*Baobab (*Adansonia digitata *L.) and Tamarind (*Tamarindus indica *L.) Management Strategies in the Midst of Conflict and Change: A Dogon Case Study from Mali*

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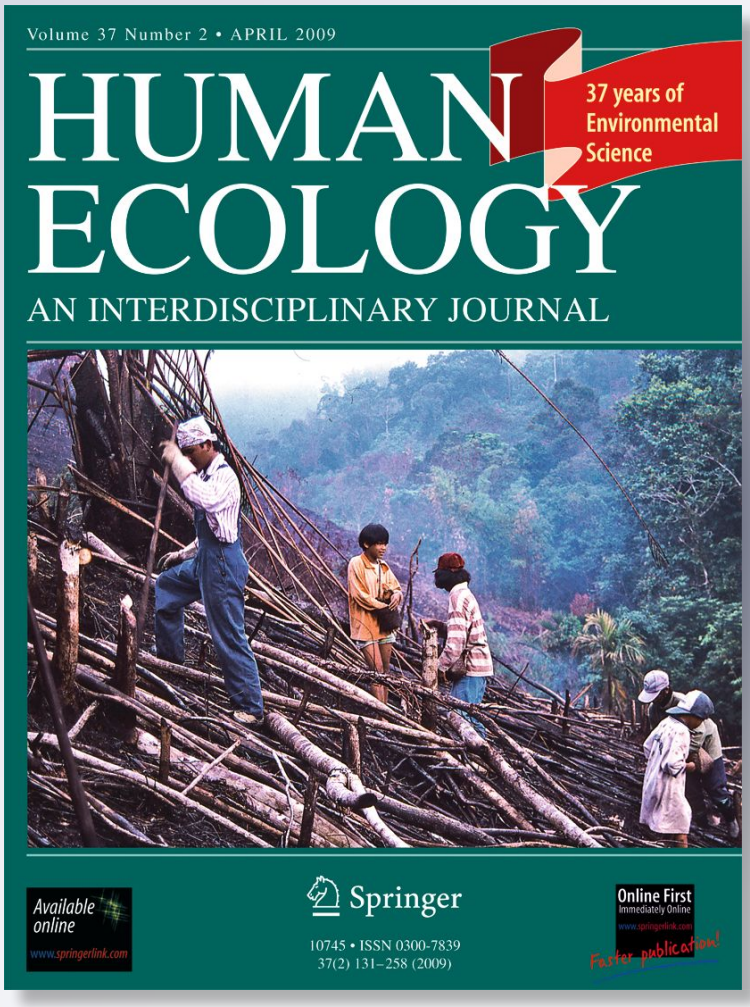

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Baobab (*Adansonia digitata* L.) and Tamarind (*Tamarindus indica* L.) Management Strategies in the Midst of Conflict and Change: A Dogon Case Study from Mali

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Abstract The tree management practices of a Dogon village in Mali, West Africa were investigated to learn how a rural population adapts its strategies to cope with institutional change, climate change, unequal land distribution, and expanding market access. A range of methodologies was used, including semi-structured interviews, seasonal calendars, community mapping and matrices. Special focus was given to baobab (*Adansonia digitata* L.) and tamarind (*Tamarindus indica* L.), two highly used and valuable trees within this community. This research reveals that community members have realized that traditional management practices are no longer effective in dealing with the impacts of these transitions, and highlights the fact that management practices, while historically uniform, have begun to diverge in recent years based on unequal land and water endowments within the village. Understanding the rights and abilities of all users to access and protect these species is crucial to their conservation.

Keywords *Adansonia digitata* · Management institutions · Resource management · *Tamarindus indica* · Dogon · West Africa

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Introduction

Baobab (*Adansonia digitata L.)* and tamarind (*Tamarindus indica L.)* are crucial components of rural livelihoods in the Sahel of West Africa. Besides providing essential nutrients and minerals to rural diets, these trees are also harvested for medicine, fuel, other non-edible products and for the raw materials for processed goods (Havinga *et al.* 2010; Wickens and Lowe 2008; El-Siddig *et al.* 2006; Sidibé and Williams 2002). Often these two species provide opportunities to marginalized members of the community, such as women and the poor, since they are a valuable source of income and help to mitigate risk during crisis by providing alternative food and economic resources (Gustad *et al.* 2004; Bonkoungou *et al.* 1999; Guinko and Pasgo 1992).

Development agencies have struggled to understand what motivates people to protect and propagate certain species, while letting other, seemingly more valuable species disappear. Factors such as degree and type of commercialization, climatic variation, age, gender, religion and kinship can influence which tree types are favored and protected (Assogbadjo *et al.* 2008; Dhillion and Gustad 2004; Gustad *et al.* 2004; Kristensen and Lykke 2003; Bonkoungou *et al.* 1999; Guinko and Pasgo 1992). If efforts to improve rural livelihoods and conserve baobab and tamarind are to be successful then it becomes critical to understand what management strategies have resulted in sustainable or unsustainable use of these trees and what factors shape management decisions.

This research focuses on how a rural West African community deals with resource change and how people adapt their management strategies accordingly by examining how individuals and management institutions in one Dogon village are handling the fairly recent impacts of institutional change, climate change, unequal land distribution and

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expanding market access, with special emphasis on baobab and tamarind management, as they are recognized as highly used and valuable trees within this community. While concentrating on changing tree management strategies in one village, our goal is to extend the value of an understanding of the villagers' varied responses and adaptations to these changes to livelihood and conservation development initiatives in other locations and contexts.

Theoretical Framework

Much attention has been focused on desertification and changes in vegetation occurring in the Sahel of West Africa (Kandji *et al.* 2006; Wezel and Lykke 2006; Wezel and Haigis 2000; Boffa 1999). Human impacts, driven by rapid population increases and shifting social and political systems resulting in part from increased mobility and decentralization, are seen to be major factors in contributing to widespread deforestation (Cissé *et al.* 2005; Bremen and Kessler 1997: 25; Ruthven and Koné 1995), which, when coupled with droughts and climate change, have caused concern that the arid regions of West Africa are seriously under threat. There is a perception that traditional land and tree management techniques are no longer effective in maintaining biodiversity and species abundance, to the degree that they are now seen as unable to combat widespread environmental degradation (Wezel and Rath 2002; Sollart 1986). Overexploitation, intensive farming and inappropriate management strategies are cited as major causes of current environmental degradation in the Sahel (Bremen and Kessler 1997; Cleaver and Schreiber 1994).

While early research after the severe droughts of the 1970s and 1980s painted a bleak future for the people of the Sahel, more recent findings have highlighted the adaptability of residents to dramatic change (Batterby and Warren 2001). A growing body of research suggests that traditional tree management is innovative and adaptive and, rather than causing environmental destruction, has in fact contributed to reforestation in many areas (Duvall 2007; Ickowitz 2006; Rasmussen *et al.* 2001; Ribot 1999; Fairhead and Leach 1995; Posey 1985).

Development agencies have learned that resource conservation cannot be effectively addressed outside the context of rural livelihoods (Batterby and Warren 2001). By understanding tree management as a social-ecological system (Berkes and Folke 1998) the dual concerns of resource conservation and livelihood preservation can be addressed. It is often societies most directly dependent on the natural resources of their environment for their livelihoods that have developed the widest array of strategies for adapting to change (Yami *et al.* 2009; Mwangi and Ostrom 2009; Berkes *et al.* 2000).

Analyses of socio-ecological factors, such as tree tenure, land and tree property and access rights, as well as the distribution of benefits derived from tree resources, provide insight into the decision-making and power *loci* of a community (Howard and Nabanoga 2007; von Benda-Beckmann *et al.* 2006; Ostrom 1990; Fortmann and Bruce 1988). If the institution that creates and enforces tenure regulations is weak, then the regulations, no matter how well formulated, may not be enforced or abided by (Toulmin *et al.* 2002; Gibson *et al.* 1998; Ostrom and Gardener 1993). Ostrom (1990) argues that these institutions work best when they are adaptive, when rules are clear, enforced and nuanced, when they are legitimized by external organizations, and are faced with slow exogenous change. Yami *et al.* (2009) argue further that collaboration between informal and formal institutions is essential for effective resource management. Therefore, an understanding of the legal and social institutions governing management is just as important to the formulation of effective conservation policies as knowing how trees are used.

Traditional West African tree tenure systems are extremely complex (Berry 1988) and further complicated by current movements towards decentralization through much of West Africa (Alinon and Kalinganire 2008; Toulmin *et al.* 2002). Tenure is more than just legal ownership; it creates beneficiaries and victims based on how ownership is divided and what "bundles of powers and obligations" accompany that ownership (Howard and Nabanoga 2007:3). Von Benda-Beckmann *et al.* (2006) suggest that this includes not only the many rights that one owner may have in tree resources and the rights that many owners may have in one resource, but also the ways in which these rights are expressed through ideology, legal institutions, social relations and daily practice. In addition, tenure affects people's standard of living, as well as the protection and planting of trees and the surrounding ecosystem (Fortmann and Bruce 1988: 3). A failure to recognize the complexity of local tree management regulations could be detrimental for domestication initiatives, resource sustainability and human welfare (Howard and Nabanoga 2007).

Ethnographic Background

Research was conducted in the Dogon village of Mendolo (14°3′48.31″N, 3°47′49.96″W), a village of approximately 700 people, located 75 km southeast from the regional capital of Mopti, Mali. The nine hamlets of Mendolo are scattered along the southern edge of the 150-km-long Bandiagara escarpment and on the sandy valley floor of the Gondo plain below, in the central plateau region of the country.

The study site lies between the Sudano-Sahelian and the Western Sahelian agroecological zones of sub-Saharan Africa, with between 200 and 500 mm of rainfall annually (UNEP 2008). There were frequent droughts in the Sahel in

the 1970s and 1980s. According to the Intergovernmental Panel on Climate Change, rainfall in the Sahel decreased by 29%–49% from 1968 to 1997 as compared to the 1931–1960 baseline (Kandji *et al.* 2006: 9), which left the region facing agricultural and livestock shortages, malnutrition, economic hardships and loss of lives, necessitating innovative adaptive strategies on the part of the local populations.

Comprising 8% of the total population, and numbering approximately 800,000 (Library of Congress Federal Research Division 2005), the Dogon are agriculturalists, cultivating millet and sorghum as their staple grains. Like much of West Africa, in Mendolo men are the landholders (Berry 1988), although women are able to borrow land from men to cultivate. As trees are the property of the landowner, people plant trees only on their own land. Not all hamlets have farming land allocated on the same quality terrain and consequently farmers in different hamlets face different environmental constraints, the most critical of which is lack of water.

While many Dogon are animists, a growing number follow Islam, sometimes incorporating Islamic beliefs into existing animist cosmology although often abandoning animist practices altogether. Most residents of Mendolo converted to Islam approximately 35 years ago and discarded many animist practices. A minority of Dogon are Christian. The incorporation of Islam and Christianity into Dogon belief systems is fairly recent, due in part to the impenetrability of the cliffs bordering their territory (UNEP 2008). The Dogon fled to this region at the turn of the sixteenth century to escape Islamic religious campaigns and slave raids (van Beek and Banga 1992: 66), and this afforded them protection and isolation long after the rest of West Africa had been conquered. Colonization by the French and the subsequent *pax gallica* slowly opened up the region to outside contact by the mid-twentieth century, and as a result the Dogon moved onto the plains, increasing contact with other ethnic groups of the region, expanding their territories and undergoing population growth. With little threat of invasion, the Dogon people also became more mobile, increasing their short-term and seasonal migrations (Ruthven and Koné 1995). Colonization also brought improvements to infrastructure, with new roads easily connecting people to large centers of commerce and trade.

Methods

The first author conducted field research in Mendolo for seven weeks between May and June 2009.[1] Community mapping, seasonal calendars, matrices, focus groups, semi-structured interviews and participant observation were used to collect data to examine current tree management strategies as they related to baobab and tamarind conservation[2] (Bernard 2006; Martin 2004; Pretty *et al.* 1995; Freudenberger 1994; Bruce 1989).

As the hamlets in the village are located on diverse physiographic zones (rocky cliff, sandy valley and plateau), care was taken to ensure that villagers from each hamlet were interviewed, as landscape condition could influence people's interaction with trees (Arnold and Dewees 1997) (Fig. 1). Focus groups were divided according to cliff, valley or plateau residence, with each zone having separate male and female focus groups to allow for more open and unguarded communication, for a total of six focus groups with an average of eight participants per group.

Initial focus group activities included community mapping (as a means to understand local perceptions of boundaries, resource distribution and resource availability) and seasonal calendars (as a means to understand tree tenure and access), followed by historical and conflict matrices (as a means to capture changes in management over time and to highlight inequalities in management, respectively), as outlined in Freudenberger (1994).[3] These activities were conducted in a group to encourage discussion and debate among participants as well as permit people to elaborate on responses and share the motivations behind decisions (Bernard 2006: 236).

In the historical matrix activity, male focus groups from each of the three landscape zones discussed the abundance of six resources (common land, private land, cows, sheep/goats, baobab and tamarind trees) during the distinct periods of village management (animist, post-animist and the present community consensus) as well as their predictions for future resource distribution (Fig. 2). For the conflict matrix, female focus groups from each landscape zone were asked to discuss the perceived degree of conflict between themselves and different user groups (residents of Mendolo, residents of neighboring villages, strangers, the state) in regard to eight resources (livestock, water, land, tamarind leaves, tamarind fruit, baobab leaves,

[1] She had an excellent rapport with the community and a comprehensive knowledge of Tomo kan, the Dogon dialect spoken in the village having lived and worked in Mendolo from April 2005 to December 2007.

[2] Efforts are underway to develop sustainable production systems and domestication strategies of baobab and tamarind in West Africa (DADOBAT 2009; Maranz *et al.* 2008). The potential domestication of these trees will have social as well as environmental impacts on the long-term survival of the species, rural livelihoods and local management practices.

[3] Due to time constraints, only one matrix was completed with each focus group. The first author chose to conduct historical matrices with men, as they are the primary resource owners in the village, and conflict matrices with women, since they are the primary gatherers of tree products and would be more likely to experience direct conflict over these resources. While these matrix results do not represent the perceptions of all user groups in the village, they do provide an indication of some of the varying viewpoints held by residents about resource abundance and access.

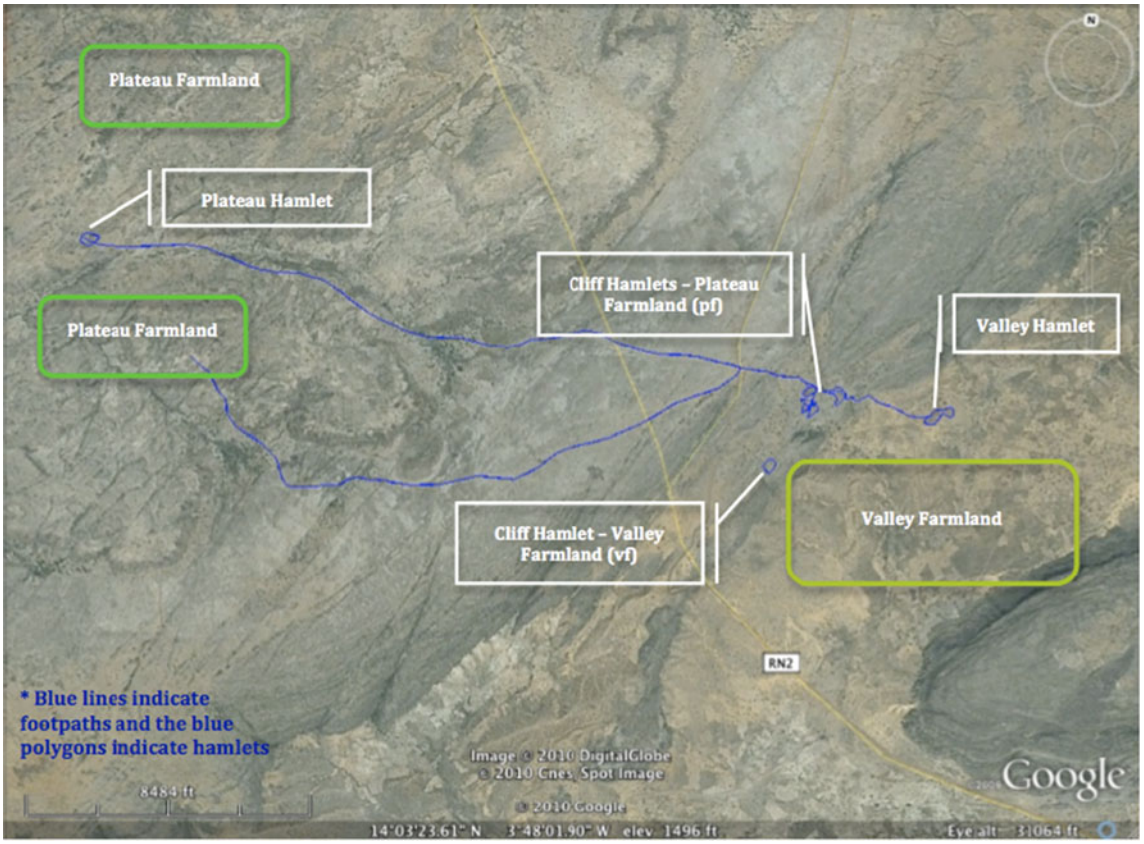

Fig. 1 Map of Mendolo showing hamlets and the location of farmland for each hamlet

baobab fruit and baobab bark). For the historical matrix, men placed increasing or decreasing numbers of seeds on a grid to represent changes in resource abundance over time, relative to other resources. The women placed seeds in each category based on their perceptions of how much conflict they experience with different user groups over resources. The seeds were then counted and the numeric value recorded for each category, after which the data could be represented graphically.

Fig. 2 A resident of Mendolo explains the historical matrix activity to members of a male focus group (credit: H. Leach 2009)

Semi-structured interviews were conducted in Tomo kan, as well as English and French when translators were available. Villagers were asked to discuss their use of baobab and tamarind, ownership of trees, access to trees, revenue generated from trees and changes that they have seen in tree populations in village over their lifetimes. Participants were also asked what species they found to be important and what species they planted.

Informants were chosen to include men (n=42), women (n=41), young (aged 17–33, n=18), middle-aged (aged 34–64, n=42) and elderly (aged 65–91, n=23) of varying socio-economic statuses, as well as experts from within and outside the community (n=6). This was particularly important, as research indicates that tree management practices and access to trees differ based on factors such age, sex and economic status (Howard and Nabanoga 2007; Rocheleau and Edmunds 1997; Agarwal 1989). In total 89 people representing all nine hamlets took part in the study: 36 in semi-structured interviews, 47 in focus groups and six in expert interviews that included residents of Mendolo and people outside of the village (Table 1).

As research was focused on two easily identifiable species, no plant specimens were collected. When other species were

Table 1 Methods used during data collection and number of participants involved in each research method

Methods used during data collection								
Data collection tools	Topics discussed	Participants						
		Mendolo residents						Experts
		Cliff		Valley		Plateau		
		M	F	M	F	M	F	All male
Semi-structured interviews	Important species, planted species, use of baobab and tamarind, ownership of trees, access to trees, revenue generated from trees, and changes seen in tree populations in the village	10	9	4	4	5	4	6
Focus groups	Community mapping, seasonal calendars, historical matrices (male only) and conflict matrices (female only)	9	10	5	6	9	8	
Participant observation	Cooking, market visits, and farming							

mentioned, they were recorded in the language in which they were reported and then identified with field guides and assistance from local botanical researchers. Qualitative data were transcribed from voice recordings and coded. Microsoft EXCEL was used to represent the analyzed data graphically.

Results and Discussion

Uses

Informants interviewed in village reported 33 species to be important; 81% stated that baobab was important and 67% that tamarind was important (n=36). These species were the two most frequently listed species, followed by shea nut (*Vitellaria paradoxa)*, mentioned by 20 informants and mango (*Mangifera spp.*), mentioned by 14 informants.

All informants stated that they had used baobab and tamarind in some capacity within the past year. Most villagers said that they used baobab daily in their morning and evening meals as the main ingredient of a sauce for sorghum or millet mush (the preferred meal of this region; Assogbadjo *et al.* 2008; Sidibé and Williams 2002; van Beek and Banga 1992). Tamarind is typically consumed once daily as flavoring for the midday meal of millet cream; villagers use both the fruits and the leaves, although if available fruit is preferred.

Besides food, villagers used baobab and tamarind products, including leaves, fruit, bark, wood, roots, seeds and exudates, for medicinal, artisanal and agricultural purposes (see also Buchmann *et al*. in press, 2009; Assogbadjo *et al.* 2008; Sidibé and Williams 2002).[4]

[4] These uses will not be elaborated further as management decisions in Mendolo are based primarily on the dietary uses of baobab and tamarind.

Seasonality

The availability of many baobab and tamarind tree products is seasonally dependant, while use of products for cooking remains fairly consistent throughout the year, so baobab and tamarind products must be stored and/or purchased in order to meet these needs.

Baobab trees begin to leaf early in the rainy season (beginning in June), but women harvest only a basket or two at a time during the rainy months (Fig. 3). After the rains have ended in late August or early September and the fields have dried families cut all the remaining leaves from

Fig. 3 A teenaged girl climbs a baobab tree close to village in order to harvest fresh leaves for the evening meal (credit: H. Leach 2009)

their trees in one large harvest. Harvesting an individual tree takes only a few hours but it may take a family days or weeks to cut, gather, dry, and divide the leaves from all of their trees among household members for use during the rest of the year. Often supplies are insufficient for the year, and households must buy leaves to supplement their coffers (see below).

Not every household in the village participates in the dry season baobab fruit harvest because trees that are intensively managed for leaf production do not always fruit. It may be only very large old trees that are too tall to harvest, or trees with particularly bitter leaves that are infrequently harvested that produce fruit. With enough trees to provide an adequate supply of leaves for the year, villagers might leave the top section of the tree uncut so that it will produce fruit. All respondents stated that, while fruit is a welcome supplement to the diet, it is secondary to leaf production, and management practices are geared towards maximizing leaf production even if it diminishes fruit production.

Tamarind trees flower in May and June, and owners discourage leaf collection during that time because it can damage flowers and hinder fruit production. Tamarind fruit is ready for harvest during the cooler months of January and February. Each tree produces copious quantities of fruit so the harvest can take months. Even as late as in June it was possible to find fruits still on the trees.

Although tamarind fruits are preferred for flavoring porridges, if they are not available people will use tamarind leaves instead; in fact, some households relied solely on tamarind leaves for cooking. Tamarind trees are evergreen, but the bulk of the leaf harvest occurs during rainy season when the previous year's supply of fruit has been exhausted and the new crop is still developing. Stored tamarind fruit typically lasts between 4 and 9 months, but while some households have ample supplies for the entire year, others have none at all. Even though tamarind trees and their fruit belong to the farmer on whose land they grow, tamarind leaves are a common pool resource and are available to anyone in village to harvest.

Change Drivers

We argue that there are three drivers of management change impacting current tree management decisions in Mendolo: institutional change, unequal land distribution and expanding market access. The combined synergy of all drivers has resulted in the changes currently taking place in the villages, although some may be more influential than others.

Institutional Change

From Alo Moju Na to Community Consensus The village has undergone an institutional shift within the last 40 years from an animist system of tree management headed by the *Alo Moju Na*, the traditional guardian of the trees (Fig. 4), to current management by community consensus. The Alo Moju Na was a masked man who would patrol on the look out for inappropriate tree use on the part of the villagers. He had the power to enforce management rules by punishments ranging from demanding offerings of millet beer and goats to even sealing up granaries. Not surprisingly memories of the Alo Moju Na are still strong in the village; as one informant said, "If you harvested unripe fruit, he would fine you and take everything that you owned in your house away from you…People really feared the Alo Moju Na" (man, aged 70*)*. People expressed a sense that the system worked under the Alo Moju Na, that there were more trees under his authority, and that people were better at protecting trees during that era.

During this period Mendolo villagers commonly used fetishes and taboo to safeguard their tree resources. Objects such as animal skins, skulls or teeth and plants were tied to a tree to indicate ill would befall anyone who tried to steal from it. Certain areas of the village were protected by a taboo; there were trees that were forbidden to climb, areas that were off limits to males or females, and places and trees that were sacred. Studies from diverse regions suggest that the designation of sacred sites by local communities is as much a conservation strategy as an expression of religious beliefs (Dudley *et al.* 2009; Bagwat and Rutte 2006), so these techniques were an integral part of baobab and tamarind conservation.

Fig. 4 Two men of a neighboring village wear the mask traditionally worn by the Alo Moju Na when patrolling the bush (credit: H. Leach 2009)

The era of the Alo Moju Na, marked by strict enforcement of management rules through the use of ritual and taboo, while effective in safeguarding resources, did not lead to resolution of conflict among villagers but rather an avoidance of confrontation altogether. However, the dynamics of tree management in Mendolo shifted with the conversion to Islam.

The adoption of Islam was marked by the destruction of fetish sites, the removal of taboos and the end of other distinctly animist practices. When the incumbent Alo Moju Na died during this period, he was not replaced and no corresponding village institution was put into place. When the role of the Alo Moju Na came up in interviews, the Malian Department of Water and Forestry (*Eaux et Forets*), the governmental agency created in 1938 to monitor citizens' use of tree resources, was invariably mentioned as well. Attitudes towards Eaux et Forets in Mendolo ranged from tolerance to ambivalence to outright distain.

While the Eaux et Forets agent responsible for patrolling the borough where Mendolo is located said that he probably caught three people last year in the borough, the Alo Moju Na of a neighboring village said that he and his band of "soldiers" caught approximately 30 people in the fields surrounding his village and neighboring villages alone.[5] These results accord with other research in West Africa, where state authority is retreating and increasingly ineffective due to decentralization (Alinon and Kalinganire 2008) and poor funding, and local people are turning towards "acts of communal self-justice" to fill the gaps left by state institutions (Grätz 2007: 82). The Eaux et Forts agent voiced frustration, saying that he was responsible for patrolling 23 villages, which was too much for him to effectively monitor on his own, and even if he could, "Where would I find the money to fill my gas tank for that much travelling?" State institutions, if they intervene at all, are often regarded as ineffective by local people (Grätz 2007: 83). Interestingly Mendolo villagers are renewing their interest in the Alo Moju system, and the Alo Moju Na in the neighboring village said that he has many young men working with him wanting to learn this specialized traditional knowledge. Other Dogon villages in the area have also returned to the Alo Moju system in recent years (Ruthven and Koné 1995).

Without the Alo Moju Na to protect the bush land, tree resources became overexploited, and informants reported a predictable decline in tree populations. With no effective deterrents, stealing became a problem. Only with the realization that all of the old trees were dying did people decide on action. They extended the system of community consensus, or *kan cembu*, which already existed in the form of a village council of elders, to include the protection trees. Kan cembu involves discussions among elders who make decisions on behalf of the community as a whole.

According to the village chief, kan cembu now encourages villagers to plant trees, particularly baobab, and to look after found seedlings of other important trees such as the African locust bean (*Parkia biglobosa*), tamarind, mango (Mangifera ssp.), fan palm (*Borassus aethiopum*), guava (*Psidium guajava* L.) and eucalyptus (*Eucalyptus spp.)*. These practices were occurring, although with somewhat different species, during the time of the Alo Moju Na. Kan cembu has been encouraging villagers to keep a vigilant watch on the trees as well. Anyone who sees someone illegally cutting or harvesting should report to the village council, which will fine the offender. The chief reported, "We caught six people last year who were harvesting baobab leaves that they should not have been. They paid 1000 FCFA[6] and were told not to do it again. If someone can't pay money, then we collect the fine in millet or cloth." While not as effective as the Alo Moju Na in the neighbouring village, the kan cembu in Mendolo punished more illegal activity than the Eaux et Forets agent was able to. Several villagers expressed the view that the success of kan cembu lies in its ability to resolve conflicts peacefully and make decisions in the interests of the community as a whole.

History of Resource Abundance The graphic representation of the qualitative data gathered from the historical matrices reveals a picture of perceived tree resource change over time (Figs. 5, 6 and 7). With the exception of cattle, which have allowed farmers to cultivate larger plots of land, no local resource has had a similar growth trajectory in all three hamlets. Both the cliff and valley hamlets acknowledged a decrease in the abundance of common land and tamarind trees, while informants on the plateau stated that their common land has increased as people have moved away, and residents are protecting self-sown tamarind seedlings so that their numbers are on the rise. Valley residents expressed a desire to return to communal farming practices as a way to cope with poor soil fertility and increase yields. Although both cliff and valley informants stated that tamarind tree populations have declined, villagers are not actively planting the species. Residents of the valley say that their poor soil and low water table prevent the trees from growing, while cliff residents say

[5] While the Alo Moju Na system of management was abandoned in Mendolo, other villages in the region continue to use the animist system. This is due in large part to the fact that not all villages in the region converted to Islam, or only a minority of people in the village practice Islam. The Alo Moju Na that was interviewed during this research comes from a village that is still strongly animist.

[6] This is equivalent to 1,52 €. The FCFA (Franc Communauté Financière Africaine) is the monetary unit used in Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. The exchange rate is fixed to the Euro (655.957 FCFA=1€).

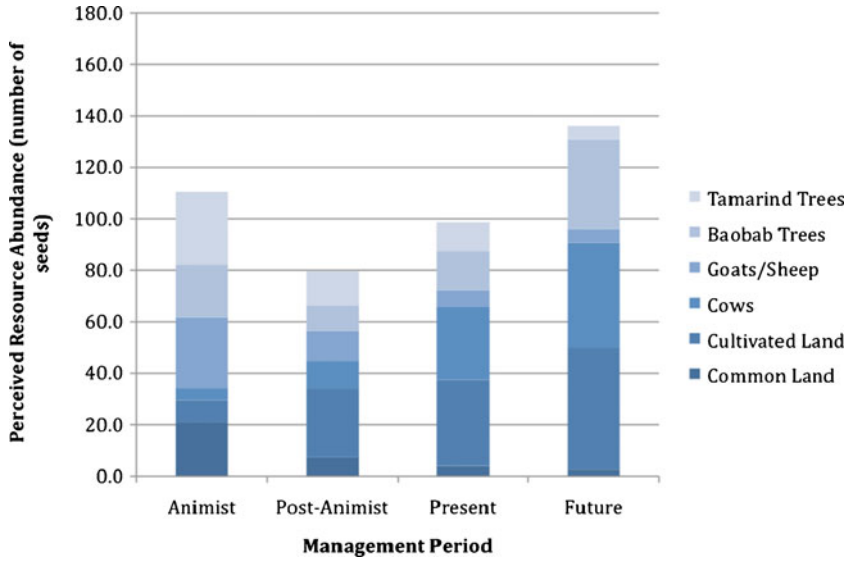

Fig. 5 Results of historical matrix about resource abundance created by the cliff male focus group based on the use of 425 seeds for all management periods and resources as indicators of resource abundance ($n=9$)

that current numbers are still sufficient for their needs and that tamarind requires too much work to grow. On the other hand, all three hamlets recognize that baobab populations have decreased, and differences lie in whether or not they have already started to replant trees.

While baobab trees were more plentiful during the animist period, populations declined sharply in the subsequent interval of open access when there was no management institution in place to regulate use. In the face of declining baobab populations villagers decided that a formal system of regulations was needed to manage use and protect the trees. Due to the community consensus plan now in place, cliff and valley residents perceive baobab populations to be increasing, and they are eager to continue that trend by planting more trees each year. Plateau residents recognize the need to plant baobab trees, but only recently began to do so.

Historical matrices indicate that resources have changed since the time of the Alo Moju Na. For the most part, perceptions are that baobab and tamarind numbers dropped sharply after the end of the animist period, when the departure of the Alo Moju Na left a gap that Islam did not completely fill. With the implementation of kan cembu, baobab populations are starting to rebound.

Whether villagers looked for a return to the Alo Moju Na system or were satisfied with kan cembu, they expressed a common desire for a strong institution capable of enforcing adherence to internal regulations—in the case of the Alo Moju Na, by fear of fines or property loss, and in the case of the kan cembu, fear of social ostracism. No one saw the government as able to protect tree resources, although there is potential for its role to be strengthened if Eaux et Forests starts to work more closely with existing institutions in the village. Referring back to Ostrom's

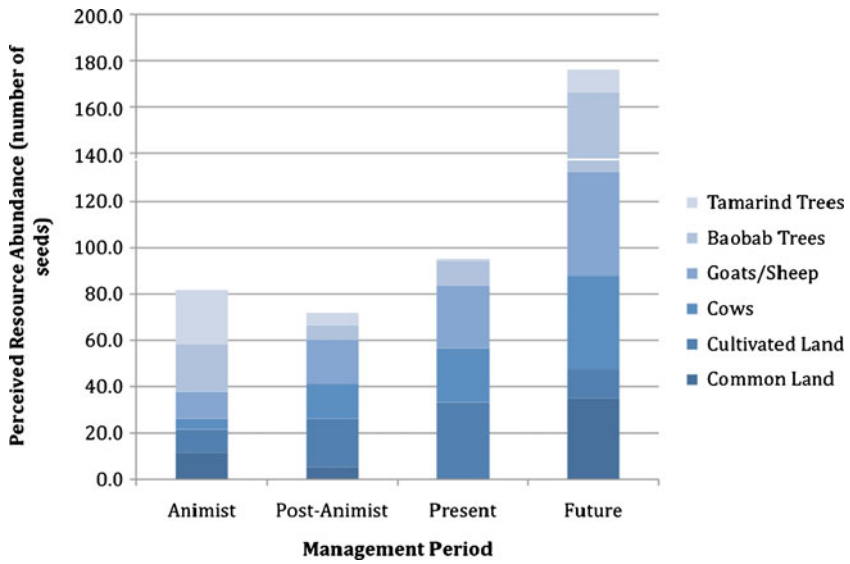

Fig. 6 Results of historical matrix about resource abundance created by the valley male focus group based on the use of 425 seeds for all management periods and resources as indicators of resource abundance ($n=5$)

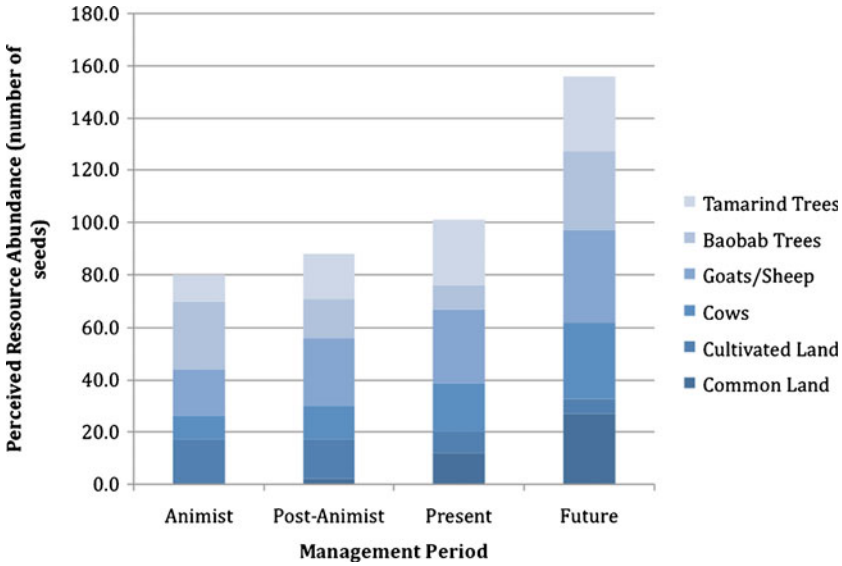

Fig. 7 Results of historical matrix about resource abundance created by the plateau male focus group based on the use of 425 seeds for all management periods and resources as indicators of resource abundance (n=9)

(1990) requirements for successful institutions (that they are adaptive, that rules are clear, enforced and nuanced, that they are legitimized by external organizations, and the institutions are faced with slow exogenous change), it is clear that kan cembu is adaptive and clear in enforcing the rules and, while not strongly partnered with the government, it is certainly not at odds with Eaux et Forets. Yet some tree resources are declining and conflict exists.

Land Distribution

While religious and institutional changes that have occurred in Mendolo have impacted current tree management practices, both land quality and water availability also constrain people's tree management decisions. Of the 36 Mendolo residents interviewed, all but two were primarily farmers.[7] Most respondents (94%) reported a decrease in tree populations, most noticeable in the fields surrounding the village, as compared to the past and stated that this was due to decreased rainfall or lack of water. They also mentioned previously there were many baobab and tamarind trees on common land and in the 'bush' that were available to all, but in recent years, in order to counteract declining crop yields, most of this land has been parceled into private plots for cultivation.

Focus groups were divided according to the location of the hamlets (cliff, valley or plateau), although the lands they farm vary in quality, so that landholding rather than residence determines individual tree management practices. Landholding of farmland in the village is divided between the valley and the plateau, with farmland on the plateau having more fertile soils, more trees and a higher water table. Farmland in the valley is characterized by sandy soil, sparse vegetation and a very low water table.[8] Residents of the cliff and plateau primarily own farmland on the plateau and the residents of the valley own farmland in the valley. Residents of the seven hamlets located on the cliff may own farmland in both the valley and the plateau, but for the most part every family owns some farmland on the plateau, with the notable exception of one hamlet.[9] This is an important distinction, as valley residents own no land on the plateau.

When asked if current baobab and tamarind trees were sufficient for their needs, positive responses were consistently low from informants who owned valley farmland and those who owned plateau farmland: two of 13 owning valley farmland and four of 23 owning plateau farmland reported that baobab numbers were sufficient. For tamarind, one valley farmland owner and ten plateau farmland owners reported numbers were sufficient. These responses are not surprising in light of residents' comments that almost all tamarind trees in the valley have died and those few that remain no longer bear fruit. On the other hand, cliff and plateau residents farm in the fertile soils of the village, where wells are often no more that 10–15 m deep, and grow all of the most valuable trees in their gardens: shea, (*Vitellaria paradoxa* C.F. Gaertn.), mango (*Mangifera spp.*), guava (*Psidium guajava* L.), citrus

[7] The two households that did not rely primarily on farming were the two blacksmithing households in village. While their primary income comes from production of agricultural and domestic tools, they often work in exchange for millet, so their income is still dependant on farming.

[8] The 61-meter-deep well in the valley is dry for 8 months of the year. Residents of this hamlet source their water from a natural spring approximately 2 km away.

[9] While residents from this hamlet were included in the cliff focus group, responses from semi-structured interviews with residents here were analyzed separately to highlight the differences in their management strategies.

(*Citrus spp.*), jujube (*Ziziphus mauritania* Lam.) and tamarind. Almost 50% of plateau farmers reported that there are currently enough tamarind trees for their needs.

Most informants reported that villagers were making efforts to address the decline in tree numbers by planting certain species—baobab was the species most often mentioned: 55% of respondents (n=36) said that they or their spouse had planted at least one baobab tree for their own use. One informant planted 37 baobabs during the 2 months of research.

Identifying trees planted by hamlets of each physiographic zone highlights variation from hamlet to hamlet (Fig. 8). When responses are divided between the cliff, plateau and valley zones, and the responses of the cliff residents are further divided between those who own plateau farmland and those who do not, it becomes clear that there are differences between general baobab and tamarind tree planting patterns, as well as the number and variety of trees planted by valley versus plateau farmers.

Individuals in all zones reported planting baobab trees because most of the mature baobab trees have died in recent years and new trees are not spontaneously sprouting as they had in the past. When asked why new trees are not sprouting, informants explained that all of the old fruit-bearing trees have died, and all of the recently planted young trees are managed for leaf production, which inhibits fruit set and thus reduces the possibility of generative multiplication.

Informants described baobab as easy to grow as it requires little care for a limited period of time. Baobabs planted in the village require little to no water, an advantage when lack of water is often cited as a reason for not planting trees. Even if damaged by livestock, the tree will still grow, although at a slower rate. According to the Eaux et Forets agent, a baobab tree typically has enough leaves for light harvesting in about 5 years, and within 10 years is usually large enough to provide a significant source of leaves for a family.

Only one informant, a cliff resident owning plateau farmland, reported planting tamarind (Fig. 8). When asked why people do not plant tamarind, several respondents said that tamarind self-propagates so there is no need for planting. Other said that tamarind is difficult to grow and does not tolerate transplanting well. Two said that tamarind is very slow to mature, and that it requires fenced protection for at least nine years before it is large enough to resist damage from livestock. According to informants, tamarinds require approximately 20 years to start producing fruit. Thus it appears that ease of planting, maintenance and growth rate are important considerations for tree propagation for the residents of Mendolo.

The number of tree species planted by physiographic zone suggests that cliff (plateau farmland [pf]) and plateau residents plant a greater variety of trees than valley or cliff (valley farmland [vf]) residents, with informants from the cliff (pf) planting 11 species, plateau planting seven, and valley and cliff (vf) planting only two each. Yet both of these hamlets listed many trees that they would like to plant: the eight individuals interviewed in the valley named 12 species of trees that they would like to plant,[10] and the four individuals interviewed in the cliff (vf) listed eight.[11] Every respondent listed the lack of water as the primary reason why they were not planting more trees. A male cliff (vf) informant said that he had attempted to plant lime (*Citrus* ssp.), jujube (*Ziziphus mauritania* Lam.) and mango (*Mangifera* ssp.) but they had all died due to insufficient water.

Unequal Land Distribution and Conflict Mendolo residents are aware that unequal land distribution and the effects of climate changes have led to social and economic inequalities within what has traditionally been a fairly homogenous community. Understandably that has created tension and frustration among the residents of the different hamlets, since some residents feel that village institutions, notably kan cembu, are not currently addressing these inequalities.

The results of female focus groups in the hamlets of cliff, valley and plateau using a matrix on resource conflict indicate that women in different hamlets (and different physiographic zones) view resource conflict differently (Figs. 9, 10 and 11). Those who had greater farmland endowments perceived levels of intra-village conflict as lower than disputes with neighboring villages or strangers. No focus group cited any conflict with the government. Combined results from all three hamlets showed the greatest sources of conflict were land (18%), tamarind fruit (15%) and baobab leaves (10%).

Most villagers readily agreed that land was the greatest source of conflict. Residents of a neighboring village currently trying to lay claim to the valuable plateau farmland were said to be damaging field crops and trees on the plateau. Not surprisingly, plateau residents said that it was these same villagers who were primarily responsible for the theft of tamarind fruit, tamarind leaves and baobab leaves from their fields, although they did acknowledge that strangers and people from Mendolo played a part as well. Cliff residents attributed the majority of theft to strangers

[10] The species were: baobab, mango (*Mangifera spp.*), fan palm (*Borassus aethiopum* Mart.), guava (*Psidium guajava* L.), tamarind, African locust bean (*Parkia biglobosa* (Jacq.) R. Br. Ex G. Don), banana (*Musa spp.*), papaya (*Carica papaya* L.), African mahogany (*Khaya senegalensis* A. Juss), kapok (*Bombax costatum* Pellegr. and Vuillet), date (*Phoenix dactylifera* L.) and Gmelina (*Gmelina arborea*)

[11] The species were: baobab, mango, fan palm, guava, tamarind, African locust bean, eucalyptus (*Eucalyptus spp.*) and shea (*Vitellaria paradoxa* C.F. Gaertn.).

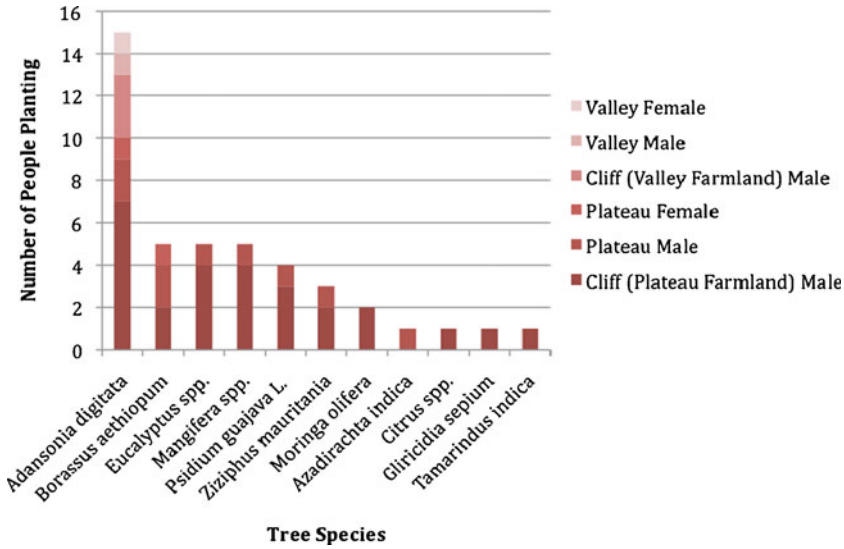

Fig. 8 Trees planted by physiographic zone with acknowledgement of farmland holdings ($n=17$ total people planting trees)

passing through their fields, while stating that neighboring villagers and people from Mendolo would occasionally steal tamarind and baobab tree products.

In marked contrast, valley residents stated that intra-village theft accounted entirely for conflict over tamarind fruit and leaves. Women in the valley focus groups admitted to picking tamarind fruit as well as leaves from trees on the plateau to supplement what they must buy at the market, but felt that theft of baobab leaves and fruit was minimal in comparison, and then only with residents of neighboring villages. While valley women regarded land conflicts with the neighboring village as significant, they cited conflicts over the scarce water resources in the village as of paramount importance—interestingly neither cliff or plateau residents listed water as a source of any conflicts.

However, conflicts are not widespread, possibly because plateau farmers are unaware of the tensions felt by valley residents. They were initially hesitant to discuss resource inequality or stealing openly. Or it may be that they perceived intra-village theft of tree products as an acceptable cost of owning an unequal share of resources. This would be in accord with the kan cembu ideal of sharing, allowing tamarind-wealthy villagers to regard it appropriate to profit privately from a resource that was once equally available to all. Such low levels of conflict may also be tolerable to resource-poor members of the community as long as it is still possible for them to earn a living by other means. This highlights the possibility that even illegal activity is an integral part of what Eidson argues is a response to "shifting, though always unequal power

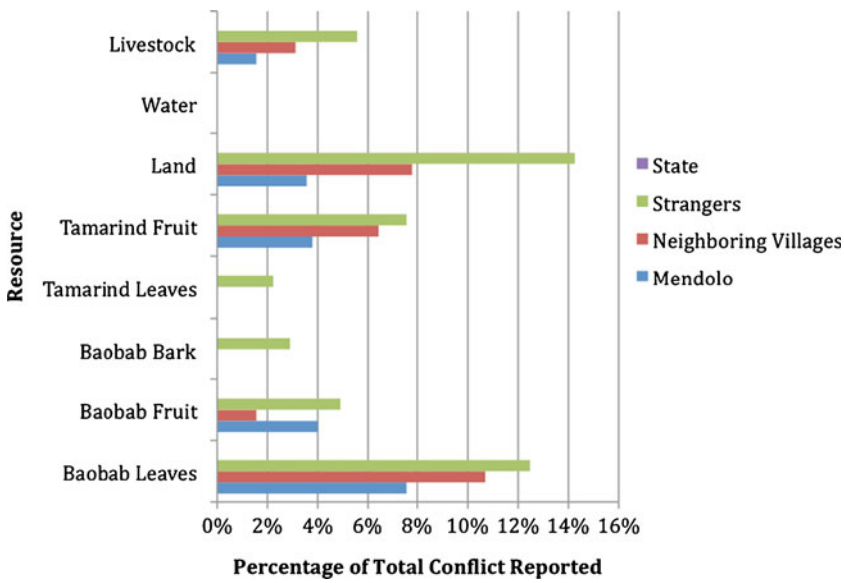

Fig. 9 Results of conflict matrix created by the cliff female focus group where individual conflicts are seen as a percentage of total reported conflict ($n=10$)

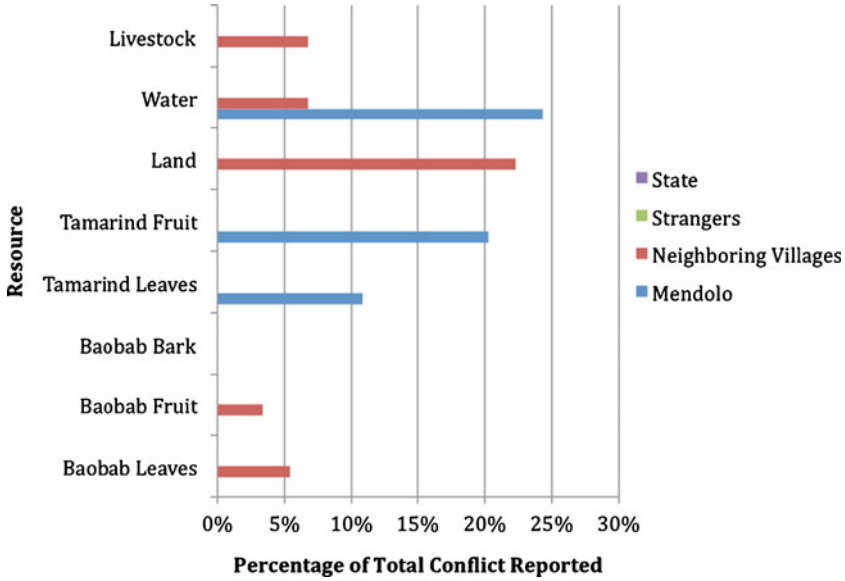

Fig. 10 Results of conflict matrix created by the valley female focus group where individual conflicts are seen as a percentage of total reported conflict ($n=6$)

relations" (von Benda-Beckmann *et al.* 2006: 9). Residents of the valley supplemented their livelihoods by stealing from the resource-rich members of the community when the kan cembu agreement of sharing failed.

Expanding Market Access

The socio-economic divide among villagers has the potential to grow when market incentives are taken into consideration, since tamarind fruit is traded widely throughout the region. Local and regional markets are becoming increasingly accessible due to improving infrastructure, and people now realize that there is a demand for goods that were once used only for subsistence. People from other villages and towns come to Mendolo to buy sacks of tamarind to resell in cities as far away as Sikasso in southern Mali. In 2008 one farmer, who regularly sells his tamarind to a trader from a neighboring village, sold him about 100 sacks destined for bigger markets such as Bandiagara, Mopti and Gao. In 2009, the wholesale price of one 100 kg rice sack[12] of tamarind averaged 3000 FCFA, so the farmer earned approximately 300,000 FCFA[13] on tamarind alone. This is a substantial sum for a rural dweller, and could easily buy a horse or two head of cattle. With the average family in the village consuming only two sacks of tamarind for subsistence use, there is a potential for economic gain in cultivating tamarind trees. While this farmer earned more from tamarind than other informants, most tamarind owners reported selling 15, 20 or even 40 bags of tamarind fruit per year.

Of 23 people interviewed in the tamarind-rich zones of the cliff (pf) and plateau, 65% earned some amount of income from the sale of tamarind fruit, and of these 40% were women, ranging in age from 20–75. While men earned the bulk of the cash, the modest amounts that women earned allow them to buy sauce ingredients and personal items like clothing and jewelry. Most of the women from cliff (pf) and plateau said that they gathered tamarind fruit from their family trees on their own time after the main harvest was over, and this is how they were able to keep the profits.

Villagers residing in the valley and cliff (vf) who own no tamarind trees, employed varying strategies based on differing social relations in village to acquire tamarind fruit. For cliff (vf) dwellers the kan cembu sharing agreement seems to be working for the most part; four out of five people interviewed received enough tamarind fruit through asking or reciprocity to last them the year when combined with leaves. In comparison, of the eight people interviewed in the valley, all but one reported that they needed to buy tamarind fruit last year. Families purchased, on average, two baskets[14] of tamarind fruit a year at 1000 FCFA per basket, mostly from a neighboring market town. This quantity is usually sufficient to last a year if it is combined with requesting and/or occasionally stealing a basket of tamarind fruit from other residents, and harvesting tamarind leaves from other people's trees. Residents of the valley said that because they are unable to make money

[12] A 100 kg rice sack indicates the size of the bag and not the weight of the tamarind within it. These bags are commonly used as a measure of reference when discussing traded goods.

[13] This is equivalent to 457,35 €. The exchange rate is fixed to the Euro (655.957 FCFA=1€).

[14] Three baskets will fill a 100 kg rice sack.

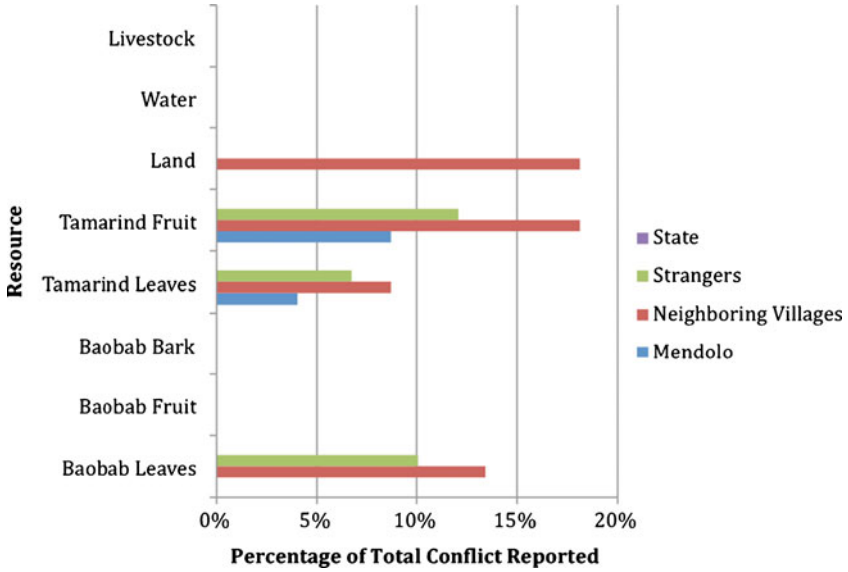

Fig. 11 Results of conflict matrix created by the plateau female focus group where individual conflicts are seen as a percentage of total reported conflict (n=8)

from tree fruits like tamarind, they now focus their income generating activities on livestock, which they can graze even on poor soils.

Unlike tamarind fruit, there are not enough baobab leaves to sell in large enough quantities to generate substantial income, and informants from all hamlets need to buy leaves to supplement their diet. Only one person (n=36) said that his family was able to sell baobab leaves in a neighboring market town last year. Everyone else either purchased leaves or relied on their own trees. Baobab leaves were much more readily given away than tamarind fruit. While research on West African markets indicates that baobab leaves can be an important source of revenue for rural farmers, particularly women (Gustad *et al.* 2004; Bonkoungou *et al.* 1999; Guinko and Pasgo 1992), potential returns from baobab leaf sales in Mendolo are low, so villagers may not feel that there is much benefit to trying to sell what little they have. This is significant for developing conservation strategies for baobab trees, because while it is clear that tamarind is economically valuable, it is currently not being planted. Baobab, on the other hand, has little market value for residents of Mendolo, but is the most widely planted tree.

Individuals or households may not be able to respond to seemingly identical environmental pressures in the same way, due in large part to the quality of their land and water endowments, and management strategies can diverge as a result. Those who farm on the plateau, where there is more water and arable land, are able to cultivate and sell a greater variety of tree products, particularly tamarind fruit. This amplifies any social or class differences that exist in the village, and as a result the beneficiaries and victims begin to develop dissimilar adaptive strategies and incentives. Stealing is one way that the disadvantaged in village have chosen to cope. This differentiation has led to economic changes as well, so that within a small community, one resource can be a source of income to one household and an expense to another.

The rights of the villagers to plant trees or sell their products are relative and not strong for those who are unable exercise them (Howard and Smith 2006). Members of the valley and cliff (vf) communities cannot rely on tree resources for income generating opportunities. "What people do with rights is likely to depend on the mixture of rights they have and their wealth. Poor people… who have very few resources to invest in their private land have different options and are likely to employ resources differently than might others better endowed" (von Benda-Beckmann *et al.* 2006: 26).

However, the question of why baobab and tamarind are treated differently when it comes to propagation, use and sharing remains. Both are scarce resources and clearly both are very important in the daily lives of the villagers of Mendolo. Yet while populations of both trees have declined, the decline in baobab populations has been met by a uniform and relatively active effort on the part of villagers to replant trees from seed, a practice that was not customary in the past. Tamarind trees, on the other hand, are not being replanted, probably due in part to the perceived abundance of tamarind fruit by the members of the community who are able to plant it. At the same time, baobab grows on all land types in the village, so everyone has an equal capacity to plant it. Also, the relatively small baobab population in the village keeps it from becoming a significant commodity. While recent research argues that expanding market opportunities provide farmers with incentives to plant trees or protect species (Russell and Franzel 2004) this does not appear to be the case for tamarind in this village, and we

should be wary of assuming that new market opportunities will influence people's management decisions to increase production. Other factors, such as the cultural and symbolic meanings of the trees, may play a part in why these trees are planted or not (Dudley *et al.* 2009; Rival 1998), and further research into the subject is warranted. For example, recent research in West Africa indicates that a traditional belief that spirits inhabit both baobab and tamarind trees may prevent people from planting these species (Buchmann *et al.* 2009). In Mendolo, animist beliefs that baobab trees were fetish sites and the dwellings for spirits may still linger, even if they are no longer practiced openly, inspiring people to plant and protect them in preference to other species.

Conclusion

People living in the Sahel contend with shifting social institutions, political unrest, increased mobility, religious conversion and expanding market access. This study provides evidence that traditional societies do adapt tree management practices in response to endogenous and exogenous change with the aims of protecting, using and controlling access to trees. Villagers in Mendolo indicate that they prefer a strong internal institution to administer regulations for tree use, whether within the current system of kan cembu or the traditional system of the Alo Moju Na. Villagers perceive that resources are more sustainably used when there is a strong management institution in place. Efforts have been made in recent years on the part of the village to increase self-governance by strengthening the kan cembu system with regard to trees by encouraging planting of certain species and policing illegal activity.

Yet to be meaningful for all resource users, it is vital that a strong management institution be adaptive as well. Priorities and management decisions are dictated in large part by the resources available to users, so that management may diverge as social differentiation develops in a community. A management institution must respond to these divergences and provide a flexible system that allows for and addresses the multiple needs and socioeconomic differences of all actors.

Tenure is bundled to accommodate many users in different capacities as well as the many ways of viewing regulations: as ideology, as law, as social relations and as daily practice. All of these operate simultaneously at different levels, and influence individual incentives for tree conservation and use. This study highlights the social as well as ecological nature of conservation, and an understanding of social and class differentiations is as crucial to conservation initiatives as an appreciation of plant adaptability or uses. In the case of Mendolo, it is not enough to know that baobab and tamarind populations are decreasing and people are interested in their conservation; it is just as important to know that resource ownership and market access are driving social systems that determine people's abilities to utilize these trees. It is this ability of different resource users within Mendolo to utilize baobab and tamarind that will determine the incentives that people have to conserve these species and steer any conservation strategy that the village or others may undertake. It is important to identify all tree resource users when exploring issues of conservation and to shape conservation and livelihood initiatives by stressing the importance of a holistic and social approach to looking at people's relationship to trees.

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