Madagascar protected area network sustainable financing
Economic analysis Perspective

Jean-Christophe Carret[1]
Denis Loyer[2]

Executive Summary

Madagascar, with international community support, has for ten years now successfully invested in the creation of a network of terrestrial protected areas; to date there are 41 protected areas covering approximately 1.5 million hectares , i.e 3% of national territory surface. The issue is sustainable financing of the management of this network and of its essential complement: financing economic alternatives to deforestation of agricultural and energetic origin is not easy to achieve. Through monetary evaluation of the three types of benefits of protected areas (biodiversity conservation, eco-tourism, hydrological protection of watersheds) and identification of gainers (water users, tourism operators, *Association Nationale pour la Gestion des Aires Protégées(ANGAP*), solutions for sustainable financing of the network and alternatives can be put forward.

National benefits of biodiversity conservation and eco-tourism are the two potential sources of the protected area network sustainable financing of the network management cost estimated to be an annual $ 5 per hectare of protected area. For a sustainable coverage of this cost, direct payment for biodiversity conservation from the North countries must be capitalized in an Endowment Fund and part of eco-tourism national added value transferred thanks to a network management tax. A $ 50 million Endowment Fund, doubled protected area entrance fees, withdrawing from tourism visa fees (50% of 50$) would ensure sustainable financing of the current network and its extension if any, entrance fees and revenues from tourism visas increasing by 5% a year together with the number of tourists.

Water users' willingness to pay (irrigated rice farmers and drinkable water consumers) downstream the watersheds protected within the network is in theory a sustainable and sufficient source of financing ($3 per hectare of protected area, increasing with time) to compensate the revenues lost by the communities who are forbidden to clear forests in protected areas for rice cultivation and wood fuel collection. However, transferring downstream water users' willingness to pay in the form of payment for environmental services to potential forest clearers upstream is not a conceivable solution in Madagascar at present . Therefore, public aid to development is required to finance conservation agriculture projects and biodiversity business development that are both alternatives to forest clearing of agricultural and energetic origin and are currently tried in Madagascar. Unlike a pure financial system of compensation, this source of financing, though not sustainable, may bring about a long lasting change of mentalities.

Thus the real challenge in terms of protected area sustainable financing is to be met outside protected areas themselves and recourse to PAD is justified to complement redistribution mechanisms of national benefits generated by protected areas .

Key words : Madagascar, protected areas, environment, rural development, cost/benefit analysis .

[1] Natural Resources Economist, World Bank, Region Africa ; jcarret@worldbank.org
[2] Head of Environment and Natural Resources Department, Agence Française de Développement ; loyerd@afd.fr

Introduction

With the help of the international community, the Malagasy government has for ten years now invested $ 75 million in the formation of a protected area network with a view to prevent forest ecosystems from deforestation of agricultural and energetic origin and preserve the rarest and the most endangered animal and vegetal species in Madagascar.

Ten years later, assessment of this initiative is in broad terms deemed satisfactory for three reasons : (i) the existing network comprising 41 protected areas of different legal status (national parks, integral national reserves, special reserves) and covering approximately 1.5 million hectares (forest surface), i.e 3 % of Madagascar surface is efficiently protected from deforestation , (ii) most of the network is well managed by a national agency possessing the necessary capacities and competence , the *Association Nationale pour la Gestion des Aires Protégées* (ANGAP), and (iii) the protected areas attract more and more visitors, which is an active contribution to the development of tourism in Madagascar.

However, sustainability of investment in the protected area network remains uncertain.

Firstly, ANGAP financing relies exclusively on Public Aid to Development (PAD) that may not be sustainable even if what is at stake is the financing of a global public good such as biodiversity.

Secondly, alternatives to deforestation as proposed to the communities penalized by the creation of protected areas, within the framework of Integrated Conservation and Development Programs (*Programmes de Conservation et de Développement Intégrés* (PCDI) are also financed by PAD, and to top it all, total abandonment of deforestation practices is not guaranteed at these programs' end.

In other words, although the results of the creation of a protected area network were remarkable, ten years later, sustainable financing of this network and of the alternatives to deforestation is not yet achieved.

This paper is a cost/benefit evaluation of Madagascar protected areas, then a benefit/loss evaluation for the concerned communities. Based on this , points for thought on protected area network sustainable financing and of alternatives to deforestation are proposed.

A. Protected area network benefits

The function of Madagascar protected area network is protection of a global public good: biodiversity.

Apart from this global function that is biodiversity protection, the PA network also has two other local functions: (i) direct use function as a support to nature tourism development in Madagascar ; (ii) indirect use function , for in preserving forest cover it ensures regular supply of drinkable water to cities and irrigation water to fields downstream and it protects irrigated perimeters from sediment deposits which would be more important in case of deforestation.

Identification, quantification and monetary evaluation of the flow of national benefits linked to these three functions is made possible through economic analysis.

Net benefits of biodiversity conservation

Because of its geological history, Madagascar is an island with biological mega diversity, that is a global region where a very high number of global animal and vegetal species are concentrated (12, 000 species of plants and 1,000 species of vertebrates – mammals, reptiles, amphibians, birds) most of which are endemic to the region (9,700 plants and 770 vertebrates).

Besides, because of the high rate of deforestation of agricultural and energetic origin, the island is also one of the 25 global *hot spots*, that is one of the places on earth where biological diversity is at the same time concentrated on a small surface and highly endangered.

There is no comprehensive inventory of biodiversity existing in the 41 protected areas of the network. Only an inventory of the endangered vertebrate animal species (mammals including primates, reptiles, amphibians, fishes) encountered in the protected areas has begun and is currently under way.

However, the network representation of the island forest habitats is rather satisfactory(although middle altitude dense humid forests are over represented against dry and thorny forests) and it is believed to shelter thousands of plant species that are unique on earth, of which 38 of the 45 inventoried lemur species.

As bio-prospecting permits for pharmaceutical purposes are not awarded in the protected area network, even with payment of royalties, national

benefits derived from biodiversity conservation are the international NGOs direct payments (net of management expenses) to ANGAP, the various environment funds and international NGOs financing (net of structure charges) for the management of the 10 out of 41 protected areas that are under their direct management.

Direct payment to ANGAP is on the average estimated at an annual $ 3 million over these last four years. International NGOs management expenses for the 8 protected under their direct management are estimated at $ 1.5 million a year.

Thus , the total national benefits of animal and vegetal biodiversity conservation in Madagascar PA network are approximately $3 per hectare of protected area per year.

For the time being, these are not sustainable benefits, for they rely on the international NGOs and environment funds capacity to capture rich countries households' willingness to pay for biodiversity conservation in general and on Madagascar capacity to attract part of these funds to preserve Malagasy biodiversity.

Moreover, given that direct payments for Malagasy biodiversity conservation are already relatively high, significant increase of these benefits is unlikely in the years to come. Reduction of these benefits is even most probable as it seems easier for an international NGO to obtain financing for the creation of a new protected area than for the management of an existing network managed by a national agency. A conservative assumption of these payments decreasing by 5% a year gives net benefits of $1.5 after 15 years.

Net benefits of eco-tourism

With an average annual 10% growth rate these last ten years, tourism is a sector in full expansion in Madagascar and has become after fishery and vanilla the country's third hard currency supplier . In 2000,. 160,000 tourists came to visit this big island and more than half of them (55%)came for eco-tourism, the protected areas being as of now among the main tourist attractions of the island.

Ten protected areas (see Table 1 below) actively contribute to the development of tourism in Madagascar as they attract a growing number of tourists : about 100,000 visitors in 2001, the latest year of reference. Besides, five other protected areas, (Masoala, Tsimanampesotse, Kirindy Mitea, Baie de Baly et Zombitse) are endowed with undeniable attractions and should reinforce the network's contribution to the development of tourism in Madagascar in the years to come.

Table 1 : protected areas for eco-tourism

Name of protected area (from north to south)	Surface in ha	Number of visitors in 2001 (% of total)
Montagne d'Ambre	18 200	8 170 (8 %)
Ankarana	18 825	6 898 (7 %)
Ankarafantsika	60 520	4 617 (5 %)
Tsingy de Bemaraha	66 630	3 351 (3 %)
Mantadia/Analamazaotra	10 000	26 478 (27 %)
Ranomafana	41 601	15 668 (16 %)
Andringitra	31 160	1 750 (2 %)
Isalo	81 540	27 678 (28 %)
Andohahela	76 020	1 636 (2 %)
Total	**404 496**	**96 246 (98 %)**

Source : ANGAP, 2003.

What makes up national benefits of eco-tourism are on the one hand entrance fees collected by ANGAP in the 10 protected areas currently visited and on the other direct (transport, hotels, catering services, local crafts, guides) and indirect national added value (activities induced from the first ones) of eco-tourism in these ten protected areas.

With 100,000 visitors in 2001, the latest year of reference, an average $5 entrance fee per visitor and a $55 direct and indirect national added value per visitor (recently measured for 5 of the ten visited protected areas –Andasibe, Ranomafana, Isalo, Andringitra, Ankarantiska), the protected areas generate $ 6 million net revenues per year to the country.

Thus , the total of national benefits of eco-tourism in protected areas is approximately $4 per hectare of protected area per year.

These are sustainable benefits that will keep increasing with the number of visitors. The Global Tourism Organisation (*Organisation Mondiale du Tourisme,* OMT) foresees a 6-8% tourist visit annual growth rate in the Indian Ocean for the coming 15 years. A conservative assumption of a 5% visit increase per year for 15 years forecasts an annual 8% net income from eco-tourism

Benefits per visitor may also increase with time. Indeed , surveys on the subject show that eco-tourists' willingness to pay for their visits to protected areas in good conditions is higher than $5 and even closer to $15. Moreover, Madagascar is at present a destination for nature linked adventure tourism, but it could progressively become a destination for top quality eco-tourism as is the case for Nepal ; it could also be a destination for specialized eco-tourism, for example for associations

of bird watchers who, like hunters, are always in search of the most interesting sites. In that case, added value per tourist may be higher than $55 resulting in growing national benefits of eco-tourism.

Net benefits o f hydrological protection of watersheds

Hydrological benefits means avoided loss of productivity or quality of produce by the economic infrastructures situated downstream the protected area watersheds where the river springs supplying them with water are located

In Madagascar, the major effects of deforestation upstream the watersheds are mainly visible (i) in irrigated perimeters for rice cultivation (the most productive land in Madagascar) and (ii) in town drinkable water supplying, downstream these watersheds. Cases of partially uncultivated perimeters or of canal maintenance overcost due to silting are numerous. However, other infrastructures such as hydroelectric dams , ports or drinkable water supply of villages are also affected by deforestation.

As a matter of fact, forest cover in protected areas regulates water flow, which partly prevents risks of flood in rainy season and risk of water shortage in dry season. Preserving protected areas is also instrumental in reducing the volume of sediment that would accumulate in the forebays and/or irrigation canals if forest cover disappeared and the soil exposed to erosion.

Analysis, for each watershed, of the 1996 National Ecological and Forest Inventory (*Inventaire Ecologique et Forestier National* (IEFN)) spatial data as provided by LANDSAT satellite image processing and statistics from the water and power supply company JIRAMA, demonstrates obvious hydrological linkages between on the one hand 20 out of 41 protected areas located upstream and at least 430,000 hectares of irrigated perimeters and 17 towns with an annual 8.4 m3 drinkable water consumption situated downstream on the other.

Table 2 :Protected areas with hydrological function

Name of protected area	Surface of protected area (ha)	Surface of irrigated perimeters (ha)	Volume of drinkable water(m3)
Manongarivo	39491	59239	309983
Anjanaharibe Sud	70288		220077
Ankarafantsika	100848	36486	48140
Marojejy	70288	17448	250842
Ambatovaky	24158	2616	
Marotandrano	33795	2616	19529
Betampona	2342	681	
Mangerivola	8919	19142	
Midongy du sud	153522	14907	6226
Pic d'Ivohibe	3302	16479	1228
Manombo	2013		20754
Ranomafana	36412	14557	42705
Andringitra	15884	16479	
Tsaratanana	43733	45037	309983
Zahamena	62491	18232	71303
Andohahela	62384	8713	68952
Anjozorobe	259695	47115	
Bemaraha	80484	22615	1.699
Mantadia	14736	22703	
Montagne d'Ambre	18164	66093	7.0142.40
Total	**1.102.949**	**431.158**	**8.385.661**

Source : ANGAP, 2003.

As for irrigated perimeters, two approaches may be applied for quantification of the effects of preserving protected areas and their forest cover and monetary[3] evaluation of their benefits : i) evaluation of avoided losses of production, which provides the most reliable figures when they can be calculated ii) evaluation of rice farmers' *Willingness to Pay* (WTP) to avoid deforestation, which is easier to calculate but less reliable because more subjective. Because of their poverty and their small contribution capacity, rice farmers indeed pay only a tiny portion of investment and maintenance cost of irrigated perimeters which are largely government subsidized. It is therefore reasonable to assume that WTP for irrigated perimeters protection is lower than the earning expected.

A survey recently conducted in the region of Maraoantsetra in the north east of Madagascar on WTP of rice farmers situated in the lowlands to avoid silting and flooding of their tiny irrigated perimeters shows a monetary value of $5 per hectare of irrigated perimeter, i.e the monetary equivalent of 30 kg of paddy at farm gate price, although productivity in the region is 2.5 tons per hectare.

[3] Unlike the case for biodiversity conservation and eco-tourism , quantification and monetary evaluation of hydrological benefits resulting from avoided deforestation in protected areas are more difficult to understand because of the complex biophysical relation between deforestation, change of water flow, worsening erosion on the one hand and change of productivity in irrigated perimeters or change of drinkable water production on the other. It is to note that all results of studies on the subject are controversial.

This is a most interesting evaluation as Maroantsetra region has one of the rare sets of Madagascar watersheds where forest cover is still higher than 70% of watersheds' surface, the average figure being lower than 30%. Consequently, this gives a monetary value of hydrological benefits resulting from preserving forest cover in protected areas, which is certainly a conservative assumption.

Two recent evaluations of losses in production due to bad irrigation and canal sand silting in Madagascar irrigated perimeters are available ; however, they do not permit to establish a cause to effect relation between a certain watershed forest cover level and a certain deforestation process upstream. These evaluations present production losses comprised between $ 40 (Maroantsetra region) and $ 80 (Alaotra region) per hectare.

With an average productivity of 2.5 tons of paddy per hectare in irrigated perimeters and a farm gate price of $ 160/t , $ 40 loss of revenue per hectare of irrigated perimeter is the equivalent of 10% loss of production (250 kg of paddy) ; such loss may be either or simultaneously due to silted irrigation canals because of worsening erosion and resulting sediment deposits, to bad irrigation in dry season and flooding in rainy season, as both occurrences result from degradation of water flow regulation ensured by forest cover.

This loss of production is eight times higher than Maroantsetra watershed rice farmers' WTP, which confirms that this evaluation provides a conservative appraisal of hydrological benefits of protected areas and can be transferred to all the irrigated perimeters that are under the influence of protected areas.

As for drinkable water in urban areas, there are two approaches : (i) water users' willingness to pay , (ii) evaluation of the cost of replacing natural filtration and water storing system with an artificial one.

The only available figure is from a recent survey of households willingness to pay more in order to benefit from clean and of regular flow water conducted in Fianarantsoa. This evaluation provides an additional WTP of $ 0.30/ m3 against the present price which is $ 0.15 per m3. Failing to have other supplementary data, this evaluation is the one retained for the analysis concerning all the towns supplied with drinkable water by the rivers having their springs within the protected area network.

In retaining as a conservative assumption that WTP accumulated amount means the will to prevent silting and flooding in irrigated perimeters and to have a steady supply of clean drinkable water, in applying it to all the infrastructures affected by the protected area network (400,000 hectares of irrigated perimeters and 8.4 million m3 of drinkable water), the sum of the two WTPs is $3 per hectare of protected area per year, of which $ 1.3 relates to irrigated perimeters and $ 1.7 to drinkable water.

Thus, the total of national benefits of hydrological protection of watersheds is approximately $3 per hectare of protected area per year .

Moreover, these benefits are sustainable and increase with time. Indeed, productivity and quality of production are lower when forest cover in protected areas progressively disappears as a result of forest clearing of agricultural and energetic origin. If we take as a conservative assumption a 5% increase of water users' WTP per year for 15 years, it gives $ 6 per hectare of net benefit of hydrological protection of watersheds.

Conclusions

The three national benefits of Madagascar protected areas have been, as far as possible, that is as far as available data and techniques allowed it , been identified, quantified and their monetary evaluation made. A map attached hereto shows spatial representation of these benefits.

With all the reserves as stated above, one hectare of Madagascar protected area would bring about an average $ 10 net benefit per hectare, of which $ 3 from biodiversity conservation, $ 4 from eco-tourism and $ 3 from protection of watersheds.

Two remarks : (i) these benefits are not equally distributed among protected areas (see map in annex hereto), some of them combining the three benefits [4], others only one (biodiversity conservation) ; (ii) two of these benefits will certainly increase with time , whereas we think that the evolution of the third one (biodiversity conservation) will be more uncertain. With the assumptions we have retained, net benefits would be $ 16.5 15 years from now.

B. Cost of protected area network

Cost of preserving protected areas in its current configuration (41 protected areas for approximately 1.5 million hectares) includes (i) management cost of the 41 protected areas and (ii) opportunity cost linked with prohibiting deforestation in the 41 protected areas thereby with the loss of revenues from slash

[4] In that respect, the case of Montagne d'Ambre national park is remarkable for it protects 13 % of the surface of irrigated perimeters, 88% of the volume of drinkable water within the network and accommodates 8% of tourists visiting the network.

and burn agriculture and wood fuel collection which are the main causes of deforestation.

Cost of network management

Cost of network management includes operation cost (head office, regional office, site operation and daily activities) and investment cost (managing biodiversity, developing eco-tourism, environmental education).

In a recent audit report , ANGAP operation cost is estimated at $ 2.5 per hectare per year, which amounts to $ 3.75 million a year for a network covering one and a half million hectares.

For the five coming years, developing activities (surveillance and control of protected areas, continuing research on biodiversity, creating new park discovery trails and environmental education) will require , according to ANGAP forecasts, a $19 million investment, that is approximately $ 2.5 per hectare and per year.

For the five coming years therefore, management cost of the protected area network, without any extension of the latter, is estimated to be $5 per hectare per year, without actualization to make it simpler.

Opportunity cost of the network preservation

Opportunity cost of the network preservation deserves to be taken into account although most protected areas were created ten years ago. Indeed , in the course of these ten years, deforestation rate outside protected areas is estimated to be 1% per year, a result of comparisons made with LANDSAT 5 and 7 satellite images. Moreover, deforestation is not totally absent from protected areas although it is five times lower than the one observed outside these areas. Therefore, if managing protected areas were to cease, it is more than likely that deforestation will be resumed and will continue at the speed of 1% a year, that is 15,000 hectares a year.

Opportunity cost is essentially made up with lost revenues from slash and burn agriculture and from unsustainable wood fuel collection. However, these practices which are destructive to forests are also accompanied by collection of non wood forestry products (*Produits forestiers non ligneux* PFNL), mainly fruits and animals in the surroundings of the areas destroyed.

Of the 1.5 million hectares of the network, 600,000 hectares are in the west of the country in the provinces of Tuléar and Mahajanga and 900,000 hectares in the east , in the provinces of Antananrivo, Toamasina and Antsiranana. In the first two provinces, forests are destroyed to plant rainfed rice and collect wood fuel, whereas in the three others forests are only destroyed for rainfed rice planting, for wood fuel is taken from forest plantations.

Besides, in the western provinces, *tavy* is practiced for three years, which means land is cultivated for thee years where the forest has been cleared and then abandoned for good whereas in the eastern provinces , forest is cleared then land is cultivated as *tavy* for three years then let lie fallow for five years (before cultivating this cleared land again, it must be let lie fallow for a rather long period to reconstitute its soil fertility).

With all these assumptions, the first year when deforestation is resumed , 15,000 hectares are cultivated as *tavy*, of which 6,000 hectares also supply wood fuel in a non sustainable way.

A reasonable estimation published in 1994 shows that for the farmer, net revenue from forest land cultivated as *tavy* (farm gate price less labour cost) is the equivalent of 0.5 ton/ha of paddy per year , i.e one third of the forest land yield cultivated as *tavy* which is 1.5 ton/ha a year for three years. With current farm gate price which is $ 160 per ton, income earned from forest land cultivated as *tavy* is $ 80 per hectare per year. Therefore farming revenues lost amount to $ 1.2 million, which makes $0.8 per hectare per year when spread over the total surface of protected areas.

As for wood fuel collection , from an average estimation made for the western part of the country , forest productivity being varied from north to south, it is considered that wood fuel collected on one hectare of forest in an unsustainable way is 25 tons and that net revenue from wood fuel collection is half the producer price, it means that with present producer price which is $ 15 per ton, income earned from forests is $ 187.5 per hectare per year. Therefore, the first year wood fuel revenues lost are about $ 1.125 million, which makes $ 0.75 per hectare per year when spread over the total surface of protected areas.

In a recent survey concerning non woody forest resources conducted in the region of Ambohitantely , to the north east of Madagascar, it is estimated that the revenue from the collection of fruits, animals and more marginally medicinal plants for artisan use is $ 4 per hectare for 150 households who cover 1,500 hectares of forests, that is 10 hectares per household.

About 10,000 households are involved in deforestation the first year, assuming in that case that they may go all over 100,000 hectares of protected areas to collect non woody forest resources the first year. Therefore, forest revenues lost amount to $ 400,000 the first year, which makes $ 0.25 per hectare per year when spread over the total surface of protected areas.

With all these assumptions, opportunity cost for preserving the protected area network amounts to $ 1.8 per hectare per year the first year and to $ 5.85 per hectare per year the fifteenth year[5].

As a conclusion, opportunity cost for preserving the protected areas is relatively low at the outset but with time and years, in the medium term it increases with the surface of cleared forest land ; however, it decreases in the long term, first because unsustainable collection of wood fuel and *tavy* lead to deforestation with no prospect of reforestation, secondly because one can expect these unsustainable practices to be abandoned some day.

Comparing costs and benefits of protected areas preservation

If we compare[6], without actualization to make it simpler, the sum of the three national benefits of protected areas (eco-tourism, biodiversity conservation and protection of watersheds) with network preservation cost (management cost and opportunity cost linked with avoided deforestation), then the sum of benefits amounts to an annual $ 10 per hectare the first year and to an annual $ 16.5 per hectare the fifteenth year while all the costs linked with this network preservation are valued at an annual $ 6.8 per hectare the first year, and at an annual $ 10.85 per hectare the tenth year, taking deforestation process into account.

This analysis is considered as a cautious one as the methodology chosen to calculate rice farming benefits of watershed protection (WTP instead of productivity change) is very conservative.

With these plausible and cautious assumptions , *Net Present Value* (NPV) of protected area network preservation at a rate of 10% is valued at $ 15.70 per hectare of protected area and *Economic Rate of Return* is 54%

Table 3 : Cost/benefit analysis of protected area network

Cost/benefit per hectare of protected area	Amount (present value over 15 years , 10% actualization rate)
Management cost	-41,82 $
Opportunity cost	-30,79 $
Biodiversity conservation	+17,98 $
Eco-tourism	+40,19 $
Protection of watersheds	+30,14 $
Net Present Value	**+15,70 $**

This result is obviously a first approximation for it is sensitive to the assumptions on the evolution of benefits with time. Besides, it hides great disparities among protected areas. Indeed, only some protected areas are visited and/or protect infrastructures from sediment deposits and some protected areas are richer in biodiversity (measured by the number of species and endemism rate in the protected area or in the country).

In light of this analysis, there is good reason to say that preserving the protected area network is economically beneficial to the country.

Lastly, it is to note that this analysis has not considered the benefits in terms of carbon as represented by forest cover preservation. Indeed , protected areas constitute a source of carbon whose future theoretical value is real but within current Kyoto protocol, taking it into account is not yet conceivable. The same for the conversion of surfaces that have been subjected to slash and burn (*tavy*) into cultivated parcels and whose rate of organic matter could also be counted owing to the carbon it contains.

C. Gainers/losers

Preserving the protected area network is beneficial to four social groups : households (i) rice farmers in irrigated plains and (ii) drinkable water consumers in the towns where water is supplied by rivers having their springs in protected areas, (iii) tourism operators and lastly (iv) the National Association for the management of protected areas (*l'Association Nationale pour la Gestion des Aires Protégées* (ANGAP).

[5] 10 years after deforestation is resumed (when the lands let lie fallow in the east are cultivated again), 3% of forest surface in the west would be cultivated as *tavy* (18,000 hectares) of which 1/3 would produce wood fuel for collection, while 6% of eastern forest surface would be cultivated as *tavy* (54,000 hectares) , involving 48,000 households engaged in forest clearing and who covered 480,000 hectares of protected areas, (that is the third) to collect non wood forest products.

[6] Let us consider a fifteen year period. Over this period, it is supposed that ANGAP level of investment remains constant and that the behaviour of the people engaged in forest clearing does not change, in spite of environment awareness raising campaigns: in other words, if protected areas cease to be managed, deforestation will be resumed, at a rate of 1% a year. Besides, it is supposed that , if the protected area network is well managed, the number of visitors will increase by 5% a year , the same for irrigated rice farmers' and water consumers' WTP which will increase by 5% a year, while direct payments for biodiversity conservation will tend to decrease by 5% a year.

Tourism operators record the highest flow of net benefits with $ 37 per hectare of protected area. (protected area entrance fees must indeed be subtracted). Benefits of rice farmers and drinkable water consumers (about 290, 000 households, mainly rice farmers) are $ 30 per hectare and those of ANGAP are approximately $ 20 per hectare. Such benefits come mainly from direct payments for biodiversity conservation as eco-tourism benefits are marginal with present entrance fees at $ 3 and have to be shared by half with protected area neighboring communities.

In number, the main beneficiaries of the protected area preservation are the 265,000 rice farmer households (1.5 hectare of rice field per household) and the 25,000 households supplied with drinkable water in urban areas, situated downstream the protected areas. Therefore, it can be said that biodiversity conservation has a positive economic effect on poor populations in Madagascar for loss of revenues and welfare is avoided.

On the other hand, preserving the protected areas, to the extent that it prevents deforestation through slash and burn practices, may be detrimental to a fifth social group: the slash and burn farmers (about 50, 000 households after 10 years). This social group's present losses of revenues amount to $ 31 per hectare. Besides, unlike the communities benefiting from protected area network preservation, this social group who already lives in extreme poverty loses all the revenues which they may potentially get from agricultural and energy resources contained in the protected areas.

With this identification of the winners and losers and monetary evaluation of earnings/losses , four remarks can be made:

(i) ANGAP is the worst-off among the three categories of beneficiaries and its main source of revenues (direct payment for biodiversity conservation) is uncertain and is likely to decrease.

(ii) ANGAP nearly receives nothing from eco-tourism benefits, as the quasi totality of earnings go to tourism operators, although the protected area network is a natural asset that is essential for the development of tourism in Madagascar.

(iii) the earnings of the 290,000 households of rice farmers and drinkable water consumers compensate the losses of the 50,000 slash and burn farmers , practicing *tavy* ; such earnings increase with time whereas the losses of the farmers practicing *tavy* stabilize after 10 years because of fallow periods necessary for the soil to recover its fertility

(iv) No compensation mechanism exists between the winning and losing communities. Such mechanism would anyway raise serious problems: identification of the losers ; sustainable change of their behavior in case of financial compensation from the winners.

D . Sustainable financing of the network and of the alternatives to deforestation

This economic analysis highlighted uncertainties on the sustainable financing (i) of ANGAP for the management of protected areas (ii) of the alternatives to deforestation for the injured communities. Two questions must be asked : how can sustainable financing of the protected areas managed by ANGAP be achieved and can financial compensation be given to the losers while encouraging them to change their behavior?

Network sustainable financing

In the short term, ANGAP's annual needs for the management of the network are estimated at $ 7.5 million, i.e $ 4 per hectare, of which $ 3.75 million are to finance operations and the other $3.75 million to finance new investments.

ANGAP financial resources at present amount to $ 4.75 million per year ; they are provided on the one hand by direct payments for biodiversity conservation ($4.5 million these last few years) and on the other by entrance fees paid by eco-tourists visiting the protected areas, that is $ 250,000 for 100,000 visitors.

Entrance fees should normally increase with the number of visitors but maintaining direct payments at such exceptional level for a long time is uncertain though it is to be noted that the latter makes up the major part of ANGAP financial resources.

Consequently, ANGAP financial resources are not sufficient to cover their current and investment expenses and above all they are not sustainable. For the time being, ANGAP is surviving thanks to international community support , namely the World Bank and USAID.

Three proposals are put forward to meet this structural financing deficit for the management of protected areas : (i) putting an *Endowment Fund* in place, (ii) increasing entrance fees at protected areas, (iii) creating a green tax.

(i) A $ 50 million *Endowment Fund* is being raised. Assuming a 6 % interest rate and 10% operating costs a year , this endowment fund would ensure

sustainable financing up to $ 2.5 million a year. This level of financing confirms the assumption of the downward biodiversity conservation direct payment trend in the form of *sinking fund*.

(ii) Doubling park entrance fees ($ 10 per visitor because willingness to pay for visiting parks is higher than $ 5 and closer to $ 15) would increase ANGAP tourism revenues to $ 0.5 million a year.

(iii) Protected areas and their accommodation infrastructures are essential assets for the development of tourism in general in Madagascar. Therefore, a green tax could be established for tourism operators and tourists themselves. It could be withdrawn from tourism visa revenues. Madagascar hosts 200,000 foreign visitors a year and they pay $50 each for a tourism visa. To achieve $ 4.5 million financing a year, about half of these tourism visa revenues should be transferred to ANGAP (this proportion would decrease with the expected increase of visitors).

Financing sustainable alternatives to deforestation

Preservation of protected areas result each year in growing losses for slash and burn farmers.

Assuming that entrance fees at protected areas are doubled, part of it ($ 0.5 million) shall be allocated to neighboring communities to finance alternative activities to deforestation. However, the effects of the investments made by the communes are unlikely to cover the slash and burn farmers revenue losses.

For reasons of equity, establishing a system of transfer by which the winning households would financially compensate the losing ones is conceivable in theory and is economically possible, but it raises three kinds of difficulties:

(i) It is not easy to identify the households that would practise *tavy* if the protected areas ceased to be managed. These households could be the poorest of the rice farmers that work around the protected areas (*a priori* the farmers who plant rainfed rice on *tanety* and not those who have irrigated fields),or they could be landless poor people who have come from Madagascar other provinces, attracted by the possibility to engage in forest clearing or they could be urban poor, even if this latter case seems to be most unlikely.

(ii) Assuming that identifying the losers is possible, establishing a mechanism that would transfer part of the winners' benefits to the losers would certainly imply high transaction costs because of the great number of beneficiaries and of the difficulty to organize automatic withdrawals from these beneficiaries. As a matter of fact, the associations managing irrigated perimeters already encounter difficulties in collecting taxes for organization and maintenance although these are far from being heavy compared to those applied in other countries (approximately $ 10 per hectare per year).

(iii) Madagascar is one of the poorest countries in the world. Consequently, the majority of the winning households, whether in urban or rural areas, live under absolute poverty line ($ 1 a day). *A priori* it seems difficult , from a political point of view , to ask poor people , even if they are the "winners", to give a financial compensation to other poor people who may be potential slash and burn farmers.

It is then most improbable that *Payments for Environmental Services* (PES) from rice farmers with irrigated fields and urban water users (willingness to pay to avoid deforestation) could be applied on a large scale to cover slash and burn farmers' revenue losses.

A second solution, a rather attractive one from the economic point of view, would be to relocate populations to other regions that offer real opportunities, either downstream the watersheds (provided there is an ambitious rehabilitation and extension program for irrigated perimeters and for rainfed crops) or to towns where job opportunities are higher than in villages. In practice, implementing such relocation seems extremely risky from the political and social point of view and is only mentioned as a matter of interest.

The third solution would be to promote alternative activities to pressures and to promote sources of revenues in the peripheral communes of the protected areas. These would mainly be conservation agriculture but also forest management transfer to grassroots communities, together with the development of biodiversity business activities.

This solution is the one currently favoured in Madagascar where trials have been done and mastered at the level of watersheds or *tapia* forests where silkworm breeding is possible. It has two advantages and one drawback:

(i) Conservation agriculture and forest management transfer to grassroots communities are real economic alternatives to slash and burn practices for they stabilize the systems of cultivation and collection of wood fuel ; they also enhance productivity with a range of proposals with or without inputs and a range of biodiversity businesses that are adjusted to the poorest rice farmers.

(ii) Conservation agriculture techniques maintain permanent vegetal cover (cultivated or crop residues) and sowing is done (cereals, legumes, tubers, or fodder) without tilling the soil which is never left bare. These two techniques enable trapping eroded soil on parcels cultivated with rainfed crops, at the same level as forest cover in protected areas.

(iii) these two solutions present an environmental risk in the sense that in some cases , increase of revenues may encourage forest clearing , if revenues change more rapidly than mentalities.

Developing cultivation systems that preserve the soil and transferring management to grassroots communities are therefore two long term approaches which must not only result in a sustainable replacement of the revenues lost because of prohibition of slash and burn practices but also in change of mentalities. For this reason , PAD is still necessary for a sustainable abandonment of deforestation while providing financial alternatives to the losing communities.

Conclusions

This analysis has shown that the creation of a protected area network thanks to international community support is beneficial to Madagascar from the economic point of view.

However, mechanisms for ANGAP sustainable financing are not yet in place, namely there is still a need for an Endowment Fund and an instrument for transferring part of tourism benefits to ANGAP. Besides, the various solutions proposed to compensate and stabilize slash and burn farmers require financing from public aid to development and must in some way still prove their efficiency and their replication capacity.

From a more global point of view, this analysis has also shown that preserving protected areas is, as illustrated by the example of Madagascar, in the heart of North and South countries common interests.

As a matter of fact, in demonstrating that the main beneficiaries of the conservation of the global public good that is Madagascar endemic biodiversity are the national water users, it has legitimated recourse to national financing and financing from Public Aid to Development.

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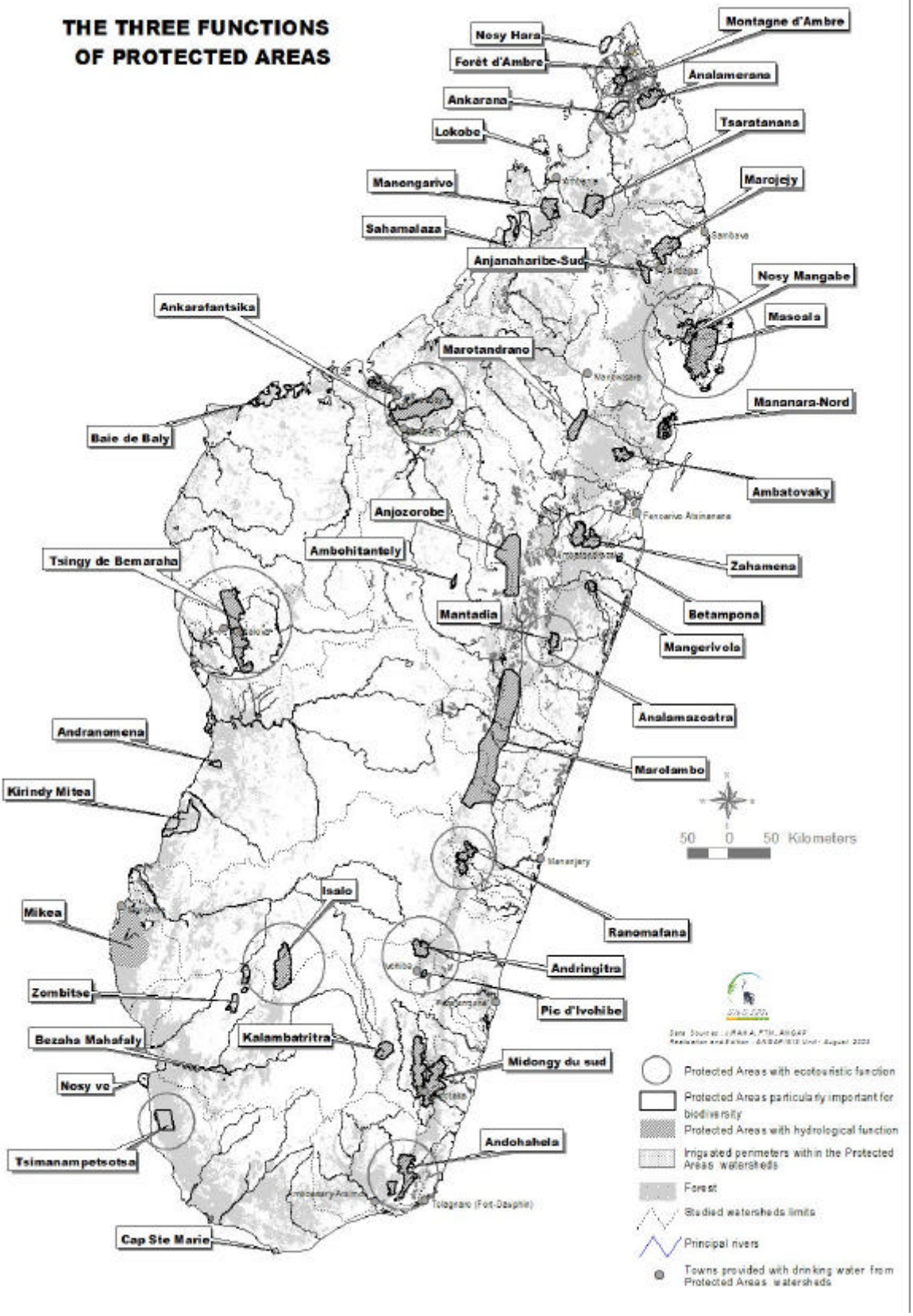
THE THREE FUNCTIONS
OF PROTECTED AREAS
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Nosy Mangabe
Ankarafantsika
Maroala
Marotandrano
Mananara-Nord
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Ambatovaky
Anjozorobe
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Cap Ste Marie
Protected Areas with ecotouristic function
Protected Areas particularly important for biodiversity
Protected Areas with hydrological function
Irrigated perimeters within the Protected Areas watersheds
Forest
Studied watersheds limits
Principal rivers
Towns provided with drinking water from Protected Areas watersheds