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Participatory ecological monitoring of the Alaotra wetlands in Madagascar

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Abstract. Participatory ecological monitoring is a realistic and effective approach in wetlands such as Alaotra, Madagascar, where important biodiversity is found in an area with high human population density. Since 2001, Durrell Wildlife Conservation Trust, government technical services, regional non-governmental organisations and local communities have collected data on key species, such as waterbirds, a locally endemic lemur and useful natural resources. The monitoring was linked with environmental quizzes and an inter-village competition, which helped raise interest in the monitoring and publicise results. The monitoring has assisted wetland management by guiding amendments to and increasing respect for the regional fishing convention, raising awareness, catalysing marsh management transfer to communities and stimulating collaboration and good governance. The sustainability of the monitoring scheme and the usefulness of the data for detecting trends and guiding local managements are discussed.

Introduction

Madagascar, one of the world's 12 biodiversity hotspots (Mittermeier et al. 1994), is most famous for its lemurs, all of which are endemic to Madagascar. Over 99% of amphibians are endemic (Glaw and Vences 2003), 96% of reptiles (Raxworthy 2003), 85% of vascular plants (Gautier and Goodman 2003) and 51% of birds (Hawkins and Goodman 2003). Nearly all Madagascar's endemic species reside in forests and wetlands.

The Alaotra wetlands constitute the largest wetlands in the country. Alaotra is an example of a shallow wetland that is a highly productive ecosystem, very valuable for people and biodiversity, but also vulnerable to degradation, particularly in terms of sedimentation. This process is easily affected by human activities, such as agriculture causing increased erosion and siltation, and introduction of aquatic plants and fish causing dramatic changes in the trophic structure of the ecosystem.

Since 2001, Durrell Wildlife Conservation Trust (Durrell Wildlife) has organised annual participatory ecological monitoring in Alaotra, both to evaluate the

effectiveness of management initiatives and to reinforce local commitment to management by demonstrating the impacts. Participatory methods were used to facilitate data collection and also to develop broader local knowledge of the wetland biodiversity and resources and the level of threats. Involving local residents in monitoring may foster greater local ownership of resource monitoring and management and help ensure future sustainability (Danielsen et al. 2003). The goal of this scheme is to detect natural and/or human-induced changes in the state of the biodiversity and natural resources as an aid to evaluating and improving management.

While locally-based monitoring of freshwater wetlands are undertaken in several Northern countries (e.g. Engel and Voshell 2002; Boylen et al. 2004) there are few documented examples of participatory wetland monitoring from developing countries (see Townsend et al. 2005 (this issue) for an example from Ecuador). The paucity of wetland monitoring schemes in developing countries is surprising because wetlands often provide substantial direct and indirect benefits to their residents. Local stakeholders may therefore be particularly interested in participating in monitoring initiatives. This paper examines the wetland monitoring programme at Alaotra, presenting initial results and assessing current and potential impact. The sustainability of the monitoring scheme and the usefulness of the data for detecting trends and guiding local management are also evaluated.

Study area

The Alaotra wetlands is located in central eastern Madagascar (17°02′–18°10′ S, 48°00′–48°40′ E). Lake Alaotra is 20,000 ha, has an average depth of 2–4 m and is situated at 750 m asl. Surrounding the lake are 23,000 ha of marshes dominated by papyrus *Cyperus madagascariensis* and reeds *Phragmites communis* and then 120,000 ha of rice-fields within a watershed encompassing 722,500 ha and reaching 1300 m at its highest point (Andrianandrasana et al. 2002).

Three taxa are endemic to Alaotra, all of which are critically endangered: Alaotran gentle lemur *Hapalemur griseus alaotrensis* which has shown a 30% decline over 5 years (Mutschler et al. 2001), Alaotra little grebe *Tachybaptus rufolavatus* and Madagascar pochard *Aythya innotata*. These two endemic bird species may already be extinct, probably because of exotic fish introduction and excessive drowning in fishing nets. Local people claim that the carnivorous introduced fish *Channa striata* has been a significant predator of young of diving species such as the endemic grebe, which had limited flight capacity (Hawkins et al. 2000). Of the 50 waterbird species recorded at the lake (Langrand 1995), eight are Madagascar endemics. Six fish species are Madagascar endemics.

The endemic fauna at Alaotra is threatened due to major environmental changes including:

- habitat degradation,
- over-hunting,
- over-fishing,
- competition and predation by introduced fish species,
- siltation from erosion,
- pollution by human waste, fertilisers and pesticides and
- invasion of introduced aquatic plants (Pidgeon 1996).

The human population living in the Alaotra watershed has increased five-fold from 109,000 in 1960 (Pidgeon 1996) to approximately 550,000 people today (PRD 2003), the majority of whom depend on rice cultivation and fishing for their livelihood. The Alaotra region is the most important rice production area in the country and one of the most important for inland fisheries.

Since a peak in the 1960s of 4,000 tonnes (Pidgeon 1996), annual fish catches have declined to around 2,000 tonnes (Razanadrakoto 2004) probably as a result of over-fishing, acidification and other changes related to introduced species and siltation. The number of fishermen increased from 1,000 in 1963 (Pidgeon 1996) to 4,000 in 2003 (Razanadrakoto 2004) and fishing intensified following the introduction of Tilapia and seine nets in 1960s. There are now 50 nets more than 1 km long and some nets have mesh sizes down to 1 mm (Razanadrakoto 2004).

Once forested, most hills around the lake are now denuded, causing development of accentuated erosion gullies which deposit infertile laterite and sands on lower land resulting in loss of rice fields, silting of irrigation canals and acidification of the lake. Only 81,500 ha are now under cultivation giving an annual rice production of around 250,000 tonnes (Rakotonierana 2004). Since the 1950s, the water lilies (*Nymphea* spp.) that covered large parts of the lake (Pidgeon 1996) have almost disappeared and over 70% of the waterways and lakes within the marshes have been invaded by *Azolla* sp., *Salvinia molesta* and *Eichhornia crassipes* (Andrianandrasana 2002). Most of the marshes, home to the lemurs, have been transformed into rice fields, while remaining marshes have been burned frequently either in an attempt to create further rice fields, to create pasture for cattle, or to create open areas for fishing as a result of choking of traditional fishing areas by invasive plants.

Durrell Wildlife began research in 1986 on local endemics at Alaotra and began a public awareness campaign from 1997 involving village festivals and environmental education in schools. This catalysed grass-roots interest in marsh conservation, as villagers recognised that they provide a refuge and breeding ground for fish and birds, provide materials for houses- as well as woven baskets and mats and dried rhizomes for cooking fuel. They furthermore form a barrier protecting the lake from siltation and pollution. Building on this local interest in marsh conservation, a series of meetings and workshops at village-, commune- (group of villages) and regional levels stimulated local conservation and management initiatives from 2001.

Nine communities received resource-management rights through a 3-year renewable contract with the State (the legal owner of the lake and marshes) giving them management control over 35% of all the marshes. These management transfer contracts give communities the right to exclude people from outside their community from using resources, to receive fees for resource use, to charge fines to those who don't respect the rules they establish and protect the area from private land claims. The entire marsh area will soon be legally managed by surrounding communities. Sustainable use and marsh protection have been developed through the creation of by-laws ('dina') and federations of community associations. Regional fishing laws have been adopted since 1998 that control fishing practices with the aim of maintaining fish stocks and have become progressively more effective with enforcement of a 2-month closed fishing period from 2001.

The entire Alaotra watershed was designated as a Ramsar site according to the Convention on Wetlands in 2003, formalising the new regional and national commitment to conserving its biodiversity and maintaining the ecosystem functions through sustainable use. A regional organisation representing all stakeholders has been created to coordinate wetland management. The entire lake and marshes will become a new type of protected area (IUCN Category VI) currently under development in Madagascar (*Site de Conservation*) including a strict conservation area (no extractive use) of 8,900 ha.

Methods

Logistical organisation of monitoring

Monitoring began in 2001 with five key sites (villages known to have lemurs in their marshes) covering 80% of existing marshes, and was extended to a total of 16 sites in 2002, covering more than 98% of the marshes (Figure 1).

In 2002 and 2003 the monitoring took 3 months, from February to April, when lemurs are most active and the water level enables use of canoes in the marshes and after dry season fires and the closed fishing season (October–December). Each site takes 3–4 days; half a day meeting with villagers to explain and organise the work, 2 days of data collection and a final half-day for a public environmental quiz and to present results of the monitoring. A summary of the results is presented orally to the assembled public after the quiz by one of the village members of the monitoring team and copies, together with all the data sheets, are signed and kept by the monitoring team, by the president of the community association and by local authority (mayor).

Monitoring teams at each site consist of up to 17 people: 10 villagers and seven technicians. Following a preparatory visit a week before, the participants are chosen at the initial meeting on the first day of the monitoring to which all community members are invited. Selection criteria include a good knowledge

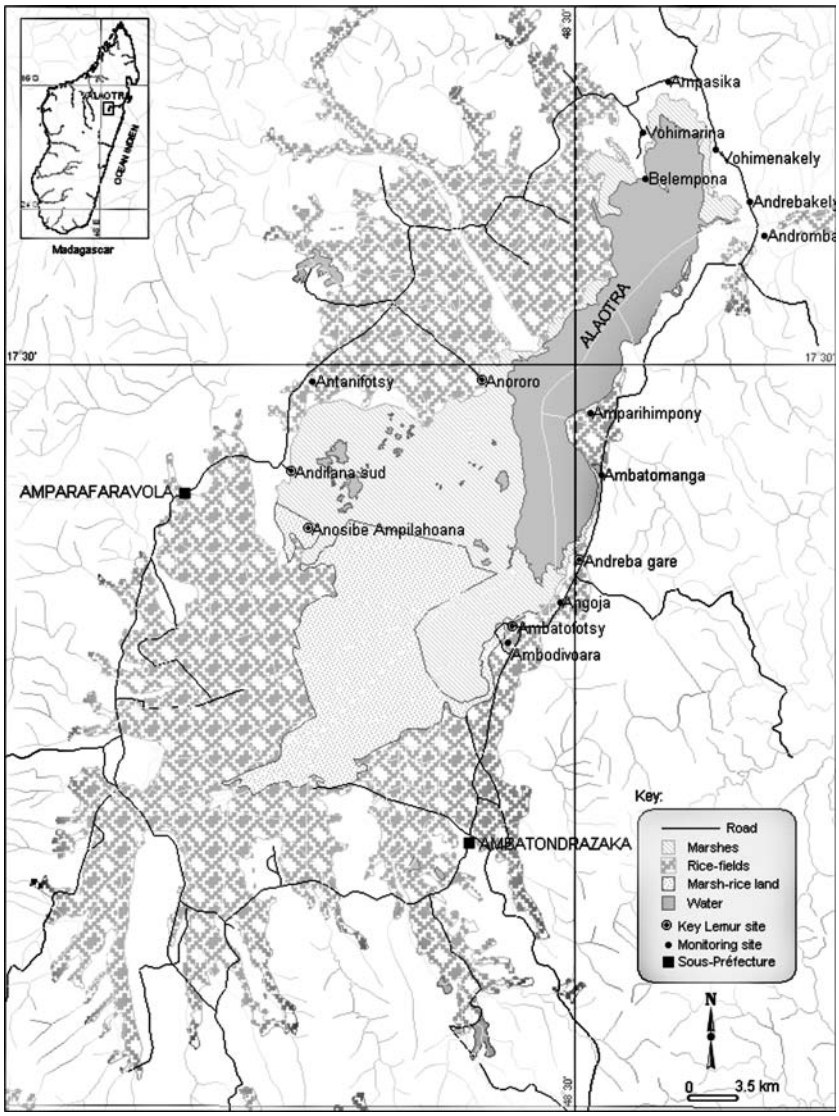

Figure 1. Map of the Alaotra wetlands, Madagascar.

of marshes and animals and literacy. Candidates are discussed after which the village head (administrative appointment) and traditional clan leaders (*Tangalamena*) propose the participants, trying to ensure that they are knowledgeable and will work openly and assiduously with the monitoring team. Individuals can also volunteer for the work and must be accepted by the village meeting. They are paid 12,500 Malagasy francs (fmg) per day ($2), which is less than average earnings from fishing. Most participants want to

continue the monitoring in subsequent years. Technicians are from the regional Water and Forests service, the Fisheries service, Durrell Wildlife, regional development NGOs plus two local experts (lemur and bird specialists who have worked with research teams). Durrell Wildlife technicians have university degrees whereas other technicians have secondary school education. Since 2002, the village participants, most of whom have primary school education, have received training in data collection.

Environmental quiz

Since 2003, a quiz has been used to evaluate local knowledge and as an occasion to raise environmental awareness. Approximately 50 questions are posed to adults and children in separate groups. The questions are divided into three sets based on biodiversity, ecology and environmental rules and regulations.

The quiz takes about 4 h including speeches from elders followed by a small party with traditional singing and dancing on an environmental theme. Prizes such as t-shirts, soap, pens and exercise books are given to winners. Typically a community will receive prizes of a total value of 250,000 fmg ($40).

Participatory ecological monitoring as a competition

A competition was launched to increase local interest in the monitoring, to publicise results of the monitoring and to strengthen short-term positive incentives for good environmental management until longer-term benefits became clearer. In 2002, the 16 sites were divided into three groups according to their location and the extent of marsh found at the site. A marking scheme was used based on the monitoring criteria outlined in Table 1 with higher marks awarded for positive environmental results (e.g. smaller areas of marsh burned). Sites only competed against others from the same group.

Results were announced two months after the monitoring and 1,300,000 fmg ($225) was awarded for first prize in each group, 900,000 fmg ($150) for second prize and 400,000 fmg ($70) for third and fourth places. Prizes were given as the equivalent value in materials chosen by the community such as material towards building a well or a school.

From the beginning of the monitoring through to final judging, regional radio and TV publicised the competition with a special programme for the prize-giving ceremonies attended by local and national dignitaries. An annual monitoring report is given to all the regional Government services, other partners and journalists.

Table 1. Five indicators monitored at Alaotra.

	Indicator 1: *H.g. alaotrensis*	Indicator 2: *Water birds*	Indicator 3: *Fish catches*	Indicator 4: *Marshes*	Indicator 5: *Hunting*
Indicators	Observation or signs of lemurs	Number of species seen along transects.	Weight and sizes of fish caught by fishermen.	Marsh areas destroyed for example by burning or illegal rush cutting.	Number of birds hunted and the reasons for the hunting.
			Number of endemic fish caught in relation to introduced species.		Hunting pressure on key species.
			Number of undersized fish (< 13 cm long) in fish catches.		
			Number of fishermen using illegal nets (mesh sizes less than 3.5 cm diameter).		
Use	Indicates changes in area of occupation of the species.	Indicates changes in species richness and rate of decline of endemic species.	Indicates changes in fish productivity	Indicates changes in proportion of marsh appropriate for lemurs	Indicates changes in levels of hunting of different species and the level of commerce.
	Possible influence on the delimitation of the strict conservation zone.		Indicates dominance of introduced species.		
			Indicates level of illegal fishing practices.		

Table 1. Continued.

	Indicator 1: *H.g. alaotrensis*	Indicator 2: *Water birds*	Indicator 3: *Fish catches*	Indicator 4: *Marshes*	Indicator 5: *Hunting*
Field methods	Observations along transects by canoe in zones indicated as important by villagers.	Observations along fixed transects by canoe.	Identifying species, weighing and measuring fish caught from the first 3 fishing groups arriving at the shore for each different fishing method.	Group discussions with fishermen Observation from high points Delimitation of burned or otherwise destroyed marsh areas with GPS	Semi-structured household interviews from stratified samples of different main activities (fishing, rice cultivation etc).
Data collected	GPS of locality	GPS of locality	Type of fishing equipment used	Exact locality and GPS coordinates of limits of each area affected	Estimated number of animals captured per species per year in the village
	Transect		Number of fish per species		Methods used and objectives of the capture
	Observation or signs of presence	Transect	Weight of fish more and less than 13 cm long	Date, village, people involved and reason for the damage	Prices and markets
	Number of animals seen Behaviour Habitat type	List of species observed			

Equipment	Local dugout canoe, maps, binoculars, GPS, compass	Local canoe, maps, GPS, compass, binoculars, bird field guide	Weighing scales	Canoe, maps, management plan of site, GPS, binoculars, compass	Water bird poster, lemur poster
Strengths	This method is adapted to the marshes and only needs three people (one local expert and two guides).	This method facilitates data comparison because the same team visits the same sites at the same time of year.	This method is easy to undertake but needs good preparation so that fishermen are willing to collaborate.	We believe that all fires are detected and the method is accurate.	This method is rapid and gives a general estimation for each village.
Weaknesses	Observations are limited by existing canals. Change in accessibility between years due to invasive plants can influence results.	Seasonal variation is not taken into account. Ideally this monitoring would be undertaken twice each year.	Identification of species is only to genus.	This method requires strenuous physical effort.	We are not convinced of the accuracy of estimates given by the villagers as these vary with age, education and occupation.
Remarks	Village representatives are highly motivated to show the visitors that their marsh is inhabited by lemurs	Participants chosen by villagers generally know birds well.	Explanations are made during the preparatory meeting to reassure fishermen that the monitoring is not for punishment but to help them monitor the quality of their fish resources.	Village participants are chosen to be honest and indicate all burned areas. GPS points are entered into GIS and superimposed on a Landsat 2000 image.	Explanations are given in the preparatory meeting to reassure villagers that their responses will not result in punishment

Table 2. Area of Alaotra marsh burned from 2000 to 2003.

Year	2000	2001	2002	2003
Marsh area burned (ha)	7300	4430	392	2500–2600[a]
% of total marsh area (23,000 ha)	31.7	19.3	1.7	>10[a]

[a]Estimated by Durrell Wildlife, September 2003. Precise figure to be determined during 2004 monitoring. Areas recorded in a monitoring visit were from fires in the dry season of the previous year.

Results

Examples of key findings of the monitoring

The participatory monitoring shows promise as a tool to enable the government and villagers to keep track of the annual extent of marsh burned Table 2.

The monitoring showed a considerable reduction in marsh fires from 2000 to 2002. The increase in 2003 is mainly due to one large fire. Durrell Wildlife increased its education activities from 2000 and launched the first participatory ecological monitoring from 2001, at the same time that the Government strengthened application of laws banning bush fires.

The monitoring can also assist the government and villagers to assess the impact of management on fisheries. No Madagascar endemic species were observed since 2001 and fish catches are dominated by introduced *Tilapia* spp. The average catch rate varies between 0.2 and 0.4 kg/person/h (Table 3) with a significant increase from 2002 to 2003 (paired t-test $p \leq 0.05$), although the longer term data will be important to show if this is a real trend. Regional by-laws ban catching fish less than 13 cm long yet there is still a low appearance of these in catches.

It should be noted that the two-month closed fishing season (15 October to 15 December) has only been strictly applied since 2002, which, in addition to the gradual improvement in application of the regional fishing by-laws, could account for this promising increase in fish catches.

Table 3. Monitoring of fish catches at Alaotra, Madagascar, from 2001 to 2003.

Year	2001[a]	2002	2003
Number of fish catches examined	59	121	151
Total mass of catches (kg)	314.9	652.6	1089.4
Average catch/person (kg)	5.33	5.39	7.21
Average catch rate (kg/person/h)	0.26	0.23	0.39
Fish <13 cm long (% of catch)	17.6	18.7	15.8
Number of endemic/indigenous species observed	0	0	0
Proportion of Tilapia by weight (% of catch)	84.6	86.1	87.1

[a]2001 figures are from the five key sites, whereas 2002 and 2003 are from 16 sites.

Village surveys indicated that large numbers of birds are hunted. 5600 birds were hunted in the 16 villages in 2003, and 4,800 birds in 2002, most of which were ducks and other waterbirds that hunters caught in traps and by hand. The birds hunted are mostly species that are resident in Alaotra wetlands: *Dendrocygna viduata*, *Sarkidiornis melanotos*, *Anas melleri*, *Anas erythrorhyncha*, *Anas hottentota* and *Fulica cristata*. These figures are the total for 16 villages of the mean of responses given by different people on the estimated numbers of each species hunted in their village. There were rumours that lemur hunting persists at some sites (Table 4). Birds are usually hunted for local consumption. There is not much commerce in these wild-caught birds and the hunting is more intense in villages with a lower standard of living.

Interviews undertaken during the monitoring indicate that lemur hunting persisted in 3 of the 16 villages in 2003, as opposed to 4 in 2002. In addition to this reported reduction in lemur hunting, the known area of lemur occupancy was extended by monitoring in 2003, when lemurs were found at Belempona in the north, where no lemurs had been seen since 1999 and they were believed to have disappeared.

Table 4. Quiz results in order of position in inter-village competition 2003 in Alaotra, Madagascar.

	Marsh area (ha)	Correct responses to quiz questions (%)	Area of marsh burned (ha)	Fish < 13 cm long (%)	Number of birds hunted	Hunting lemurs
Small sites in E < 1000 ha						
Andreba	235	64	0	1	3	No
Ambatofotsy	700	59	0	3	50	Yes
Ambatomanga	70	43	0	0	0	No
Andromba	180	29	0	84	1716	No
Amparihimpony	15	34	0	9	3	No
Angoja	400	16	300	12	12	No
Big sites in SW > 1000 ha						
Andilana	5700	61	0	0	60	Yes
Anororo	9850	47	38	3	188	No
Ambodivoara	1700	49	0	3	30	No
Antanifotsy	1000	34	3	12	328	Yes
Anosibe	1500	11	51	26	917	No
Small sites in N < 1000 ha						
Belempona	300	40	0	4	44	No
Vohimarina	300	54	0	1	1	No
Vohimena[a]	400	–	0	0	692	No
Ampasika	140	11	0	1	214	No
Andrebakely[a]	320	–	0	77	1371	No
Total	22,810		392		5629	

[a]Quizzes were not held due to other events in the village.

Local knowledge of biodiversity and ecology

There appears to be a strong correlation between level of knowledge (a higher % correct responses) and positive environmental management (less marsh burned, less hunting, fewer fish < 13 cm) (Table 4). This suggests that environmental awareness and education leads to improved environmental management, and *vice versa*.

Cost and effort of monitoring

The following time input were provided by the participants:

1. Villagers 50 days (3–4 days per village).
2. Regional technicians (Government, NGO, local experts) 57 days.
3. Durrell Wildlife technicians 127 days.

The field missions for the monitoring in 2002 cost $4,825, excluding the salaries of Durrell Wildlife and Government technicians, and the competition prizes cost $1,125.

The total cost of the monitoring were divided on the following budget lines (in US$; 2002-data): Travel (USD 325), Food and Accomodation (1935), Daily Salaries (1200), Materials (240), Prizes for quizzes (645) and Prize giving ceremonies (480).

Wetland management actions

The 2002 monitoring programme helped the regional fisheries service and fishing associations to amend the regional fishing convention. Several new destructive practices identified during the monitoring were banned, such as burning marshes to create fishing ponds and creating fences to retain fish. These fishing practices have not been observed in subsequent monitoring so the bans seem to have been respected. In July 2002, the regional fishing convention also banned hunting of locally endemic species and all the village by-laws have subsequently been similarly amended.

Several communities were keen to accelerate contractual transfer of marsh management with the regional forestry service following the monitoring, and the GPS (global positioning system) points and habitat maps from the monitoring assisted with this process. Habitat maps are also being used to guide a regional zoning exercise prior to the creation of the new protected area.

Discussion

Technical capacity, data accuracy and long-term usefulness of the data

There are only three years of data for this monitoring scheme so it is not yet possible to draw firm conclusions on long term trends. It is worth evaluating

to what extent the adoption of these simple low-cost methods will provide effective long-term monitoring. The participatory nature of the monitoring contributed both positive and negative aspects. Working with local people facilitated use of their intimate knowledge of the area, for example where lemurs could be found. However, lemur and waterbird monitoring was very simplistic during the participatory monitoring, only noting presence and diversity of species. Over the long term such data will enable monitoring of a change in area of lemur occupancy, which is an important aspect of conservation status, but it will not enable precise detection of changes in population. The bird lists will only show if any species stopped using Alaotra wetland over the long term, and more extensive surveys will still be required for confirmation. More quantitative lemur and waterbird surveys require trained technical staff with a greater time and financial investment and these are currently undertaken separately by Durrell Wildlife so have not been described in this paper.

The village hunting surveys are not very reliable because the families chosen at random do not necessarily know the waterbirds and the estimates of the number of individuals and eggs taken varies with level of education, with type of livelihood activities and with age. Some old people get confused with what happened in the past and it is not clear they are responding with respect to the current year. Less educated people tend to be nervous and we are not sure if they give accurate estimates of the numbers. It is not clear how accurate the figures are for people who are not hunters themselves. Hunting figures from these surveys only indicate orders of magnitude of hunting of different species and which villages are most involved, which helps with targeting conservation action, but are not sufficiently robust to indicate trends.

The evaluation of areas burned is accurate to the error of the GPS unit, which is around 10 m. We are confident that all burned areas are found by observation from high points and group interviews in villages, and that these data will be useful in monitoring long-term trends.

The fish catch data, although only for 3 years, gives an indication that fishermen's opinions that fish catches and fish sizes are increasing may be true. However, given the economic importance of fishing and the potential of linking increased fish catches with good environmental management and conservation, this aspect of the monitoring should be strengthened. For example the number of fish catches evaluated should be increased at each site to become more statistically robust and fish sizes should also be recorded.

Transparency and good governance

The participatory aspect of the monitoring improved collaboration between the villagers, the government technical services, regional NGOs and Durrell Wildlife. The participation of the Government technical services gave an opportunity to clarify the laws and responsibilities concerning natural

resources. It increased contact and trust between Government agents and villagers and enabled them to visit marshes together rather than meeting in the village. The joint monitoring ensures that all parties know if there have been infractions. We believe that monitoring helped to reduce burning and clearance of marshes for rice fields because villagers were worried they would be caught and punished. The monitoring and the competition encouraged villagers to monitor each other's actions so that culprits could be identified if burned areas were found. Most villagers want to enforce laws concerning illegal or banned unsustainable practices but do not have sufficient authority so they welcome the presence of the Government agents.

The monitoring also encourages transparency and good governance from the Government agents as the public profile during the monitoring provides pressure not to indulge in corruption or partiality. For example, fisheries agents have become much more strict about enforcing fisheries regulations by confiscating fish caught illegally and burying them publicly and confiscating and destroying illegal nets and boats.

We believe that the generally positive effects of increased enforcement, an important aspect of good resource management, are likely to continue.

Government agents and village leaders make speeches during the public meetings in support of conservation and sustainable resource use, which clarifies and reinforces these as public policy. Once they have made speeches they are held more accountable for their actions and there is a motivation to practice what they preach. This provides leadership for other members of the community.

Vehicle for awareness raising and enlisting support for wetland management and monitoring

Even though the data presented here are insufficient to prove any real trends, the development of sustainable resource management rules and institutions and the apparent grass-roots interest and support for conservation lead us to be cautiously optimistic that these preliminary results will continue positively.

The villagers who participate in the monitoring become interested in the environmental changes and explain the results to their peers. More people want to join the team each year, despite a lower wage than from fishing. This could be because their participation gives them special standing as technical experts within the village and also because they get the opportunity and training to use technical materials like binoculars and GPS. In addition, more people join the community associations following the monitoring.

The announcement of the competition results and the prize-giving ceremonies provide an opportunity to involve dignitaries and get regional media coverage. This heightens the pride taken by each village in their monitoring results and also publicises the importance of wetland conservation and management.

The quizzes, in particular, raise awareness of local biodiversity and the regional fishing convention. Local knowledge is reinforced by public repetition. The quizzes are an effective means of environmental education and further enhance the conservation impact of the monitoring. Monitoring was equally effective in generating data without the quiz but after quizzes were added we think there was broader awareness and interest throughout the community and a greater likelihood of leading to improved management actions. For example, we believe that the ecological monitoring helped raise awareness that led to amendments in the regional fishing convention and banning of hunting of certain species.

Sustainability

It is possible that this apparent interest in sustainable resource use and conservation has only led to temporary behaviour change and previous unsustainable practices that are economically attractive in the short term will return. The institutions and rules for sustainable resource use will help to ensure that the minority cannot plunder common resources at the expense of the majority. Only time will tell if this is effective and the monitoring programme will help to facilitate adaptive management by providing an indicator of when and where further action is required.

Sustainability of any monitoring programme depends on its usefulness to the managers, their capacity to implement it and its cost. We believe that the monitoring has been instrumental in raising interest in sustainable resource use and conservation, in particular because of its participatory nature and that future managers will continue the necessary effort and investment.

It is necessary to use GPS units, maps and computer applications to analyse and store the data. The villagers, communes and even the Government technical services do not currently have these materials or have the capacity to collect the data and do the analysis without support from Durrell Wildlife. This should be resolved by an investment in training and donation of such equipment. All the necessary equipment can be maintained in the capital city (225 km or 8 h drive away).

At around $5,000 per year this monitoring programme is not particularly expensive which is a very important factor in ensuring sustainability. Monitoring is currently funded by Durrell Wildlife, with the aim that within the next 3 years the regional Ramsar Management Committee (NGO) will seek and manage future funding, ideally with a contribution from improved fish production. The relatively low cost of monitoring makes potential future transfer to a regional authority a feasible proposition, especially given the high economic importance of the region for rice and fish. If more sophisticated and higher cost monitoring had been developed, for example using satellite images and over-flights, such transfer would be much less likely. Designation as a Ramsar site and future gazetting as a protected area with a strict conservation

area of at least 8,900 ha will help to ensure local, regional, national and will be an important lever for international support and potential funding.

We think that this kind of participatory monitoring could play a similar role in other wetlands in Madagascar and beyond. Participatory monitoring is particularly appropriate in wetlands because local inhabitants often rely heavily on the wetland resources for their livelihood, and the fisheries can improve with management measures that also favour biodiversity.

Recommendations regarding monitoring methods

On the basis of our experiences from this scheme, we recommend the following:

- Use simple methods that are easy to implement by villagers and Government partners.
- Avoid unnecessary changes in the monitoring methods.
- Separate the monitoring of populations of key species (lemur, waterbirds), which require greater technical capacity, from the participatory ecological monitoring.
- Try to ensure that the factors monitored include those with an economic or development interest for the villagers (such as fish), to help maintain their motivation.

Conclusion

The participatory ecological monitoring is becoming an accepted part of regional environmental management in Madagascar. The results have assisted the regional government development committee in preparing the regional development plan, and will help Madagascar to report to international conventions such as Ramsar and the Convention on Biological Diversity. We think that this approach could be adopted effectively by other developing countries where the livelihood of the citizens depends greatly on the sustainable use of natural resources to be monitored, which is often the case for wetlands. Participatory ecological monitoring not only encourages improved management and reduction of human-induced threats, but also fosters respect for biodiversity and wise use of natural resources.

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