Community Management of Natural Resources: A Case Study from Ankarafantsika National Park, Madagascar

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Abstract We analyzed the management, resource use and conservation of the Ankarafantsika National Park (Madagascar) to develop a management plan, which provides a sustainable development strategy of the area while empowering the local residents. Using qualitative methodology we performed interviews with villagers and local organizations to assess the park's successes and failures from local stakeholders' perspectives. People living in a village with a permanent Madagascar National Parks (MNP) agent are more favorable to and supportive of the park conservation. People living in the park are supportive but are more divided. On the other hand, people living on the periphery of the park see conservation as more of a burden. Strategies like more equitable distribution of wealth, environment improvement and decentralization of power are discussed to achieve a more sustainable management plan based on community natural resources management. Short-term, medium, and long-term interventions from park authorities are needed to ensure the cooperation of local people in conservation endeavors.

Keywords Community management · Rural development · Decentralization · Qualitative methodology

INTRODUCTION

The present state of environmental conservation in Madagascar is intriguing on many levels. First of all, the biological diversity of the island has made it an international conservation priority for a number of years (Myers 1988; Wilson 1992; Hannah et al. 1998; Goodman and Benstead 2005). Madagascar was already a global conservation priority in the 1990s (Myers 1988; Mittermeier et al. 1990)

and is still considered to be a “hot spot” of biodiversity, mostly because of its biodiversity richness and its high level of forest degradation (Hannah et al. 1998; Mittermeier et al. 2004; Goodman and Benstead 2005). Madagascar is home to about 14 000 species of plants with an endemism rate of 90 % and more than 1000 vertebrate species and subspecies (mammals, reptiles, amphibians, birds) all endemic except birds (Ramanahadray et al. 2010). As a result, the country contains more genetic information per surface unit than any other place in the world, making the conservation of one hectare of forest in Madagascar more important than almost any other hectare of natural area anywhere in the world (Hannah et al. 1998; Garcia and Goodman 2003).

Conservation in Madagascar is an international priority, particularly because anthropic pressures that occurred during the last decades have been detrimental to the long-term survival of this unique place (Jenkins et al. 2003). Disappearance of forest is primarily due to socioeconomic factors, as the Malagasy population has experienced one of the highest poverty rates in the world (Human Development Index <0.50). More than 70 % of the populations live in “extreme poverty” as described by the World Bank (2004). As the annual population growth is around 2.8 %, the population has more than doubled since the country's independence in 1960, reaching 19 600 000 persons in 2004 (Institut National de la Statistique de Madagascar 2006). These socioeconomic conditions are the basis of an increasing anthropic pressure, which results primarily in uncontrolled deforestation, mainly caused by forest clearing, by slash-and-burn agriculture, and by brush fire in zebu (*Bos primigenius Indicus*) pasture. Forest destruction estimations show that 50–80 % of the original Malagasy forest cover has disappeared since the settlement of human populations 1500 to 2000 years ago (Ormsby and Kaplin 2005).

Today, the forest covers around 9 400 000 hectares (Ramanahadray et al. 2010).

In a more narrowed scale, the Malagasy western dry forest represents one of the world's most threatened biomes, having been reduced to less than 3 % of its original cover (Pons et al. 2003; Pons and Wendenburg 2005). The remaining forest continues to be destroyed by agricultural practices dominated by slash-and-burn agriculture (*Tavy* in vernacular name) and by zebu breeding. Even if agricultural practices are abandoned, it is unlikely that the cleared surfaces could be recovered to their original surface area (Ganzhorn and Sorg 1996; Harper et al. 2007; Sheddon et al. 2008).

Engaging local people in the process of national park management has been advocated as a successful model for long time (Kellert et al. 2000; Adetoro et al. 2011). However, considerable challenges exist in the process (Kellert et al. 2000). One of the main challenges arising during the introduction of new land conservation efforts is the integration of local populations in the implementation process (Bunch 1992; Dinerstein 2003; Post and Snel 2003; Hayes 2006; Straede and Treue 2006). Previous studies have demonstrated that conflicts often arise when local populations express dissatisfaction with the regulations imposed by the protected area managers (Ormsby and Kaplin 2005; Hayes 2006). One of the most important steps to take in the conservation process is to transform a traditionally “top down” approach to one that is more “bottom up”. Even if local populations are known to conserve natural areas since their survival is highly dependent on the presence and accessibility of natural resources (Abbot et al. 2001; Holmes 2003; Gibson et al. 2005), it is still necessary to impose regulations on local populations' activities in the protected area (Holmes 2003; Ormsby and Kaplin 2005). The park managers should then compensate local populations for this supplementary effort and for the loss of access to previously available lands (Songorwa 1999; Straede and Treue 2006).

We conducted an exploratory study in the Ankarafantsika National Park, northwestern Madagascar, to research the relationship between the local communities and the park management. The main research questions were: (1) What is the local residents' knowledge of park?; (2) What are the main benefits and disadvantages of the implementation of the park for the locals?; (3) What is the global perception of the villagers' behavior, the park staff's behavior, and the park management in general from different points of view?; (4) How is park's staff perceived by the local villagers? The ultimate goal of the study was to develop a management plan which provides a sustainable development strategy of the area while empowering the local residents.

MATERIALS AND METHODS

Study Area

The study was conducted at Ankarafantsika National Park (ANP), located in the northwestern region of Madagascar (Fig. 1). The protected area covers a total of 132 400 ha, cut in two parts by the national road n°4 (RN4), a highway that links Mahajanga to Antananarivo (Perez 1992; ANGAP 2000). The ANP represents the biggest of the five last remaining fragments of the Madagascar western dry forest ecosystem, consisting of dry deciduous forests and savannas supporting a vast floristic community (Albignac et al. 1992; Pons et al. 2003; Pons and Wendenburg 2005). Even though the area is legally protected, the forest is victim to different types of exploitations (TRM 1997; Rakotoarimanana 2005; Raymond 2007).

The ANP is a result of the fusion of two old reserves, Integral Natural Reserve (INR) and the Forest Reserve (FR), that was realized in 2003 (ANGAP 2007). From the creation of the INR in 1927 to the classification as a national park, the protected area was led by different governmental and non-governmental organizations, namely the Malagasy Ministry of Water and Forest, the World Wide Fund for Nature (WWF, formerly World Wildlife Fund), the United Nation's Development Program with United Nations Educational, Scientific and Cultural Organization (UNDP–UNESCO), and Conservation International (CI). Since 2000, the *Association Nationale pour la Gestion des Aires Protégées* (ANGAP) or the actual Madagascar National Parks (MNP), a semi-public institution, is in charge of the management and conservation of all protected areas in Madagascar (ANGAP 2000, 2001, 2007). Currently, the ANP also works in association with a local conservation management organization, the Ankarafantsika *Integrated Conservation and Development Project* (PCDI), mainly financed by the German bank *Kreditanstalt fuer Wiederaufbau* (KfW).

Considering the local context and the primary importance of the park's conservation, the MNP has chosen the strategy of a “biosphere reserve” following the concept of “Man and Biosphere” as defined by UNESCO (2005). The park includes local populations in its management and planning (2150 people living in the park and 27 300 living on the periphery with some limited access to the park) recognizing the importance of motivating local populations in order to reduce human impact on natural resources (ANGAP 2000). The ANP is divided into three main areas: the central core area with total protection, the buffer zone with limited access and the protection zone on the periphery of the park, which is managed entirely by the local population. A tourist zone that is conserved and

Fig. 1 Localization of Ankarafantsika National Park in Madagascar. *Shaded area* in the centre is the National park

maintained for use by tourists is also included in the buffer zone.

One of the particularities of the protected areas under the MNP management is the recognition of the importance of local community development in the conservation strategy (ANGAP 2000, 2007). So, the MNP has decided to dedicate 50 % of the entry fees (*Droits d'Entrée au Parc*, DEAP) collected to finance micro-projects that improve life of local communities while enhancing the conservation strategy.

Data Collection

Our study was performed at the ANP between October and December 2007. This study is the first of this kind to be pursued in this particular context; it uses an exploratory approach with a qualitative methodology. To obtain a broad range of perspectives, we interviewed people from two main groups (Brydon-Miller 1997; Greenwood and Levin 1998): the villagers and the members of

organizations working in the local development context. We divided the villagers into three main groups: the villagers living in the central core area (ZOC, inside the park), the villagers living at the periphery of the park (i. e., immediately beyond park boundary), and the villagers living in the MNP bases (villages where a permanent MNP agents reside). ZOC is the area with >1 km distance from non-forested edge of the park (Harper et al. 2007). For the organizations group, we interviewed all state ministers and NGOs working in the local context in the areas of agriculture, forestry, health and tourism using semi-structured questionnaires following the themes outlined in Table 1. We interviewed representatives of 9 organizations: the direction of the MNP at Ankarafantsika, the Ankarafantsika nature guides, the Inter-Regional MNP direction of the Mahajanga district, the Inter-Regional Water and Forest Ministry direction, the Inter-Regional Tourism direction, the Regional Rural Development direction, the *Projet de Soutien au Développement Rural* (PSDR), the *Gesellschaft für International Zusammenarbeit* (GIZ formerly GTZ)

Table 1 Themes used for the questionnaires by the group of persons interviewed

Question themes	Villagers	Organizations
Zoning policies	+	+
Respect of regulations	+	
Park/villagers communication	+	
Environmental risks	+	+
Risks of the human presence in the park	+	+
Risks of the human presence at the periphery of the park	+	+
Importance of development projects for local populations	+	+
Management quality of the park	+	+
Importance to give more responsibility to villagers	+	+
General quality of the park	+	+

santé, and the *Alliance Française* of Mahajanga. In all cases, we tried to respect an equal representation of gender and social classes (Wells and Brandon 1992; Creswell 1994; Ormsby and Kaplin 2005). In the practice, it was difficult to obtain an equal representation of gender since female villagers were more difficult to approach than male villagers. Thus, two local translators (from both genders) were used to improve communication, linguistically and cross-culturally (Tucker 2007).

We first used semi-structured open-ended questions to perform our individual interviews (Table 1). While performing interviews, we attempted to increase confidence by explaining our independence from the MNP and by not insisting that all questions be answered. We used 37 questions covering the 10 thematic areas (Table 1) that would be used to propose improvements in the existing management plan. Progressively, we found that villagers were hesitant to respond honestly to some of the more controversial or contentious questions (e.g., how people are expelled from the park?). We reformulated our questionnaire and created more closed and indirect questions. This indirect strategy allowed us to obtain answers to some questions that the villagers would not provide otherwise.

In total, we interviewed 101 villagers distributed in 19 *fokontany* (villages). For the people living in the ZOC, we visited 7 *fokontany* (77 % of the households in the ZOC) and interviewed 41 households (13 % of total ZOC households). For the people living in the periphery, we visited 8 *fokontany* (21.5 % of the peripheral households) and interviewed 44 households (5 % of total peripheral households). Finally for the people living in the ANGAP bases, we visited 4 *fokontany* (representing 35 % of households in the bases) and interviewed 16 households (1.3 % of total bases households).

Statistical Analysis

Two groups of questions were asked to the respondents; dummy (with answers as yes (1) or no (0)) and ordinal (in a scale of 1 to 5 with 5 being on strong agreement and 1 being on strong disagreement) focusing on ten themes (Table 1). We used the results from the communities to study and infer relationship between the communities and park management. We classified the questions to seven broad themes (Tables 2, 3, 4) and respondents into three categories; living in core zone (ZOC), living in the villages where bases of park agents are located and living in the villages in the park peripheries away from the bases of park agents. Then we compared the responses of each theme by different group of the respondents using contingency tables and tested the significance of differences in the knowledge of these themes among respondents through non-parametric Chi square tests (Steel et al. 1997). All analyses were conducted with a significance level of 0.05 using statistical software SAS 9.1.3 (SAS Institute Inc. 2005). Results from the organizations were used to validate the findings from villagers. They were also used for the management plan's improvement proposal.

RESULTS

The Zoning Strategy: A Base for Conservation?

It was found that people living in the ZOC and in the MNP bases have a similar and fairly in-depth knowledge and understanding of the different zones and their policies (Tables 2, 3). People in the MNP bases and ZOC received more information about the park and the latter already contributed to the zoning by helping to define the boundaries of their ZOC. On the other hand, we realized that people living in the periphery of the park appear to have a limited knowledge of the existence of zones and therefore a more limited knowledge of the differences existing between these zones and their limits (Table 2), as well as the rights and restrictions of park use (Table 3).

Stakeholders' Relationship: Fair and Equal?

In Ankarafantsika, 78.2 % of the villagers seem to be fairly aware of the importance of the national park for their quality of life. The main importance of the park for the villagers (51.4 %) is that it represents a source of water for numerous rice paddies (the Marovoay plain being the second biggest rice granary of Madagascar) since the forest cover allows the persistence of streams and lakes. The second main reason given by villagers (43.5 %) is that the park provides the forest resources that locals depend on for some of their daily basic needs. Moreover, the park

Table 2 Knowledge on the zoning of the National Park of Ankarafantsika

Group of villagers	Knowledge of the existence of the different zones			Knowledge of the differences between the different zones			Knowledge of the limits of the different zones		
	Yes	No	Total	Yes	No	Total	Yes	No	Total
ZOC	37	4	41	31	10	41	30	11	41
Periphery	30	14	44	19	25	44	18	26	44
ANGAP bases	16	0	16	15	1	16	14	2	16
Chi square tests	Value	DF	Significance	Value	DF	Significance	Value	DF	Significance
ZOC/Periphery	4.94	1	0.008	9.21	1	0.002	8.99	1	0.002
Chi square ($N = 85$)									
Periphery/Bases	6.64	1	0.006	12.2	1	0.0004	10.2	1	0.003
Chi square ($N = 60$)									

Table 3 Knowledge and understanding of the regulations in the National Park of Ankarafantsika

Knowledge of the regulations in the different zones				Reason of respect the park's regulations			
Group of villagers	Fear of repressions	Comprehension of the conservation needs	Total	Group of villagers	Fear of repressions	Comprehension of the conservation needs	Total
ZOC	37	4	41	ZOC	28	13	41
Periphery	28	16	44	Periphery	32	12	44
ANGAP bases	16	0	16	ANGAP bases	5	11	16
Chi square tests	Value	DF	Significance	Chi square tests	Value	DF	Significance
ZOC/Periphery	7.93	1	0.007	ZOC/Periphery	6.479	1	0.008
Chi square ($N = 85$)				Chi square ($N = 57$)			
Periphery/Bases	8.35	1	0.002	Periphery/Bases	8.539	1	0.004
Chi square ($N = 60$)				Chi square ($N = 60$)			

Table 4 Effects from the presence of the Ankarafantsika national Park and implementation of development projects

Change in environment quality since ANGAP takeover				Change in financial potential since ANGAP takeover			
Group of villagers	Improvement/stabilization	Decrease	Total	Group of villagers	Improvement	No change/decrease	Total
ZOC	29	12	41	ZOC	20	21	41
Periphery	18	21	39	Periphery	10	33	43
ANGAP bases	14	2	16	ANGAP bases	12	4	16
Chi square tests	Value	DF	Significance	Chi square tests	Value	DF	Significance
ZOC/Periphery	4.982	1	0.023	ZOC/Periphery	5.956	1	0.023
Chi square ($N = 80$)				Chi square ($N = 84$)			
Periphery/Bases	7.972	1	0.003	ZOC/Bases	3.214	1	0.007
Chi square ($N = 55$)				Chi square ($N = 57$)			
				Periphery/Bases	13.351	1	0.0003
				Chi square ($N = 59$)			

contains many spiritual sites and is of primary significance for the local Malagasy culture and its conservation is also linked to the survival of local traditional culture (34.6 %).

The majority of the villagers (76 %) were satisfied with their communication with the MNP. The MNP agents provide various trainings to the village officials to give

them the latest park updates and to discuss the current issues. Even considering the seemingly ideal results showing that 83.5 % of villagers collectively agree that park protection is a priority for their survival and that their behavior should be protection oriented. However, the facts show that regulations are not evenly respected. A great majority (75.2 %) of villagers affirm being aware of illegal activities and it is not unrealistic to conclude that some people in every village perform such illegal activities. People living in the ZOC seem to have the highest tendency to respect the regulations mainly because they are afraid of the consequences and potential expulsion if they break the rules (Table 3). People living in the peripheral area have the same general attitude towards regulations (Table 3).

The Environmental Issue: A Life Survival

Villages in the ZOC and the MNP bases have experienced a decrease in anthropic pressures while increasing local involvement in tree planting initiatives. People living in the periphery have experienced an opposite trend, hence, the environmental quality on the periphery is lower than in the ZOC and much lower than in the bases (Table 4).

One other major environmental issue that the park's management must confront is the climatic events. Cyclones are the most frequently identified (80 %) dramatic events, destroying people's houses and crops, while creating major disturbances in the forest. Droughts (29.7 %) are known to dramatically decrease crop yields. Floods (35.6 %) can be very detrimental to crops, promoting sand accumulation in the fields and therefore decreasing land fertility and productivity.

Villagers' Benefits: Who Benefits from the Park?

Our study shows that, people in the MNP bases have experienced a more concrete improvement in their quality of life since the implementation of projects, especially because they receive double benefits (money from the DEAP as well as farm equipment and wells from the PCDI). People in the ZOC have received smaller (Table 4) but still reasonable support, building workshops and wells and receiving training to develop businesses (especially for the women). People in the periphery have received even less support than the other villages studied (Table 4). In the periphery, 7 % of the people interviewed were completely unaware of the MNP policy of sharing half of the DEAP revenues.

Our result shows that empowering local communities is the determining factor of garnering their support in conservation (identified by 89.3 % respondents). Other elements linked to successful conservation are:

improvement of surveillance and patrolling (identified by 39.6 % of respondents), the strengthening of regulations (36.6 %), the improvement of fire control (34.6 %), and the creation of economic opportunities (36.6 %).

DISCUSSION

The biosphere reserve style zoning strategy planned by the MNP is the primary tool of a conservation approach that includes human presence and activities in a protected area (Raondry et al. 1995). Participation of local communities in planning, management and decision making are important elements of this strategy (Stoll-Kleemann and Welp 2008). It is therefore important to make sure that the villagers are well aware of the park zoning and the significance of each of the zoning categories. According to the peripheral communities, the park's creation means limited access to forest resources. This generalized feeling among this community might put the greater conservation plan at risk by decreasing peripheral involvement and support in the project (Hayes 2006).

Local knowledge of the park zoning strategy is a first step in generating community support for it (Kellert et al. 2000; Stoll-Kleemann and Welp 2008). People in the ZOC defined their zones in 2000–2001 in relation to the number of inhabitants at this time. One big issue in the Ankara-fantsika forest, and for 72.3 % of villagers from all the groups, is the difficulty to cultivate enough food to fulfill family needs year round. With the population increase, villagers have trouble providing their families with the basic food needs. In order to get enough food supplies, villagers illegally harvest wild yam (67.3 % of residents) and hunt for bush meat (48.5 % of residents) using detrimental and unsustainable practices. Medicinal plants (harvested by 59.4 %) and construction wood or firewood are also difficult to find on a satisfying level on the villagers' designated land. The results confirmed the findings of Garcia and Goodman (2003) and Tucker (2007) that the dependence of the villagers on forest products is still high as harvesting of all forest products in the park areas had been prohibited. However, wildlife management could change the situation as in other countries (e.g., Songorwa 2008). ZOC boundaries can be redefined allowing extension of arable land or using new agricultural techniques and providing more equipment to farmers. Thus, a redefinition of the zones and an improvement of the villagers' farming skills and knowledge as well as an increase in access to resources outside of the park seem to be essential strategies to efficiently fulfill local needs while preserving the conservation efforts. Villagers' support can only be achieved if they reap some benefits from protecting the park (Chan et al. 2007). The MNP (formerly ANGAP) understood well

this dynamic and has therefore decided to equally redistribute 50 % of the entry fees (DEAP) to the 106 villages in order to accomplish local development projects that could support conservation.

Cooperation between stakeholders and reasonable satisfaction of local needs and desires is the basis for protected areas conservation efficiency. A first step to ensuring cooperation is to provide conservation education and awareness to the local communities so that they understand the importance of supporting conservation efforts (Albignac et al. 1992). Already, the MNP or a local partner is providing intensive training on raffia processing, fruit processing and business development to women's associations in the area. On the contrary, peripheral villagers feel disregarded by the MNP because they are far from the headquarters and not easily accessible. One way to change their attitude towards the project and cultivate a sense of ownership within the community will be to give them responsibility for the ZOC, which will be accessible to and managed by villagers under the direction of the MNP. This could reduce the tension between people and the park management (Hayes 2006).

Preservation of the environment is essential to people's survival and wellbeing in Madagascar where dependency on wild resources for daily life and cultural practice is high (Mittermeier et al. 1990, 2004). Some efforts have already been put forth by the MNP in order to maintain or improve environmental quality for conservation as well as for rural development and cultural preservation (ANGAP 2007). People living in the ZOC and the MNP bases have experienced an improvement or a stabilization of their immediate environment. This can be explained by the relative distance of the villages from MNP headquarters or the bases of MNP agents. Compliance with the regulations is better there so is the monitoring by park agents. The villages in the periphery, on the other hand, are far from the MNP locations making it difficult for park agents to enforce laws as the surveillance is less frequent (Gibson et al. 2005).

The villagers consider the park as a last resort after natural catastrophes especially the cyclones which rage the area frequently. The creation of a mitigation plan involving the allocation of specific areas for planting wild yam and preserving construction wood would be utmost importance. This would give local residents a secondary source of resources to ensure their survival and human needs although they are not like natural forests products (Hannah et al. 2008).

Distribution of DEAP requires an elaboration of a mini-project document and opening a bank account (ANGAP 2007). It is supported by partners so that the entire village benefits from the DEAP. The existence of these records could facilitate monitoring and traceability of money. This is a form of management transparency within the national

park other than existed with community management not administered by MNP (Randrianjafy et al. unpubl.). The unequal distribution of resources between the villages based on their visibility to tourists and officials leads one quarter of the total villagers to believe that there is corruption at some level. This could create distrust in the MNP strategy. In addition, the MNP also uses some money from the PCDI Ankarafantsika to support the development component. Unlike the DEAP, the money from the PCDI is not equally distributed amongst the different villages but is used under MNP supervision to carry out the projects they judge to be the most important.

Finally, the distribution of defined areas for the villagers to manage (following the ZOC concept) could be an efficient way to involve people in surveillance and monitoring, while creating jobs and increasing the local sense of responsibility towards the better management of the project. That is another form of decentralization of power which could indicate a significant strategy for achieving the conservation objectives. It could help to change local attitudes and behavior that could result in low human pressures in the park resources (Abbot et al. 2001).

CONCLUSION

Present management of the Ankarafantsika National Park is bringing some promising rural development but progress still needs to be made in order to achieve a more community-based management of the resources that will be the base for a more sustainable conservation strategy. From this study we can suggest some improvement strategies that could be implemented by the park's authority in order to increase community involvement in the project.

In the short term, the MNP will have to provide more frequent and generalized information to the rural population and expand village education programs. Second, emphasis should be put on the surveillance of the park, the most supported conservation strategy. The MNP should create more patrols run by villagers located in specific areas in order to increase a sense of ownership. Another project that is presently needed is the creation of numerous and diverse tree nurseries to provide fast growing and multiple-use trees for the people in the periphery. Lastly, financial incentives for village projects must be addressed. First, to continue to promote tourism has been one of the MNP priorities in recent years. An increase in tourism will provide more money, redistributed in part to local rural development projects, and more visibility to the park and the region. One key point to ensure local development will be to make sure that the money is transparently and equitably distributed and used in each village without corruption (or the perception thereof).

In the medium term, the MNP should focus on projects that will ensure park conservation and rural development (Tucker 2007). First, some agricultural practices should be improved and diversified, thereby decreasing locals' reliance on forest products. Moreover, the plantation of trees from the tree nurseries will provide villagers with their energy and construction needs. Next, demarcation of the ZOC and the transfer of management to local villages should improve local participation and decrease the burden on the MNP agents. Finally, the MNP should focus on encouraging local processing of Non-Timber Forest Products (fruits, raffia, etc.) by providing villagers thorough and diversified trainings, and adding value to the forest for the local population. The implementation of these projects will contribute to the decentralization of power, reducing costs and time investment of the MNP agents while increasing the local involvement in conservation.

In the long run several issues might arise, especially if the other projects have not been efficiently pursued. First, it will be necessary to regulate the community access to resources and settlement within and around the park. Secondly, MNP will need to increase its connections with other national and international entities in order to strengthen and diversify the interventions of the conservation project. Finally, it will be important to develop a model that is similar to the ecotourism model by implementing short and medium term projects. This model will increase local involvement in conservation and management while promoting local craft, environmental and construction knowledge. Much remains to be achieved in order to assure long-term protection and development of Ankarafantsika National Park. While many opportunities exist, national and international support will be necessary to conserve the largest remaining piece of the western dry forest ecosystem of Madagascar.

Since this study was mostly exploratory it will be necessary to conduct further research at the same site. The eventual implementation of recommendations from this study and the follow-up of progress made, present an interesting area of future research. A multidisciplinary approach to the issue could be considered since very little work has been pursued on this subject for the Ankarafantsika area.

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