Rapid Environmental Assessment

Cyclones and flooding in Madagascar

Joint UNEP/OCHA Environment Unit

May 2007

UNITED NATIONS

United Nations Office for the
Coordination of Humanitarian Affairs
(OCHA)

United Nations
Environment Programme
(UNEP)

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UNITED NATIONS
New York and Geneva, 2007

Published in Switzerland, 2007 by the Joint UNEP/OCHA Environment Unit

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Cover photo: National Bureau for Risk and Catastrophe Management (BNGRC). *Flooding in Ambanja district, northwest Madagascar.*

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Executive summary

Madagascar experienced an exceptional number of cyclones and tropical storms during the 2006-2007 cyclone season. Seven tropical cyclones either made a direct landfall and/or influenced precipitation levels and patterns on the island. The last two cyclones alone affected an estimated 190,000 people and killed 150. In response to a request of the Malagasy Government, an United Nations Disaster Assessment and Coordination (UNDAC) team was deployed to the country from 9-23 April 2007.

Because of concerns about the environmental impact of the cyclones and associated floods, the Joint UNEP/OCHA Environment Unit, in close collaboration with OCHA's Field Coordination Support Section (FCSS), provided an environmental expert as an associate member to the UNDAC team. This expert, from the United Nations Environment Programme (UNEP), was tasked to undertake a Rapid Environmental Assessment (REA) to identify any urgent and life threatening secondary environmental impacts and risks.

The major conclusion of the Rapid Environmental Assessment is that no immediate environmental impacts on and risks to human health were identified.

The series of cyclones/tropical storms experienced during this cyclone season, however, have had a substantial cumulative impact on the environment and community livelihoods in the areas affected. In the medium-term, this is likely to result in increased environmental degradation, particularly in the form of soil erosion. In addition, the high winds and storm surges associated with the cyclones have adversely affected fragile ecosystems, such as coastal forests, mangroves and coral reefs that are particularly vulnerable to cyclone damage.

A chronic problem that was aggravated by the flooding concerns the levels of biological (mainly faecal) contamination of wells for drinking water. Poor hygienic conditions and limited resources for water and sanitation underlie this situation. The most significant environmental impact of this year's cyclone season, however, will be the crop losses during the current agricultural season, which will have consequences for human welfare and livelihoods. In the medium-term (6-12 months), an increase in human pressures on natural resources is likely, particularly on forests and coral reefs, including those in protected areas. Degradation processes will probably accelerate, especially those associated with land degradation and soil erosion.

This report recommends that urgent attention be paid to the issue of polluted drinking water wells that has been aggravated by the disaster. In conclusion, the report makes a number of recommendations for consideration and inclusion in the recovery phase.

1. Introduction

Major disasters have acute, negative environmental impacts that can threaten human life and welfare. These impacts may include damage to industrial facilities containing hazardous materials as well as increased likelihood of erosion and landslides. Some effects are not life threatening and they are, therefore less urgent, but nonetheless they may well be important and require attention in the recovery process – for example, waste management.

The Joint UNEP/OCHA Environment Unit (Joint Environment Unit) is the United Nations mechanism to mobilize and coordinate the international response to environmental emergencies, including natural disasters with major environmental impacts. In situations such as the cyclones and floods in Madagascar, the Joint Environment Unit has the primary function of identifying any acute issues. If needed, the Joint Environment Unit can mobilize assistance to ensure that these issues are addressed. It can help to ensure appropriate transition and follow-up so that less urgent, longer-term issues can be addressed during the recovery and rehabilitation phases by national authorities with possible assistance from UNEP, UNDP and other bodies concerned with environmental recovery and development issues.

Context

Madagascar, with its capital Antananarivo, is the world's fourth-largest island. Situated in the Indian Ocean, it is separated from the African mainland by the Mozambique Channel. Madagascar occupies an area of 587,041 square km and is inhabitated by 17.2 million people. The island consists of a narrow coastal plain backed by a high plateau and mountains inland. The highest point is Maromokotro at 2,876 m. The island is exposed to periodic cyclones, droughts and locust infestations.

Source: http://www.reliefweb.int/rw/RWB.NSF/db900SID/SKAR-64GDXM?OpenDocument&rc=1&cc=mdg

Madagascar experienced an exceptional number of cyclones and tropical storms during the 2006-2007-cyclone season. Seven tropical cyclones either made direct landfall and/or influenced precipitation levels and patterns on the island. By comparison, during the period 1994-2001 there were only five cyclones, affecting the northern part of the country. The heavy rains associated with the tropical storms and cyclones have caused flooding in various regions of the island since December 2006. The National Bureau for Risk and Catastrophe Management (BNGRC) stated on 17 April that a total of 188,331 people had been affected by the last two cyclones (Indlala and Jaya), including 150 people dead and 126 injured. The impact on agriculture and communication was considerable, with the reported destruction of 76,105 hectares of crops and loss of or damage to 103 bridges.[1]

At the request of the Malagasy Government, an UNDAC team was deployed to the country between 9 and 23 April 2007. The Joint UNEP/OCHA Environment Unit, in close collaboration with OCHA's Field Coordination Support Section (FCSS), provided an environmental expert from the United Nations Environment Programme (UNEP) as an associate member to the UNDAC team. This expert was tasked to undertake a Rapid Environmental Assessment (REA) to identify any urgent and life threatening secondary environmental impacts and risks. The emphasis was on the effects of the last two tropical cyclones (Indlala and Jaya).

The Madagascar cyclone season: 2006-2007

The cyclone season in the southern Indian Ocean extends from mid-November to mid-April. Madagascar experiences cyclone activity almost every year, but the 2006-2007 season was distinctive because of the frequency and rapid succession of cyclones.

The cyclones, unlike the localised ones of other years, affected larger areas in the north, centre and south of the island. The main areas affected were Sava region in the northeast; Sofia and Diana regions in the northwest; the capital Antananarivo in the central highlands and the Vatovavy Fitovinany region in the southeast. Most of the damage in the coastal zone between Sambava-Antalaha-Ratsianaran and extending inland to Andapa - in the pathway of cyclones Indlala and Jaya – was caused by strong, sustained winds peaking at 235 km/hr, but the area was also affected by flooding and coastal storm surges. Most of the destruction in Maroantsetra in the north-east and along the north-western transect of Mahajanga-Mampikony-Antsohihy-Ambanja, stemming from extensive flooding associated with torrential cyclonic precipitation.

[1] UNICEF Situation Report 24 April 2007

Table 1 – Cyclone events impacting Madagascar in the 2006-2007 season

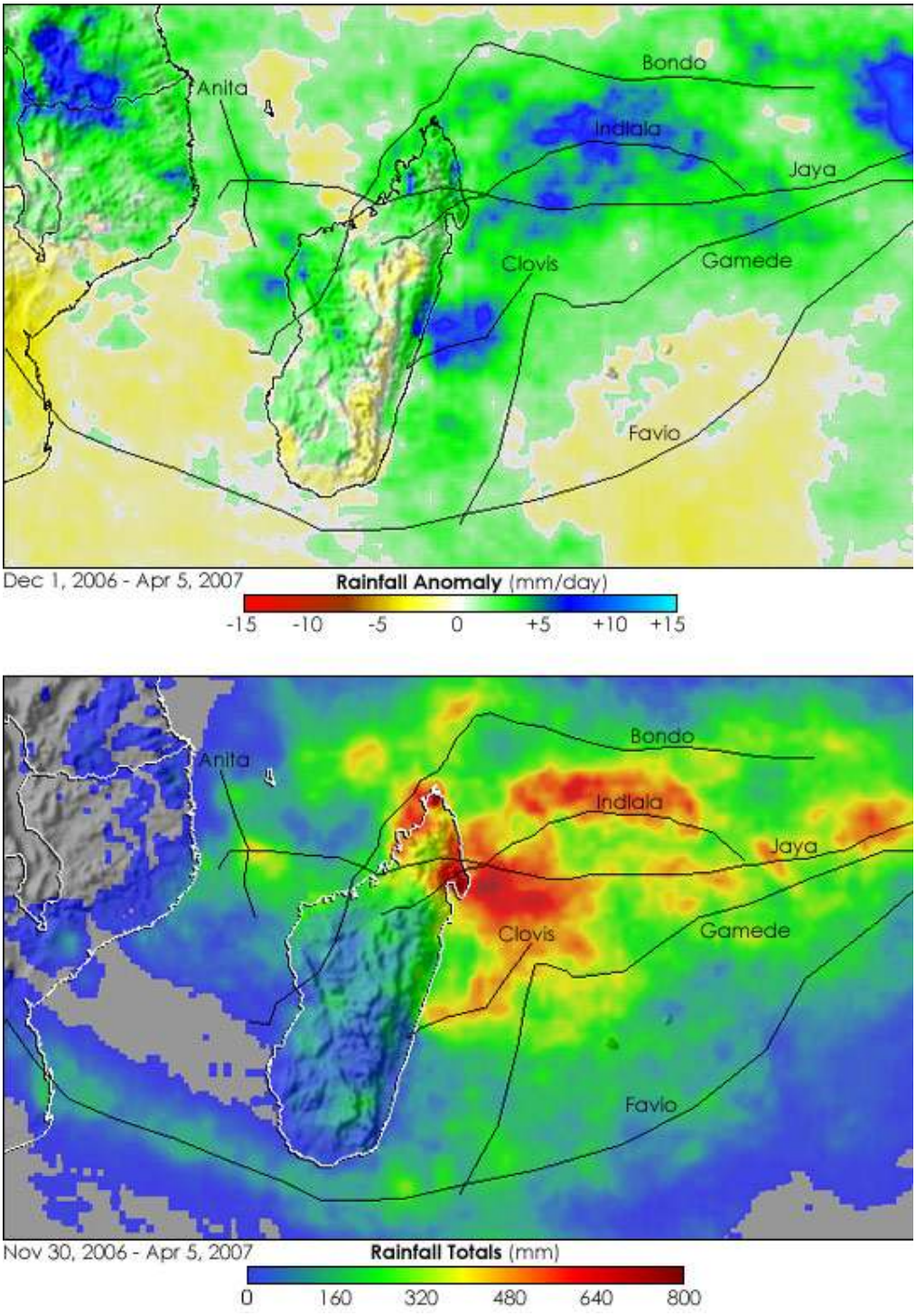
Cyclone	Category [2]	Date of landfall in Madagascar	Major damage sustained
1. Anita	1	No landfall – 30 November 2006	7 deaths Estimated 293,000 affected 7,845 homeless 90,000 ha of agricultural land damaged. 124,778 MT of rice lost[3].
2. Bondo	4	25 December 2006	
3. Clovis	1	31 December 2006	
4. Favio	3	No landfall – 20 February 2007	
5. Gamede	3	No Landfall – 23 February 2007	
6. Indlala	3	15 March 2007	88 deaths Estimated 126,017 persons affected 30,856 homeless 47,000 ha of agricultural land damaged Significant infrastructure damage (roads, brides, schools, irrigation structures)[4]
7. Jaya	3	2 April 2007	3 Deaths Damage assessment to be finalised
			Estimated total population requiring humanitarian assistance: 450,000 Estimated cumulative population affected: over 1,000,000 [5,6,7]

This report

This report summarizes the findings and recommendations resulting through field visits and discussions with national and local authorities. After an overview of the methodology used, the report describes the impact of the cyclone season on Madagascar. The assessment of potential acute environmental risks is presented, as well as an synopsis of the environmental recovery issues affecting community livelihoods. Recommendations to address the environmental concerns in the medium-term and long- term are also provided.

[2] Maximum cyclone strength reached.
[3] United Nations Residence Coordinator Situation Report No. 4, 26 February 2007
[4] United Nations Country Team Madagascar: Cyclone Indlala Situation Report No. 4, 02 April 2007
[5] UNOCHA, Madagascar Flash Appeal 2007 – Cyclones and Floods Revision (Draft)
[6] UNICEF, 3 April 2007, Humanitarian Action Madagascar Donor Update.
[7] Catholic Relief Services, 20 April 2007, http://www.reliefweb.int/rw/RWB.NSF/db900SID/DHRV-72J7US?OpenDocument

Figure 1: Madagascar cyclone season: 2006-2007



Source: NASA images produced by Hal Pierce (SSAI/NASA GSFC).

2. Assessment methodology

The REA was carried out in three stages:

1. A Profile of Preliminary Environmental Risks (PPER) was provided to United Nations Country Team, as well as to the environmental expert to assist with the preparations of the REA. The objective of a PPER is to alert the United Nations Country team of potential secondary risks posed by large infrastructure and industrial facilities containing hazardous materials located in the affected area (Annex 1).

2. Information gathering and scoping of potential major cyclone-related environmental problems was conducted through interviews and discussions with national environmental authorities, sectoral ministries, United Nations organisations and agencies and environmental and humanitarian non-governmental organisations (NGOs) based in Antananarivo.

3. Field assessments were performed in collaboration with the local district authorities of the areas affected by cyclones and floods in the Sava Region and Maroantsetra District in north-eastern Madagascar. The affected regions in the north-west and south-east were not visited at this time.

The environmental issues identified were categorised on the basis of urgency:

- those of an emergency nature requiring immediate remedial action
- the expected 'knock-on' effects or secondary risks that may undermine community livelihoods and ecosystem integrity in the future

The Rapid Environmental Assessment did not identify any urgent life threatening environmental impacts. (photo: H. Partow)

3. Assessment results

a. Potential environmental emergencies

The Rapid Environmental Assessment focused on the environmental problems caused by the last two tropical cyclones (Indlala and Jaya). It is important, however, to consider the findings within the larger context of a high-activity cyclone season. Multiple events have compounded impacts that have a significant effect in both the short-term and the medium-term on the coping capacity of communities and on the resilience of ecosystems.

No urgent environmental risks to human health were reported or observed during the field assessments. Moreover, the potential for acute environmental hazards caused by the release of hazardous materials is considered to be low given the predominantly subsistence agricultural economy of the areas affected by cyclones and floods[8]. There are no major industrial facilities in the devastated zones, resulting in very few sources of chemical contamination. Despite an unconfirmed report of damage to a cement factory in Mahajanga, the UNDAC field assessment reported limited overall impact in this region. Given the inert nature of the raw materials there is unlikely to be a significant environmental risk.

The most serious pollution stems primarily from contamination of water points by faecal matter. This problem existed before the disasters but has almost certainly been aggravated by the flooding. The risk of water contamination is high as most water points are poorly constructed, unprotected open wells, many of which are located down-gradient, and thus vulnerable to pollution by surface run-off. Most contaminated wells in Maroantsetra district (estimated at 1,200[9]) were reportedly disinfected by the humanitarian organisation, Medair. In Sambava and Antalaha districts, however, where significant contamination of wells was observed, no remedial activities seemed to have taken place, with the result that many villagers were collecting contaminated river water. River water quality was

Poor drinking water conditions were aggravated by the floodings (photo: H. Partow)

[8] Ibid., (p.90) Industrial and cash crop agriculture was estimated to cover only 1 percent of the land area of the whole province of Antsiranana (p. 90).
[9] BNGRC, 13 April 2007, Bilan des actions de secours suite au passage d'Indlala.

poor due to high levels of suspended sediments caused by flood run-off. It should be noted, however, that the pre-existing drinking water and sanitation situation in Madagascar was precarious; with only 35 per cent of the population having access to safe water and 3 per cent to adequate sanitation[10]. These indicators are even lower in the rural regions affected by the cyclones.

The potential impacts on the medical waste stream were judged insignificant for a number of reasons. One explanation is the limited number and inaccessibility of health care services to populations affected by the cyclone events (typically one PHC centre per commune), as also few injuries were reported. Another rason is that, although forty-four health centres were reportedly damaged by cyclone Indlala[11], most of them provided primary health care (PHC) only, and so generated negligible amounts of medical waste. Water-borne diseases, particularly cholera and dengue fever epidemics, posed the major health concerns, since stagnant water creates habitat for disease vectors. The incidence of malaria – an endemic problem – has reportedly increased.[12]

Thousands of livestock and poultry died in the floods[13], but as most carcasses were swept away, they do not constitute a significant source of pollution at present. As the floodwaters recede, however, some carcasses may resurface, necessitating safe disposal measures in certain localities. The Joint UNEP/OCHA Environment Unit provided guidance material on the safe disposal of carcasses to the environmental expert who shared them with relevant authorities.

Pesticide and fertilizer application in rice and vegetable cultivation in the affected regions is negligible[14] so that the risk of agrochemical contamination is low. Any possible spillage will have been significantly diluted given the large scale flooding. The Ministry of Agriculture's single pesticide warehouse in Antsohihy, Diana district, was not affected. Furthermore no damage to stocks housed in commercial retail outlets was reported by the private association of pesticide retailers (Crop Life).

The small-scale artisanal mineral exploitation, mainly of precious stones, does not use hazardous materials and therefore does not pose a threat.

The devastated zone has limited infrastructure. Most damage was to roads, bridges, schools and administrative buildings. Maroantsetra and Mananara-Avaratra districts in Analajirofo suffered damage to irrigation infrastructure,

[10] UNICEF, 3 April 2007, Humanitarian Action Madagascar Donor Update.
[11] Ministry of Interior/BNGRC. Bilan provisoire des degats après le passage du cyclone Indalala, 2 April 2007.
[12] UNICEF, 3 April 2007, Humanitarian Action Madagascar Donor Update.
[13] In Morantsetra, district 43 cows and 52,000 poultry were reportedly killed. In Diana and Sofia regions, a large number of cows were reportedly killed. BNGRC Maroantsetra, Synthese degats Indlala au 30 Mars 2007.
[14] The volume of pesticide use is estimated at 5,000 kg/annum in the rice sector for the whole region of Antsiranana. Ibid., p.62.

including to twenty-one small dams,[15] but as the average height is between 1 and 1.5m, there is no significant environmental risk.

b. Environmental concerns for the recovery phase

The most visible signs of environmental damage were the significant numbers of uprooted trees and other vegetation caused by intense winds during the cyclones. The Sambava-Antalaha-Ratsianarana coastal zone - where cyclones Indlala and Jaya made landfall,- extending inland to Andapa was the area most affected. In the coastal zone, mangrove stands and extensive tracts of coconut plantations were destroyed. Inland, secondary forests and hardwood trees, including in the Marojezy National Park[16] were seriously damaged. With the exception of the mangrove stands, the potential for natural vegetation regeneration is generally good. The other evident impact is the very high level of river and stream turbidity, indicating an intensification of soil erosion and topsoil loss caused by the flooding.

The most significant environmental impact of the cyclone season, however, is expected in the medium-term. The current agricultural season will suffer extensive crop failure which will have important consequences on people's welfare and livelihoods.

Potential threats to natural resources need to be addressed in the recovery phase (photo: H. Partow)

Rice, the island's staple food crop, has been severely affected. When the UNDAC team ended their mission, the agricultural damage assessment had not been finalised (as many areas remain inaccessible) but preliminary assessments conducted in February indicated that 260,000 people were affected by the loss of up to 80 percent of crops in certain locations. Following cyclones Indlala and Jaya in March/April these figures will rise considerably and losses will only be fully known when the harvest starts in May. In mid-April, the Ministry of Agriculture estimated that 160,000 ha of rice fields have been flooded or damaged[17]. The extensive scale of destruction was evident during the field visits.

In addition, a considerable part of the population's reserve rice and seed stocks were swept away or spoiled by the floods.

[15] Ministry of Interior/BNGRC. Bilan provisoire des degats après le passage du cyclone Indalala, 2 April 2007.
[16] As reported by the park authorities, (ANGAP).
[17] UNOCHA, Madagascar Flash Appeal 2007 – Cyclones and Floods Revision (Draft)

Important food crops other than rice on which people rely during times of food shortage, in particular the breadfruit (*Artocarpus altilis*), were destroyed by the cyclone, reducing food supply to local populations.

The damage to agriculture will have serious consequences for people's welfare and livelihood on the medium-term, if not addressed. (photo: H. Partow)

Many cash crops (vanilla, coconuts and coffee) were devastated by the cyclone, thus adversely affecting the socio-economic situation of the affected population. In Antalaha, it is estimated that 80 per cent of the vanilla crop was damaged.[18] In the country's largest coconut plantation almost 5,000 trees and 1,000 high-value nursery trees were uprooted, and as many as 2.5 million immature coconuts were knocked down[19].

The damage to the agricultural sector will likely place significant pressure on the environment as affected populations attempt to cope until and after the next harvest. Such pressures are likely to include:

- **Deforestation:** logging of precious hardwoods, including rosewood *(Dalbergia maritime)* and ebony *(Diospyros celebica)*, including encroachment into Masoala National Park[20] and the surrounding tropical coastal forest for construction use or as a source of cash income. These areas are encircled by impoverished communities with an estimated population of 120,000 people. The Park did not sustain direct damage as a result of the cyclones, but potential secondary habitat degradation will threaten rich and endangered wildlife species, including diurnal lemurs, the serpent eagle (*Eutriorchis astur)* and rare palms[21]. There is also a potential risk of wildlife poaching for food and sale in local markets.

- **Land use changes and land degradation**; slash and burn (*tavy*[22]) for agriculture is reportedly a regular occurrence following cyclones in Madagascar[23]. In the medium-term, habitat conversion for upland rice

[18] An estimated 350,000 tonnes of vanilla were destroyed by the cyclone. Personal communication with Secretary General, Ministry of Environment, Water and Forests, 13/04/2007.
[19] Soavoanio S.A., Rapport sur les dégâts causes par les cyclones « Indlala » et « Jaya », Avril 2007.
[20] Masoala National Park is Madagascar's largest protected area (240,000 ha). It is made up of terrestrial and marine areas, and comprises 80 percent of Madagascar's remaining coastal forest.
[21] Care International, Projet « réponses aux cyclones » pour le développement des communautés de la zone périphériques du Parc National Masoala (Madagascar), April 2006.
[22] Upland rice cultivation on land that has been cleared through slash and burn is known locally as "tavy", which is widely practiced on the slopes of the northeastern coastal zone.
[23] Personal communication with Secretary General, Ministry of Environment, Water and Forests, 13/04/2007.

cultivation is likely to increase as affected communities try to source an alternative means of sustenance. The resulting loss in vegetation cover will further aggravate soil erosion. It is a serious and chronic problem intensified by the steep terrain of the north-eastern part of the island. In addition, reduced soil protection diminishes the resilience of the land to torrential rains and future cyclone events. Vegetation clearance in the humid tropical setting of north-eastern Madagascar can also lead to laterization, whereby the soil surface becomes a hard and impermeable layer with limited potential for plant regeneration.

- **Relocation of communities:** Several villages[24], in both coastal areas and lowland valleys, expressed the intention of relocating to upland areas in order to escape future floods. While such relocation may afford greater protection from floods and storm surges, clearance of the vegetation followed by the cultivation of steep terrain will increase the risks of soil erosion, undermining slope stability and provoking landslides. In Ambanja-Diana district, landslides of massive rocks and boulders devastated entire villages and were the main cause of human fatalities in the area. Landslides also increase the vulnerability of the population by isolating communities and hampering humanitarian relief aid. By law, cultivation on slopes of 12 per cent or greater is prohibited, but the regulation is poorly inforced[25]. Population relocation also carries with it the risk of land conflict with the present landowners.

- **Vulnerable ecosystems:** The force of repeated cyclones may seriously harm fragile ecosystems, specifically coral reefs, mangrove stands and lowland tropical coastal forests (<400m). Coral reefs, especially branched colonies, are vulnerable to the force exerted by storm surges and have been seriously damaged in previous cyclone events in Madagascar[26]. Fortunately, the three marine areas of the Maosala National Park were not within the cyclones trajectory. Coral reefs north of the park (between Ratsianarana and Antalaha) are likely, however, to have suffered as cyclone Indlala made landfall in this area. Increased sediment loads in the rivers discharging into Antognial bay are also likely to damage the coral reefs, including in the protected area of Nosy Mangabe. In addition, since many fishermen lost their boats and equipment, there is increased exploitation of the inshore areas, including the coral reefs. Significant damage was also observed to mangroves in lagoons and estuaries between Ratsianarana and Antalaha. Mangroves provide critical spawning and nursery habitat for fish and shrimps. This loss of mangroves could

[24] For example: in Andingozabe, Antalaha District and Ivato, Maroantsetra District.
[25] Personal communication with Secretary General, Ministry of Environment, Water and Forests, 13/04/2007.
[26] Substantial damage to the coral reefs in the Masoala National Park was reported following the passage of cyclone Gafilo in 2004. Personal communication with Dr. Rémi Ratsimbazafy, WWF Madagacar/WIO, 13 April 2007.

adversely affect the fish stock available to coastal communities in the medium-term.

- **Riverbank erosion.** Severe erosion and an associated significant loss of arable land was observed along the banks of the lower Andranofotsy river. Bank erosion and channel adjustment are natural occurrences particularly after floods. The clearing of riparian vegetation (specifically bamboo) has aggravated the problem of bank subsidence, and increased sedimentation which has diminished channel capacity. There is a lack of awareness about this problem and scientific advice on basic mitigation measures to needs to be provided.

- **Damage to infrastructure in protected areas:** Cyclone damage to the offices and equipment of the National Association for the Management of the Protected Areas (ANGAP) in Antalaha will challenge the day-to-day management capacity of the park authorities. Many shelters have been damaged and tracks are blocked by fallen trees, This will impede the ability of wardens to survey and patrol the park.

- **Erosion along roads:** Poor road construction, in particular inadequate culverts to deal effectively with water run-off, has resulted in saturated road foundations and the break up and washing away of tarmac surfaces, as well as roadside erosion. In addition, hastily made and inadequately drained road deviations may cause the formation of new gullies and create other erosion problems.

The flooding was associated with serious erosion of fertile topsoil. (photo: BNGRC)

- **Rubble/solid waste**: Since the devastated area had basic infrastructure, only a limited volume of rubble and solid waste was generated. Most of the houses destroyed were a traditional construction of palm trees, raffia and mud that do not cause a waste problem. In Antalaha, many schools

were destroyed by the winds[27]. Much of the wood will be salvaged for reconstruction, so that timber demand is unlikely to increase significantly.

In many areas, wood from fallen trees and branches provides an ample supply of firewood and charcoal. Without adequate surveillance, however, it is difficult to verify the source of the wood and there is a potential risk of abuse.

Many challenges still remain in the recovery phase (photo: H. Partow)

[27] UNICEF reports that 166 classrooms were destroyed or rendered unusable in the North following cyclone Indlala, while another 1,200 classrooms were damaged in previous cyclones. UNICEF, 3 April 2007, Humanitarian Action Madagascar Donor Update.

4. Recommendations

Based on the findings of the REA, the following **short-term** recommendation is proposed:

- Disinfection and rehabilitation of contaminated water points (particularly in Sava region) should be carried out as a priority;

For the **medium-term,** the following recommendations are proposed to ensure the integration of environmental concerns into the recovery phase:

- There is a need to engage the environmental authorities in the disaster emergency response. This should include the revision of the standard multi-sectoral disaster reporting form - Enquête Initiale Multi-Aléas, EIMA – used by BNGRC (under the Ministry of Interior and Administrative Reforms) to address environmental damage assessment;

- The socio-economic impacts of the recent cyclones on communities living around the perimeters of Masoala National Park should be assessed, with a view to providing practical advice on alternative livelihood options. This proposal should include the promotion of community-based environmental projects and participation in park management;

- Environmental vulnerability mapping[28] should be undertaken to identify high-risk areas. Environmental vulnerability identification needs to be linked to existing socio-economic vulnerability analysis in order to improve preparedness for future cyclone events;

- Reforestation plans in line with the objectives of the Madagascar Action Plan (MAP), including the rehabilitation and replanting of damaged mangrove stands, need to be supported especially in coastal zones that provide a frontline buffer to incoming cyclonic winds;

- Unstable slopes that pose significant landslide risk should first be identified and mapped, before measures, such as establishing/rehabilitating vegetation, are undertaken to stabilise them;

- Assistance needs to be given to the national park authorities (ANGAP) to repair and replace damaged infrastructure and equipment in both Masoala and Marojezy national parks;

[28] Based on parameters such as topography, vegetation cover, soil erosion index, land use, and frequency of cyclone strikes.

- An assessment of damage to the coral reefs between Antalaha and Ratsianarana should be carried out, preferably in coordination with the annual coral reef assessment of the marine protected areas in Masoala National Park;

- Information on improved crop varieties and agricultural practices should be disseminated aimed at attenuating potential cyclone damage to crops and improving food supply;

- The lack of coastal zone and rural land use management plans needs to be addressed.

Annex 1 Profile of Potential Environmental Risks (PPER)

Joint UNEP/OCHA Environment Unit

Profile of Potential Environmental Risks
Cyclone Indlala - Madagascar- 5 April 2007
TC-2007-000034-MDG

Disclaimer

This profile is not a conclusive list. Other risks may be possible from sources that are not readily identifiable. The information sources used are public websites. All efforts are made to screen the websites for accuracy.

Objective:

The objective of the Profile of Potential Environmental Risks (PPER) is to alert the United Nations Cyclone Indlala struck the northeastern coast of Madagascar on 15 March, arriving with winds of more 230km/h. The storm also continued to unleash torrential rains. On 30 March, it was reported that 126,017 people were directly affected by cyclone Indlala. At least 88 people were killed and 30 disappeared, with about 30,000 left homeless, or deprived of all their belongings. Access to most affected areas continues to represent a major obstacle for delivery of humanitarian assistance. New tropical depression/cyclone JAYA is expected to land on the North East (Antalaha) Coast of Madagascar in the night between 2 and 3 April.

Summary of findings:

The following large infrastructure and industrial facilities may pose a risk

- **Cement plants** can be associated with incineration of hazardous waste, in addition to using fuels like coal, oil, petroleum coke, and natural gas.
- **Food processing** (meat, shellfish, fish, dairy, breweries, sugar, etc) can be associated with using ammonia, freons (cooling) and sulphur dioxide, which are corrosive and toxic substances.
- **Tanneries** can be associated with toxic corrosives such as trivalent chromium sulphate, sodium slats, arsenic, cyanide, ammonium sulphate, sulphuric acid, lime and aniline.
- **Detergent (soap) industry** can be associated with solvents, alkalis and phosphates which are flammable and corrosive.
- **Textile industry** often uses benzene, naphthalene, acids, alkalis, chlorine, bromine, sodium nitrate, ammonia,sodium sulphate and metals. These substances can be flammable, toxic, corrosive and oxidizing.
- **Artisanal mining** is often characterized by poor technical standards and heavy rains/floods can lead to mine collapse. In addition, (small) quantities of fuels, explosives, metals and ammonium nitrate might be present.
- **Pulp and paper mills** are known to use acids, alkalis and chlorine.
- The stability of **hydropower dams** might also be affected increasing a risk of dam collapse.
- **Petro-chemical industry (refinery)** can have large quantities of inflammable and explosive fuels.

The Joint UNEP/OCHA Environment Unit :

The Joint UNEP/OCHA Environment Unit is the United Nations mechanism to mobilize and coordinate the international response to environmental emergencies caused by natural disaster, technological accidents and complex emergencies.

Infrastructure Risks	Sources of information
Nuclear Facilities	• http://www.iaea.org/programmes/a2/index.html • http://www-pub.iaea.org/MTCD/publications/PDF/cnpp2003/CNPP_Webpage/pages/countryprofiles.htm • http://www.iaea.org/worldatom/rrdb/ • http://www.grid.unep.ch/data/download/gnv181.gif • http://www.worldenergy.org/wec-geis/publications/reports/ser/nuclear/nuclear.asp
Large hydrodams.	• http://www.worldenergy.org/wec-geis/publications/reports/ser/hydro/hydro.asp •
Large Chemical/Industrial Industries	• http://www.pops.int/documents/implementation/nips/submissions/default.htm • http://www.chem.unep.ch/pops/pcdd_activities/inventories/default.htm
Gas/Oil: Refineries, Pipelines, explorations sites	• http://www.eia.doe.gov/emeu/cabs/index.html • http://www.worldenergy.org/wec-geis/publications/reports/ser/gas/gas.asp • http://www.lib.utexas.edu/maps/map_sites/oil_and_gas_sites.html
Mining activities	• http://www.worldenergy.org/wec-geis/publications/reports/ser/coal/coal.asp • http://www.worldenergy.org/wec-geis/publications/reports/ser/uranium/uranium.asp • http://minerals.usgs.gov/minerals/pubs/country/2005/mzmyb05.pdf • http://www.camec-plc.com/Investors_Media/RNS/2004/rns_025.php
Hazardous waste storage sites	• http://www.basel.int/natreporting/compilations.html

- Conseil pour la réduction des accidents industriels majeurs (CRAIM). Risk Management Guide for Major Industrial Accidents intended for municipalities and industry. 2002 Edition.
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