NTFP extraction like rattan cane harvesting is labour-intensive (Paumgarten 2006); therefore, physical conditions such as accessibility in the forest are assumed to affect the activity.

Aside from natural accessibility, forest designation into conservation or protected areas would in theory also affect the movement of local people in conducting forest product extraction, although human activities do continue to take place in forests designated as protected or conservation areas (Gunatilake *et al*. 1993; Masozera and Alavalapati 2004; Siebert 2004; Mbile *et al.* 2005; Ndangalasi *et al*. 2007; Gubbi and MacMillan 2008). Two case studies from Uganda show contradictory effects. In one, due to the importance of the resources harvested, the existence of the protected area did not significantly affect levels of forest products extraction (Ndangalasi *et al*. 2007), whereas in another, the intensity and extent of harvesting were reduced as a result of the establishment of a protected area (Olupot *et al.* 2009).

A better understanding of factors affecting accessibility could help the designation of conservation areas to minimise conflict with livelihood practices.

Rattan Cane Harvesting in Forest with Conservation Value

Rattans are spiny climbing palms from the family Palmae or Arecaceae (Sunderland and Dransfield 2002), and are mostly from the subfamily Calamoidea (Dransfield and Manokaran 1994). The important product from rattan plants is the cane, which is the stem with the leaf stripped. The cane is strong, solid, uniform, yet highly flexible (Dransfield and Manokaran 1994; Sunderland and Dransfield 2002). The canes are widely used as materials for furniture industries, basketry and handicrafts. Rattan is an important commercial NTFP in Indonesia (Dransfield and Manokaran 1994; Rachman and Jasni 2006). In some parts of Indonesia rattan has been cultivated, but mostly it grows wild in the forest and the canes are harvested manually by local people on a small scale.

Lambusango forest, the location for this study, on Buton Island, Indonesia, is a forest with high conservation value due to its richness of endemic wildlife, e.g., IUCN-red-listed anoa 'dwarf buffalo' (*Bubalus depressicornis*) (Seymour 2006). Part of the forest has been designated a conservation area, protected by a ministerial decree issued in the 1980s (Purwanto 2005b). However, conservation efforts are challenged by continuing forest product extraction activities conducted by local people. The main NTFPs are rattan cane and honey. There is also small scale timber extraction in some areas. Other threats to the conservation efforts come from asphalt mining, forest encroachment and hunting (Purwanto 2005a).

Interactions between local people and Lambusango forest have been taking place at least since the mid-1900s (Rahim, personal communication), characterised by forest dwelling and shifting cultivation in the forest (Purwanto 2008). Most of the villagers living around Lambusango forest identified themselves as Butonese, with anecdotal information showing that some of them are the first or second generation from the Butonese who migrated from North Buton. The origin of Butonese might be related to the emergence of the Sultanate of Buton in 1300s (Palmer 2004). In the 1970s and 1980s a new forestry policy led to eviction of forest dwellers and resettlement in villages outside the forest (Purwanto 2008). The policy reflected government rejection of local community access to the forest, the forest-dwelling lifestyle and resource management practices. Shifting cultivation was considered economically unproductive and ecologically destructive. The suggested alternative livelihood activities included sedentary farming and urban-based livelihoods (Purwanto 2008).

With the continuing rattan cane harvesting activities in Lambusango forest, it is necessary to assess the level of extraction and its ecological sustainability (Purwanto 2008; Widayati, unpublished thesis). It is useful to gain a better understanding of the core aspects of the harvesting activity, such as harvesting destinations in the forest and factors that might affect harvesting activities such as accessibility in the forest and the establishment of conservation areas.

The objectives of this study are to assess rattan cane harvesting levels within and adjacent to the conservation areas and to assess whether harvesting levels are affected by accessibility factors and the conservation designation.

Study Area

Lambusango Forest on Buton Island, Indonesia, is located southeast of the island of Sulawesi (Fig. 1). Sulawesi and the smaller neighboring islands, including Buton, are within the Wallacea region, straddling the Wallace Line, located

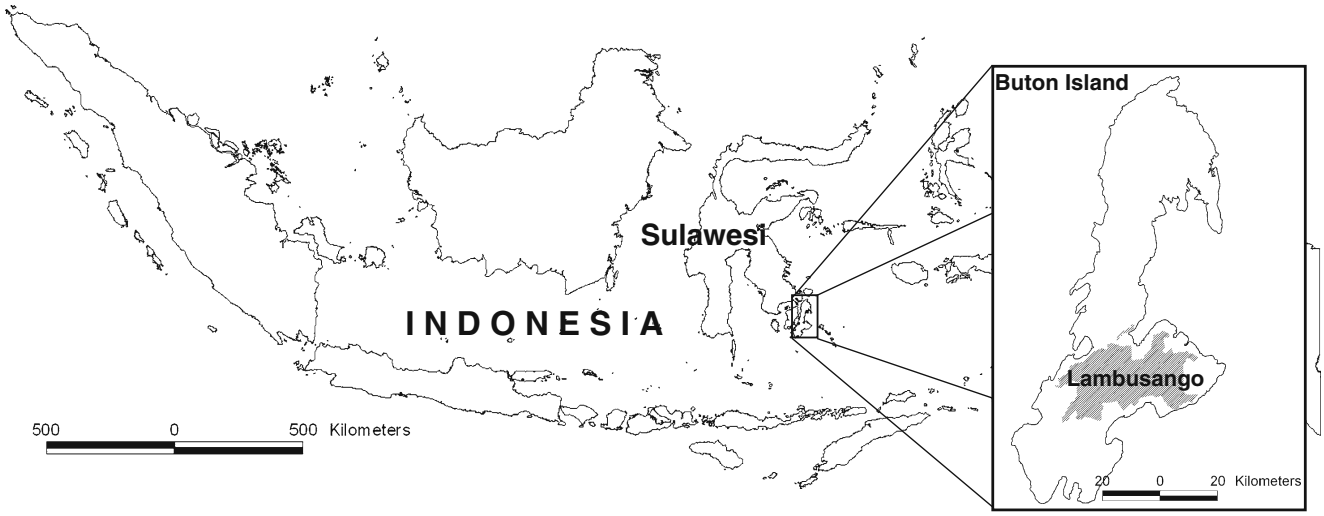

Fig. 1 Study area in the central part of Buton Island, Indonesia

between Kalimantan and Sulawesi and, to the south, between Bali and Lombok islands. This biogeographical line separates the faunal diversity of the Australian and Eurasian continents. A high proportion of Sulawesi's faunal species are endemic. Endemic fauna found on Buton include anoa 'dwarf buffalo' (*Bubalus depressicornis*), tarsier (*Tarsius spectrum*) and macaque (*Macaca ochreata brunnescens*) (Seymour 2006).

The study area is geographically located between 5°S, 122.68°E and 5.5°S, 123.22°E. Elevation ranges from sea level to 750 m above sea level (asl). The geologic formation of Buton is upper tertiary marine sediments and to a lesser extent quaternary sediments. Asphalt is impregnated in limestone areas in the southern part of the island (Whitten *et al.* 2002). The annual rainfall is 1500–2000 mm with three to four dry months a year (Whitten *et al.* 2002).

Lambusango Forest is approximately 93,000 ha of lowland evergreen forests in central Buton. The Indonesian national forestry authority (*Ditjen PHKA*) designates different types of forest zone (Ditjen PHKA 2008). Lambusango forest is made up of ±27,000 ha of Lambusango Wildlife Reserve and ±68,000 ha of Protection Forest, Production Forest and Limited Production Forest. 'Wildlife Reserve' is one form of conservation designation, defined by the national forestry authority as a nature reserve having unique or diverse wildlife and requiring protection and maintenance to ensure the persistence of its habitat (Ditjen PHKA 2008). Based on the regulations associated with this designation (*Undang Undang no 5/1990* on conservation of biological resources and their ecosystems), no extraction of flora or fauna is allowed from wildlife reserves and other reserves (President of the Republic of Indonesia 1990) (i.e., NTFP extraction is illegal). Protection Forest is defined as an area protected for its hydrological functions, while Production Forest is where extractions under various regulations are allowed to take place. Approximately 60,000 ha of land designated as Non-forest Zone surrounds the forest. In total, the study area covers approximately 160,000 ha, or 1600 km^2. For simplicity, in the remainder of this paper, the Wildlife Reserve is referred to as Conservation Forest and both Production Forest and Limited Production Forest are called Production Forest (Fig. 2).

Administratively, the study area is located in Kabupaten Buton (Buton District) which consists of six sub-districts, locally called *Kecamatan*. Each of these subdistricts consists of several villages *(Desa)* and each village usually consists of a few hamlets *(Dusun)*. Rattan canes in Lambusango forest are harvested by people living in the villages and hamlets located around the forest, and the activity is normally conducted by the men of the family, especially the household heads. The villages/hamlets approximately encircle the forest and the harvesters head inland towards the core areas of the forest. There are eight villages/hamlets selected for this study to represent different locations in the forest, different topographic conditions and the two types of designated forest zones. The selection of the villages/hamlets as the study sites was determined by considering their relation to six forest sites established for biological monitoring purposes that included rattan resources inventory (Seymour 2006). The eight study sites surveyed are: Lambusango Timur, Wakangka, Kakenauwe, Lawele, Sumbersari, Walompo, Wining East and Wining West. Some of the study sites are entire villages, while others are hamlets within villages. However, for simplicity, the term 'village' will be used to refer to study sites.

The main livelihood in these villages is farming, especially cash-crops such as cashew, coconut, teak, coffee and cacao. Lawele and Wakangka, which are located in flood plain areas, are also engaged in irrigated paddy-rice,

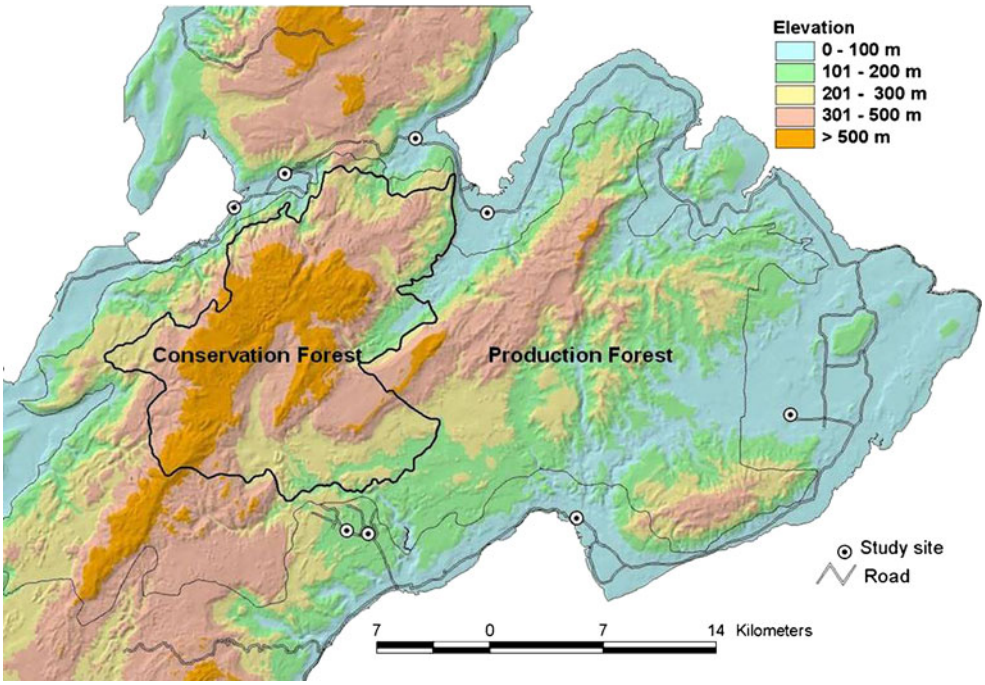

Fig. 2 Elevation, forest designation zones and villages

while some hamlets in some villages near the coast (Lambusango Timur, Kakenauwe and Lawele) are engaged in marine activities such as seaweed farming, mother-of-pearl and net-fishing. Most villagers in the study area originate from Buton, and only two villages are occupied entirely or partly by migrants. Sumbersari was originally a resettlement area for settlers joining the government's transmigration programme from the highly-populated island of Java. Wakangka has one hamlet dominated by migrants from Bali. Non-farming livelihood activities are found in Wining with an asphalt mine and electric power plant providing labour opportunities.

Despite the importance of farming activities, forest product extraction continues to occur and is still favored by most villages as a source of cash for households (Malleson 2005).

Seventeen rattan species in Lambusango forest have been identified (Powling 2009), with a few other rattan local names not yet properly identified. Less than half of the species are commercially valuable. Only commercial species are harvested, fulfilling the requirements set by buyers. Prior to this study, an inventory of rattan abundance had been carried out in the forest, and the density of rattan plants and canes for the past three years (2005–2007) associated with the eight villages had been obtained as shown in Table 1 (Widayati, unpublished thesis).

Materials and Methods

Rattan Harvesting Zones (RHZ)

In this study, a rattan harvesting zone (RHZ) is defined as the estimated area and extent of a village's rattan cane harvesting destinations in the forest. These zones do not have physical boundaries, and do not imply any official boundary for rattan cane harvesting, nor do they have management implications related to harvesting activities conducted in the forest. RHZ refers to an area delineated for the purpose of obtaining approximate harvesting extent for

Table 1 Abundance of rattan plants and canes

Village	Nbr. Plants. ha^{-1}	Nbr. Canes. ha^{-1}
Wakangka/Lambusango Timur	806	374
Lawele	1,293	863
Kakenauwe	564	226
Sumbersari/Walompo	408	1,295
Wining East	1,085	564
Wining West	1,196	518

each village, for deriving topographic and accessibility variables for further analyses and for observing the approximate adjacency with designated forest zones. RHZs were generated using a combination of participatory mapping and GIS techniques explained below.

Participatory Mapping

Participatory mapping (PM), also widely known as 'participatory resource mapping', in its broadest sense is the creation of maps by local communities, often with the involvement of supporting organizations (IFAD 2009). The 'map drawing' capability of local people has been used as part of Participatory Rural Appraisal (PRA) tools that emerged in the 1970s (Chambers 2006). Participants usually engage in discussion and construct a map that expresses their understanding of the resources familiar to them, either as a sketch map on paper or map drawing on the ground using local materials (Kalibo and Medley 2007). As VSO (2004) notes in their facilitator's guide to participatory approaches, the aim is not for cartographic accuracy but to find out what people know and how they see their own territory and situation. IFAD (2009) suggests that participatory maps provide a valuable visual representation of what a community perceives as its place and the significant features within it. These include depictions of natural physical features and resources as well as socio-cultural features. GIS technology has led to further developments in recent years and has given rise to Participatory GIS (PGIS) (Jankowski 2009; Sun *et al.* 2009), which follows the principle of PRA (Rambaldi *et al.* 2006). PGIS brings local people's knowledge into contemporary spatial data collection and management in GIS (Abbot *et al.* 1998; Tripathi and Bhattarya 2004).

Various levels of participation are possible in participatory research (see for example Agrawal 2001; Jankowski 2009). Jankowski (2009) argues that lower levels of participation (inform, consult) involve the use of informal tools such as maps, aerial photographs, virtual globes and interactive websites, while higher levels of participation (involve, collaborate, empower) may require analytical tools for 'what if' simulations of decision impacts.[1] Participatory mapping can be used effectively in combination with more formal research methods such as household surveys or structured interviews to better understand local resource use and the importance of forest products to local livelihoods (Dovie 2003; Malleson *et al.* 2008).

In this research, participatory mapping (PM) was undertaken with between eight and ten rattan harvesters at each village. Participatory mapping was conducted in seven of the eight selected villages. PM was not possible in Lambusango Timur, because the village head did not give permission for his villagers to participate.[2] The mapping exercise was on the level of 'consultative/activity specific participation' (using Agrawal's 2001 typology[3]) as, while the researchers were interested in local worldviews and knowledge, it was not an excersise in participatory conservation decision making with powerholders. Each exercise lasted approximately 3 h in a place suggested by the village head and/or agreed by the respondents. It was explained to participants that the objective was for them to produce a sketch map showing their harvesting destination areas, key landmarks, perceptions of landscape and topography and any other relevant factors affecting their harvesting in these areas (see Mbile *et al.* 2005; Duvail *et al.* 2006; Kalibo and Medley 2007). In order to gain an insight into the local understandings of the harvesting landscape, these features and factors were discussed in the group before mapping was carried out. The PM activity in this study did not attempt to delineate boundaries, as for citizens a fuzzy boundary is usually involved (Sun *et al.* 2009), although PM can be used for this purpose in some situations (Stockdale 2005).

Subsequently sketch maps were drawn onto georeferenced printouts of Landsat satellite imagery (NASA Landsat Program 2006) with the involvement of rattan harvesters.

GIS Routines

Harvesting trips can be conceived in a similar way to the drainage flow in a river catchment system. Therefore, watershed delineation routines in ArcView were used initially to delineate mountain ridges bounding the river catchments (ESRI 1999; Schäuble 2008). Information from the sketch maps was transferred to GIS and was integrated with the other layers of georeferenced information, namely stream network, elevation and land cover (Fig. 3). The stream network and a digital elevation model

[1] In forest conservation, participatory mapping and participatory GIS has the potential to be combined with resource monitoring by the community to improve understanding of the abundance or scarcity of harvested resources (Bawa *et al.* 2007) among researchers and the community themselves (Kalibo and Medley 2007; Mbile *et al.* 2005). It also has the scope to enable 'countermaps' to be produced which display the needs and requirements of the groups who are usually excluded from scientific surveys because they are socially and institutionally marginalized (McCall 2003, cited by Sun *et al.* 2009).

[2] This is likely to be because the village head felt that there was insufficient remuneration for involvement in activities that an NGO had instigated to promote conservation in the area. The first author was loosely affiliated with this NGO during her fieldwork activity

[3] Consultative participation is described as being asked an opinion in specific matters without guarantee of influencing decisions and activity specific participation is being asked (or volunteering to) undertake specific tasks (Agrawal 2001).

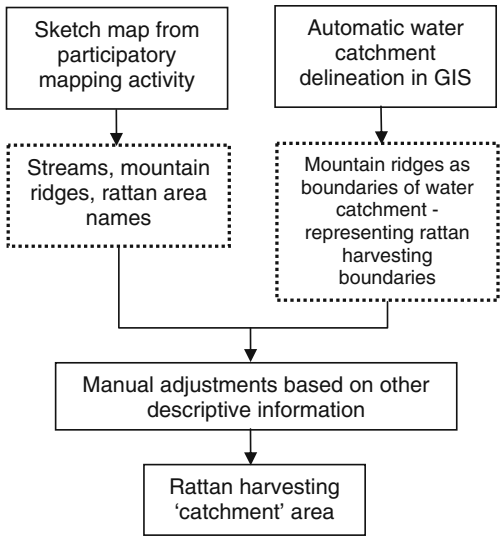

Fig. 3 Flow diagram of integrating sketch map into GIS

were derived from 1: 50,000 scale topographic maps (Bakosurtanal 1989).

To obtain the final RHZ, delineated catchment boundaries were adjusted using information on streams, distance and other landscape features recorded from the PM activity.

RHZs were superimposed on a designated forest zone map layer and three categories of RHZ were defined: i) RHZ completely within Conservation Forest, ii) RHZ partially within Conservation Forest, and iii) RHZ in Production Forest.

Accessibility Parameters

Rattan cane harvesting is labour-intensive work and physically demanding. Accessibility in the forest, represented by the distance and slope, affects the time and energy harvesters spend going into the forest and harvesting the canes. For each RHZ, accessibility measures were derived from the digital elevation model of the 1:50,000 topographical map (Bakosurtanal 1989). Distance was calculated between village and the respective points in the RHZ and was based on the planimetric distance adjusted by slope angles to give true field distance. Due to the absence of walking routes/pathways, the incorporation of slope angle into the shortest-distance measure is considered sufficient to represent field distance, although this does not take into consideration reduced accessibility due to factors such as impenetrable vegetation or river crossings.

Six accessibility variables were produced:

1. Distance to harvesting entrance point: representing how close the harvesting zone is to the village/hamlet.
2. Distance to farthest harvesting point: the greatest distance in the forest that harvesters are willing to make the effort to travel. This harvesting limit is often due to topography making further areas too inaccessible, but could also be because rattan only grows sparsely beyond this point. Information was obtained as cross-validation between the names of the areas in the forest identified in the PM and in the questionnaire survey and the farthest plot for rattan abundance inventory within RHZ (Widayati, unpublished thesis; see last paragraph of Introduction)
3. Mean slope : mean values of slope angle across an RHZ (in degree slope)
4. Standard deviation of slope: representing the variation in slope angle across the RHZ (in degree slope)
5. Proportion of flat slopes: slopes were classified into three classes and slopes of 5° or lower were considered as flat areas; the proportion of flat slopes shows how much of the area has favourable terrain.
6. Proportion of steep slopes: steep slopes were defined as slopes greater than 20°; and this represents how much of an RHZ can be considered rugged terrain that is difficult to pass through for harvesting.

Rattan Cane Harvesting Activities and Levels

Data on harvesting activities to obtain harvest level were gathered using a questionnaire survey. The questionnaire survey was conducted at sampled villages with rattan cane harvesters and it included both open and closed questions. Rattan collection is an informal employment activity and information on numbers of harvesters in each village could only be achieved after arriving on-site at the beginning of the survey. The target number of respondents for each village was determined to be either 25% of that village's harvester population or, if there were fewer than 30 harvesters, a minimum of 15 respondents. The village head provided information on the population size of the villages. Respondents were selected by accidental sampling in combination with snowball sampling (Sarantakos 2005) due to limitations in the field. In some villages, the target was not achieved, mainly due to respondents' unavailability at the time of the survey, or in a few cases, because harvesters were reluctant to participate.[4] Data gathering in each village took place over four to six days and interviewers moved from one village to another in a weekly cycle. Interviews were conducted individually with each respondent, normally at the respondent's house, at a time of

[4] The reason for this was that in some areas rattan harvesters have been, or have heard about people being prosecuted for illegal logging and feared a similar fate

day convenient to them which was usually in late afternoon or the evening after they returned from the farms. Each interview took approximately 1 to 1.5 hours.

The information gathered during the interview covered the following: distance and extent of rattan cane harvesting, harvesting methods, modes of transporting rattan, rattan species collected, quantity of harvested rattan for each trip, frequency and rotation of trips to the forest and perceptions of forest zones and rattan cane harvesting accessibility. An estimate of the total annual harvest per respondent was calculated from information gathered from the questionnaire survey, namely: cane weight pulled by the harvester per trip per day, number of harvesting days per week, average number of weeks for harvesting in a month and which month(s) in a year were allocated for harvesting over the previous rattan cane harvesting season. The collection months specified by the harvesters were triangulated against the agricultural calendar and corresponded with the low season for agricultural work, suggesting that problems with memory recall noted by other authors (e.g., Gross 1984) was not a major limitation in this case. Rattan harvesters tended to allocate specific days off for praying and resting so that ambiguity in estimates of numbers of days per week spent harvesting is unlikely. A village's annual harvest was estimated by multiplying the annual individual harvest level by the number of harvesters per village and thus refers to the total annual weight of rattan canes being harvested from a particular RHZ by the harvesters from a particular village.

Harvesting Levels and Effects of Accessibility and Forest Zone Designation

Statistical analyses were performed to assess the effects of accessibility and designated forest zones on the two response variables: 'individual annual harvest level' and 'village annual harvest level'. Predicting variables are grouped into: 'accessibility' as continuous variables and 'designated forest zones' as a categorical variable.

The seven predicting variables representing harvesting zone accessibility and size and the two response variables were checked for normality through their skewness and kurtosis values, and by comparing the data to a normal curve. Variables with skewness and kurtosis values beyond the threshold values of +3 and −3 were considered as not normally distributed (Marcoulides and Hershberger 1997; DSS 2007) and were transformed. Square root and $\log_{10}$ transformations were applied to achieve the closest-to-normal distribution.

Principal Component Analysis (PCA) is a data reduction method to obtain fewer variables that account for most of the observed variance of the original variables. PCA was conducted to reduce the seven accessibility variables into the minimum number of variables that carry most of the information. The first Principal Component (PC1) carries most of the variance and is commonly applied further as the extracted value of the original variables.

Multiple stepwise linear regressions were conducted for each of the response variables, i.e., individual annual harvest level and village annual harvest level, to determine which predicting variables contribute significantly to the variation in response variables. Relationship between RHZ size and harvesting levels was also assessed.

Further testing was conducted to determine whether designated forest zones affect the levels of individual harvest. It was considered necessary to control for the effect of accessibility factors; therefore, analysis of covariance (ANCOVA) was conducted on 'individual annual harvest levels' with the accessibility variables as the covariates. The village was incorporated in the ANCOVA as a factor to remove the co-dependence of harvesters from the same village. Post-hoc comparison using the Dunnett-T3 test was applied to identify significant differences in means of individual harvesting levels between each pair of designated forest zone categories. All statistical analyses were performed using SPSS 9.0.

Results and Discussion

Rattan Harvesting Zones

Seven sketch maps were obtained and transferred to the respective satellite image printouts. Examples of the sketch map and redrawn map on satellite image printout are given in Fig. 5 and Fig. 6, while an example of river catchment delineation can be seen in Fig. 4. Given the absence of participatory mapping in Lambusango Timur, the Wakangka RHZ was assumed to approximate the Lambusango Timur RHZ.

Discussions with rattan harvesters during the participatory mapping revealed landmarks such as burial sites and abandoned settlements as well as topographical features to be important reference points in the local harvesting landscape, but could not be located using the available geospatial data. The mapping exercise also revealed the names and locations of mountain ridges which are difficult for collectors to cross while carrying rattan canes. Trips end at those ridge tops and, with the bundle of canes to carry, the return trip takes the shortest and/or most accessible downward route to the main pathways or rivers heading back to the village.

Overlapping harvesting areas are likely to occur for some villages. Harvesters noted that there is an informal understanding among villagers that certain areas are core harvesting

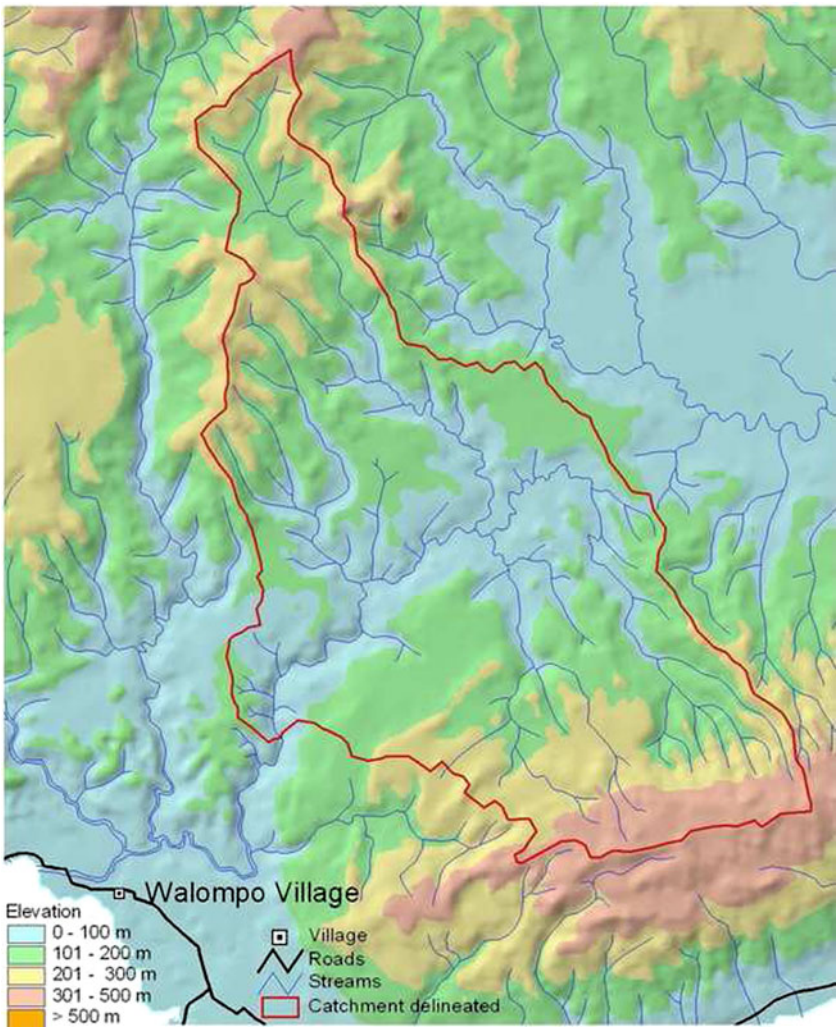

Fig. 4 Example of river catchment delineation with GIS

areas to particular villages, but towards the RHZ margins harvesters may come from different villages.

Uncertainty in the RHZ boundaries in this study is expected, therefore, the resulting boundaries should be treated as approximate and are fuzzy in reality. Crisp boundaries are not a naturally-conceived concept in indigenous spatial knowledge (McCall 2006). In addition, there are no rules restricting harvesters from entering harvesting destinations used by other villages and in this sense the property rights for rattan harvesting in Production Forest are open access. It is distance and terrain conditions that serve as natural limiting factors discouraging harvesters from harvesting in rattan areas used by other villages. Although fuzzy and approximate, the RHZ delineation is helpful in understanding harvesting area characteristics, resource abundance and availability in relation to where the harvesters come from and in further assessing the accessibility factors affecting harvesting activities.

Rattan cane harvesters in Lambusango forest shared access to different RHZs depending on rattan abundance and accessibility factors. There appear to be subtle reasons behind harvesters' preferences for shared access. Harvesters regard the forest as a potential source of income and limiting this for fellow harvesters is considered unethical. Preference for shared access is also motivated by the freedom that harvesters have enjoyed throughout their harvesting experience without any enforced regulations or law to restrict their mobility in the forest.

Rattan Harvesting Zone Accessibility and Adjacency to Conservation Forest

Seven RHZs were produced and the size of each RHZ ranges from 875 ha (Kakenauwe) to 3,944 ha (Wining East), as presented in Table 2. Accessibility variables for each village are also shown in Table 2.

Terrain conditions vary across the seven RHZs. Wining East RHZ is located in the flood plain of a tributary of the Winto River and is dominated by low elevation and flat areas. This RHZ has the most favourable terrain conditions, i.e., highest proportion of flat area (72%), no steep slopes (0%) and the lowest mean slope of 4.2°. Wining West RHZ

Fig. 5 Example of a sketch map resulting from participatory mapping

is located further west in another tributary network of the Winto River with slightly higher elevations and rougher terrain (elevation: 250–550 m, mean slope: 10°). Walompo and Sumbersari RHZs partly overlap. Both have low elevation (<200 m asl) but with rough terrain (mean slope: 8° and slope standard deviation: 6.5°). Two other RHZs with rough terrain are Lawele and Kakenauwe (mean slope: 12° and slope standard deviation: 7°), located at approximately 300–400 m asl. Wakangka/Lambusango Timur RHZ has the roughest terrain (mean slope of 14° and standard deviation of 8.5°), with the highest ratio of steep slopes (22%), located at higher elevations of 300–600 m asl.

The village with the shortest distance to the harvest area is Lambusango Timur where the RHZ begins only 2.1 km from the hamlet. The village with the farthest distance to the start of the harvest zone is Sumbersari, 6.5 km away from the settlement. For Sumbersari, the recent opening of the forest for agriculture to the west of the village about eight years ago has increased the distance to the forest from the settlement, which previously was only approximately 4.5 km. Harvesters who travel the farthest are those from Wining West (10 km) and those that go the shortest distance are Kakenauwe harvesters (5 km).

One RHZ is completely within the Conservation Forest, three are partly within Conservation Forest, and three in Production Forest.

Rattan Cane Harvesting Characteristics

One hundred and eleven rattan harvesters were interviewed to provide information on their harvesting activities. The number of respondents and the total rattan harvester population per village is summarized in Table 3. The highest number of harvesters was from Sumbersari, however this does not represent the recent situation, as the last rattan cane harvesting in Sumbersari was in 2002. The population in Sumbersari is dominated by Javanese who are not keen rattan harvesters. The expansion of agricultural lands towards the forest edge, which implies both increasing opportunity for non-forest based activity as well as farther distance of rattan area in the forest, was a disincentive to the continuation of rattan cane harvesting in this village.

Fig. 6 Example of a redrawn sketch map on satellite image (Landsat TM) printout

Six rattan species were named by harvesters as commercially valuable and are thus commonly harvested. The three most common species are: *Calamus zollingeri* (known locally as *Batang* or *Mombi,* 25–35 mm cane diameter), *Calamus ornatus (Lambang,* ± 20 mm cane diameter*)* and *Calamus sp. (Kabe,* 7 mm cane diameter*)*. Three less common species are also harvested and are normally bundled together according to their diameter classes: *Calamus mindorensis* Becc. *(Hoa)* normally grouped with *C. zollingeri,* and *Calamus symphysipus (Umbul)* and *Calamus sp. Nov 2 (Tohiti)* normally grouped with *C. ornatus*.

Rattan canes are climbers and can grow up to 40–50 m length. Harvesters are able to identify mature rattan canes

Table 2 Values of harvesting zones and accessibility variables extracted from GIS

Village	Harvesting zone size (ha)	Farthest distance (m)	Shortest distance (m)	Slope mean (degree)	Slope stdv (degree)	Proportion of flat areas	Proportion of steep areas
Lambusango Timur	2,730	6,092	2,087	14.13	8.50	0.26	0.22
Sumbersari	2,676	7,882	6,359	7.39	6.30	0.47	0.03
Wakangka	2,730	6,345	3,365	14.13	8.50	0.26	0.22
Lawele	3,157	8,163	3,914	11.08	6.73	0.32	0.08
Walompo	2,948	7,744	4,971	8.41	6.59	0.42	0.05
Wining East	3,944	7,106	4,730	4.19	4.63	0.72	0.00
Wining West	2,744	9,986	5,046	9.78	6.79	0.35	0.08
Kakenauwe	875	5,140	3,308	12.10	7.88	0.29	0.13

Table 3 Number of respondents, population of rattan harvesters and number of harvesting days

Village	Number of respondents[a]	Number of harvesters[b]	Harvesting days (days.yr^{-1})
Lambusango Timur	8 (80%)	10	54
Sumbersari	13 (11%)	118[c]	102[c]
Wakangka	13 (43%)	30	37
Lawele	18 (51%)	35	88
Walompo	15 (26%)	57	45
Wining East	7 (35%)	20	86
Wining West	16 (18%)	82	115
Kakenauwe	21 (75%)	28	33

[a] the number of respondents and the percentage of each village's total number of harvesters

[b] based on information from village authorities and/or key informants in the village.

[c] figures represent the 2002 situation

from characteristics such as peeled sheath, cane hardness, cane flexibility and colour. The harvester usually cuts mature canes into 5–7 m lengths, except for *Calamus sp. (Kabe)* canes which are cut into 12–15 m lengths.

Based on the modes of transport, rattan cane harvesting in Lambusango forest can be divided into two types: day-trip and river-rafting. For day-trip harvesting, harvesters go into the forest for between 8 and 12 h on a single day. The river-rafting harvesting usually takes a few days to harvest the canes, a couple of days to bundle the canes and a couple of days to transport them with bamboo rafts to the village. The number of days in one trip varies between 10 and 15 days. This method of transport is possible in locations where the size and depth of the streams allow harvesters to push the rafts downstream and where the river network leads to a main river and outlet near the settlements. In Lore Lindu National Park, Sulawesi, logs are used for floating the canes (Siebert 2001). In Lambusango forest bamboo is used. Day-trip harvesters are from Sumbersari, Lawele, Kakenauwe, Wakangka, Lambusango Timur and Wining West, while the river-rafting harvesters are from Walompo and Wining East.

The questionnaire survey also obtained information on harvesting time (hours), frequency (days per year) and harvest quantity per trip, with the intention of representing the characteristics of recent harvesting, i.e., 2006–2007. This intention was not entirely achieved, as rattan harvesters are not similarly active in all selected villages/hamlets. Sumbersari's harvesters mostly stopped harvesting in 2002, while for all the other villages in 2004–2006 rattan harvesters were still active. During interviewing, only Walompo and Wakangka villagers were actively harvesting due to the permanent location of a buyer there and the fact that permits had not yet been issued to companies within the vicinity of other villages.

Villagers who are engaged in rattan harvesting normally allocate their time by considering their other livelihood activities. Since most of them are farmers, they mainly harvest rattan during off-season months on the farms. The number of days per year dedicated to rattan cane harvesting are between 33 and 115 days, spread over between one and 12 months a year. Harvesters from Wining West are the most persistent harvesters as they harvest 115 days per year, while Kakenauwe harvesters have the lowest frequency at 33 days per year (Table 3).

Rattan Cane Harvesting Levels

Wining East and Wining West have been the most active rattan-harvesting hamlets, with 62 people, or approximately 50% of the household heads, engaged in rattan cane harvesting. However, the number reduced in 2006 when the asphalt mining company reopened and began to recruit labourers and when some villagers migrated to Maluku province for employment.

On a day trip, a harvester usually collects one bundle ranging from 50 to 80 kg of rattan canes, pulls it along the walking trails in the forest and stores the bundle in the river near the village until the selling day. River-rafting harvesters normally collect between 400 and 1500 kg canes per rafting trip of 10–15 days.

Harvesters from Wining East and Wining West harvest high quantities of rattan individually compared to the harvesters from other villages, approximately 6.5–6.8 t per person per year (Table 4). The lowest individual annual harvesting quantity is by harvesters from Kakenauwe at 2 t per person per year. Sumbersari annual harvesting quantity does not represent the current situation and thus is not included in further analyses.

Wining West has the highest village annual harvesting quantity of 540 t of rattan canes. Lambusango Timur, with the lowest number of harvesters and low quantity of individual harvest, has the lowest village annual harvesting quantity of 25 t/year.

Accessibility Factors that Affect Harvesting Levels

PCA of the seven predicting accessibility variables shows that PC1 represents 73.7% of the variation in the variables (Table 5).

Table 6 shows the accessibility variables and their component scores. Six variables contribute the highest

Table 4 Individual harvester's quantity and village quantity of rattan cane harvest

Village	Individual annual weight (kg.yr^{-1})	Village annual weight (kg.yr^{-1})
Lambusango Timur	2,484	24,841
Wakangka	2,919	87,579
Lawele	4,977	174,199
Walompo	3,175	181,002
Wining East	6,782	135,646
Wining West	6,588	540,254
Kakenauwe	2,045	57,273

scores to PC1: distance to harvest zone, RHZ size, mean slope, slope standard deviation, proportion of flat areas and proportion of steep areas. Due to the dominance and the highest scores of slope-derived variables, PC1 can be considered a 'slope factor variable'. Second principal component (PC2), with 13.7% of the variance, predominantly represents 'distance to farthest point'.

PC1 was used in subsequent multiple regressions to represent the slope factor, along with the original untransformed 'distance to farthest point' variable.

Multiple linear regressions for *individual annual harvest* with stepwise approach found that the slope factor is the only contributing variable with 'distance to farthest point' being removed. The significantly strong relationship (R^2= 0.676, adjusted R^2=0.612, p= *0.023*) shows that the slope factor plays an important role in the variation of individual annual harvest (Fig. 7).

Multiple stepwise regressions applied to *village annual harvest* found that 'distance to farthest point' best explains the variation in village annual harvest while the slope factor variable was removed in the process. Figure 8 shows a significantly strong positive relationship between village annual harvest and distance to farthest point (R^2=0.796, adjusted R^2= 0.755, p= *0.007*).

Harvesting zone size does not show a significant relationship with either individual annual harvest quantity or village annual harvest quantity. However, a scatter plot suggests a positive linear relationship for annual harvests of some villages (R^2=0.109, p= *0.469*) (Fig. 9).

Table 5 Results of PCA of the seven accessibility variables

Component	Initial Eigen values	
	% of variance	Cumulative%
1	73.71	73.71
2	13.72	87.43
3	10.35	97.78
4	1.51	99.3
5	0.57	99.87
6	0.13	100

The PCA-derived slope factor shows a relationship with individual annual harvest level. However, in these relationships it was noted that a village with a very high harvesting level (Wining West) presents an outlying case not linearly related to the slope factor. Forest in Wining West has the second highest density of rattan plants (Table 1), i.e., 1,196 mature plants/ha. This high rattan resource abundance seems to override the effects of accessibility on harvesting levels. Despite the relatively rough topography and medium harvesting zone size, with abundant supply, a large amount of rattan cane is harvested. Other external and socio-economic factors might also be influential factors for Wining West harvesters, such as the decline of asphalt mining production in early 2000s that caused unemployment for former labourers (Malleson 2005).[5]

Several villages have low harvesting levels and do not fit the relationships with accessibility (Fig. 7 and Fig. 8). Other factors may be more important for these villages. Rattan cane harvesting in the villages surrounding Lambusango forest is an informal occupation during the farm off-season. Despite its role as a cash source and livelihood safety net, rattan cane harvesting is considered labour intensive and physically demanding. Other more permanent livelihood sources in cash-crop farming may be more attractive to the villagers and those with good income from these sources tend to harvest less or eventually give up rattan harvesting (Widayati, unpublished thesis).

The strong relationship between distance to farthest point and village harvest quantity shows that the larger the extent of accessible rattan, the higher the quantity harvested by a village. RHZ size is a less effective surrogate for harvesting extent, reflecting that RHZ delineation is only a rough approximation, while farthest harvesting point was more accurately and specifically defined in the PM and forest survey.

Forest Zone Designation Affecting Harvesting Levels

Across the three designated forest zones, observation of the means of individual harvest levels shows that the

[5] Reopened in 2006.

Table 6 Scores for PC1 and PC2 extracted from PCA of accessibility variables

Variables	Component	
	1	2
Distance to farthest point	0.588	0.797
Distance to harvest zone	0.867	0.289
Harvest zone size	0.660	0.144
Mean slope	−0.963	0.253
Standard deviation of slope	−0.972	0.187
Proportion of flat areas (log_{10})	0.928	−0.341
Proportion of steep areas	−0.945	0.076

highest level is by harvesters going to RHZs partly within Conservation Forest (4,537 kg.yr^{-1}) followed by harvesters in Production Forest (4,136 kg.yr^{-1}), and the lowest is by harvesters going into Conservation Forest (2,750 kg.yr^{-1}), as shown in Table 7.

From the ANCOVA applied to the individual harvest levels, however, the result shows that by removing the effects of slope factor, distance to farthest point and the co-dependence of harvesters from the same village, individual harvest levels in the Conservation Forest will be significantly higher than those in the other designated forest zones (t-statistics=2.118, $p=0.037$).

The location of harvesting destinations in relation to designated forest zones does not appear to significantly affect the individual harvest level. Harvesters going to RHZs straddling Conservation Forest and Production Forest have the highest harvest levels. The fact that these RHZs have a high density of rattan plants and favourable topographic conditions may explain the high harvesting levels. An entry point in Production Forest may reduce awareness that their movement may have brought them into the Conservation Forest. This is worsened by the lack of clear signs or posts to indicate Conservation Forest boundaries.

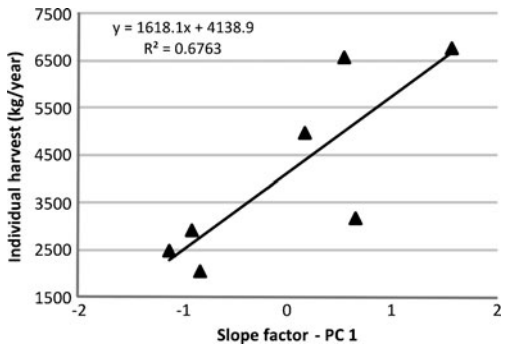

Fig. 7 Relationship between individual annual harvest quantity and the slope factor obtained from PC1. A higher PC1 score represents more accessible terrain conditions. (▲ represents village)

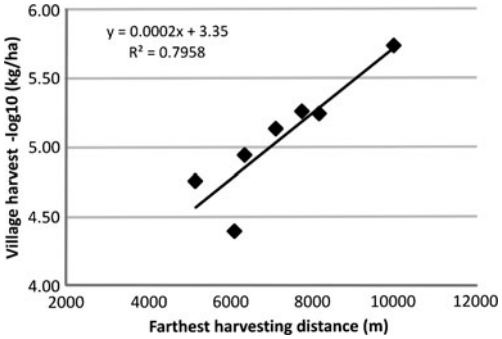

Fig. 8 Variations of village annual harvest quantity being explained by distance to the farthest point (♦ represents village)

Conservation areas are assumed to be a constraining factor encouraging less-intensive harvesting activity and thus lower harvest levels. It is very common that protected or conservation areas are located in the core areas of the forest which also coincide with rougher, if not roughest, terrains. This combination makes the area less accessible or even inaccessible. Due to this combination, however, it becomes unclear which factor contributes more strongly to the inaccessibility of the forest: topography or forest regulation. In the case of Lambusango forest, it was found that by removing the effects of slopes and extent of abundant rattans, quantity of harvesting in the Conservation Forest will be higher than in other forest zones. This demonstrates that the existence of the conservation area may not be a strong constraint on harvesting activity. Instead, topography and extent of rattans in the forest are much stronger factors.

Perceptions of Rattan Harvesting Destinations

Sixty percent of respondents noted that their harvesting destinations are exclusively used by harvesters from their own village. When asked about their preference, 52% of the respondents prefer to have exclusive harvesting destinations, and 35% prefer shared-access areas. The main premise

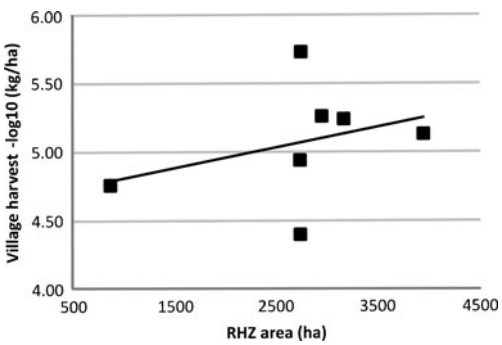

Fig. 9 Relationship between rattan harvesting zone (RHZ) size and village harvest quantity (■ represents village)

Table 7 Comparison of mean individual harvest levels among different designated forest zones

Designated forest zone	*n*	Mean individual weight (kg.yr^{-1})	Std. error
Conservation forest	18	2,750	460
Adjacent to conservation forest	41	4,538	781
Production forest	30	4,136	549

for preferring shared-access among villages is that rattan is a source of income for many villagers, so it does not feel correct to limit the sources of income in forest which belongs to all the villages surrounding Lambusango. Responses also indicate that shared-access is preferable so that harvesters are able to go to other harvesting destinations as well.

Of all the respondents, 64 harvesters (58%) use RHZs that are either solely or partially within the Conservation Forest. Of these 64 harvesters, only 23 (36%) stated that their harvesting destination included areas that lay within Conservation Forest; seventeen respondents (27%) stated their harvesting destinations were in Production Forest and 20 respondents (31%) responded that they did not know the type of designated forest zone of their harvesting destinations. Four respondents did not give their responses.

There were 47 respondents (42%) from villages with RHZs completely within Production Forest. Nearly half of them (23 respondents, 48%) thought that their harvesting destinations were in the Conservation Forest; only 4 respondents (8%) identified that they were in Production Forest and 16 (34%) were not aware of the type of designated forest zones they entered for harvesting. Four respondents did not answer.

Regardless of whether or not harvesting destinations are located in Conservation Forest, harvesters tend to state that they are aware that parts of the forest are designated as conservation areas. However, there is clearly limited understanding of Conservation Forest boundaries and whether their harvesting destinations are located inside, partly within or outside Conservation Forest. This could explain why perceptions of those harvesting in Production Forest and those harvesting partly or entirely in Conservation Forest are inconsistent with their actual harvesting destinations in relation to Conservation Forest. Harvesters also seem to have lack of awareness of the ban on forest product extraction in Conservation Forest. There is confusion between the laws restricting timber extraction in Production Forest and the laws which ban extraction or removal of any forest products in the Conservation Forest. In addition, because local communities have been harvesting forest products since long before the establishment of the designated forest zones, there is evidence of varying sentiments and reactions among villagers with regard to complying with the Conservation Forest regulations. These varying sentiments may partly be due to lack of awareness and, on top of that, a tendency to ignore the regulations when they are considered unfavorable to their livelihood activities. This latter tendency is shown by the continuing illegal timber extraction as a livelihood source in some villages despite villagers' awareness of the illegality of the activity. Instead of staying away from the activity, some villagers choose to ignore the risk but stay alert by making sure they do not let themselves to be caught. The reluctance of rattan harvesters to participate in this study is also evident of that attitude. Some rattan cane harvesters chose to avoid contact with outsiders after rumours of criminal allegations against those who participated in illegal timber extraction.

Issues on NTFP Extraction Related to Accessibility and Conservation Designation

Interlinkages between human activities in the forest and the establishment of conservation areas have brought up a few issues. First, the establishment of Conservation Forest in areas with abundant resources and relatively good accessibility inevitably creates conflicts with local interests in forest product extraction, which are likely to lead to illegal activities. This challenges the reinforcement of conservation designation. With the importance placed at the policy level on conserving biological values, such as endemic wildlife species, the accessibility and abundance of commercially valuable resources have obviously not been considered (for example by excluding part of the forest from a conservation area). This needs to be addressed not only for the effectiveness of conservation but also for the sustainability of local livelihoods.

To successfully enforce restricted access to resources in forests with a long-standing importance to local livelihoods, policy and regulation need to accommodate livelihood sustainability. As reviewed by Kaimowitz and Sheil (2007), considering that local people living in the forest periphery are often poor and vulnerable, conservation efforts need to move away from a conventional approach towards a site-specific approach that also addresses poverty issues. The way towards finding solutions might be to review the boundary delineation and/or to review the regulations related to local small scale forest product extraction.

Conclusion

This paper presents a case study addressing levels of rattan cane harvesting in a forest where there are conservation interests. The influences of accessibility factors and conservation designation on harvesting levels were assessed.

Boundaries of rattan harvesting zones have been derived from participatory mapping, but should be treated as an approximation of the informal areas that villages use for rattan cane harvesting activities in Lambusango forest. The application of GIS to the maps created by harvesters in this study proved to be an effective, objective and comprehensive tool in obtaining data and information regarding natural resource utilisation by local people.

This study has found evidence that natural factors such as terrain and accessibility have an influence on the amount harvested, due to the individual and manual nature of wild rattan cane harvesting. However, the accessibility factor is less influential where the resource is abundant and there are external factors triggering more intensive harvesting.

The forestry laws enforced through the designated forest zone system (*kawasan hutan*) do not significantly affect the levels of harvesting. In areas where forest product extraction is a long-standing and common activity, forest designations do not effectively constrain the movements of rattan harvesters. In addition, there is evidence of reluctance to recognise the relatively new conservation forest regulations.

Using the case study of Lambusango Forest, Buton, Indonesia, this paper also gives insights on the interlinkages between NTFP harvesting activities, forest accessibility, resource abundance and forestry laws restricting the activities, and presented the associated emerging issues, hence problems, on the ground. The establishment of conservation areas and the success of enforcements need to take into account the relevant local issues, in addition to biological factors as the main conservation targets.

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