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Support Zone, Community Development Programme

PNL Ecological Corridor Feasibility Analysis

Report prepared for AMBERO/IP

by

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LIST OF ABBREVIATIONS

BNP – Banhine National Park

BZ – Buffer Zone

CBD – Convention on Biological Diversity

EIA – Environmental Impact Assessment

FDA – French Development Agency

GNP - Gonarezhou National Park

GLTFCA – Greater Limpopo Transfronteir Conservation Area

GLTP - Great Limpopo Transfrontier Park

HWC – Human Wildlife Conflict

KNP – Kruger National Park

LNP – Limpopo National Park

NTFP – Non-Timber Forest Products

SADC – Southern Africa Development Community

TFCA – Transfrontier Conservation Area

ZNP – Zinave National Park

EXECUTIVE SUMMARY

Ecological corridors are essential for maintaining connectivity at all levels of biological organization, including landscapes, ecosystems, habitats, populations and genes. However, in human-dominated landscapes, such as the buffer zone of the LNP, human land use can result in habitat destruction and fragmentation, hampering wildlife access to water and dry season habitats along the Limpopo River and blocking migration routes to the BNP and areas outside national parks that are important for wildlife populations during the annual cycle. This suggests that the management of the buffer zone should not only result in a decreasing gradient of natural resource use from the buffer to the core area of the park, but also ensure that within the buffer zone, there are sections where protection measures are implemented to function as ecological corridors. In addition, some locations within the buffer zone might be of high conservation value, hence should be protected from land uses that cause changes in ecosystem structure, composition and function.

Six potential areas have been identified by LNP for the implementation of ecological corridors, namely Munguambane, Matsilele, Sihogonhe, Tchowe, Chipeluene and Matafula corridor. The objectives of this study are as follows: (i) to determine and advise on the feasibility of each of potential corridors, and (ii) identify areas that require protection from buffer zone development due to its high conservation value.

The following ecological and socio-economic criteria were applied to compare the proposed corridors in terms of their feasibility: ecosystem integrity, corridor width, habitat heterogeneity, human settlements and livelihood activities, land use types outside LNP, current use of corridors by wildlife. To describe each proposed corridor on the basis of these criteria a combination of desktop study, ecological and socio-economic methods was applied. Desktop study consisted of reviewing relevant LNP reports, management and development plans. Ecological methods included: (i) analysis of existing aerial photographs, (ii) aerial inspection of each proposed corridor and (iii) field data collection, including description of vegetation structure and composition, signs of use of proposed corridors by wildlife, evidences of human-wildlife conflicts. Socio-economic methods consisted of interviews with local communities living within each of the proposed corridor and interviews with LNP staff.

Based on the analysis of ecological and socio-economic attributes, the following corridors are recommended for implementation:

Chipeluene corridor: this corridor has a high conservation value, is highly relevant and irreplaceable in facilitating access to water by wildlife as well as wildlife migration to the Banhine National Park and the interstitial zone between the two parks. Large blocks of intact and diverse habitat remain in the area, banks of the Limpopo River are not cultivated, the number of people that will be directly affected is low and there is limited risk of human wildlife conflicts or land use conflicts. Land in the eastern side of the Limpopo River is used mainly for game farming, which is a land use compatible with biodiversity conservation. Sustainable consumptive and non-consumptive wildlife utilization projects can promoted by LNP in the eastern side of the Limpopo River to generate income to sustain park management and the socio-development of local communities, while reducing human-wildlife conflicts.

Munguambane corridor: the northern location of this corridor makes it unique in providing the link between LNP and GNP in the context of the GLTFCA. This corridor is characterized by high habitat diversity in terms of vegetation structure and composition, including large patches of riverine forests of high conservation value and floodplain grasslands. This corridor has a high potential for promoting socio-economic development of local communities through eco-tourism, which will stimulate community participation in the protection of the corridor. The risk of HWC is low because most of people living within the corridor do not rely on cultivation for subsistence, but rather on income from family members working in South Africa. To increase the feasibility of this corridor, the expansion of settlements in Munguambane village and Ndlala village should be controlled. The large patches of reverine forests prevailing within this corridor as well as the riverine forest at the border between Mozambique, South Africa and Zimbabwe, i.e. “Crooks corner” should be given special attention for protection from anthropogenic degradation.

Tchowe corridor: large patches of natural vegetation remain, making the habitat prevailing in this area suitable for a wide range of wildlife species. Nevertheless, both banks of the Limpopo River are used for cultivation, including the Panhame irrigation scheme in the southern boundary, which needs installation of an electric fence. The

eastern bank of the river is densely populated. Therefore, this corridor is not feasible as a migration route to BNP because its implementation would result in severe HWC in the eastern bank of the Limpopo River. However, it is recommended to facilitate movements of wildlife to access drinking water and dry season forage along the Limpopo River.

Matafula, Sihogonhe and Matsilele corridors were considered not feasible for implementation due to potential land use conflicts, including human-wildlife conflicts, and the generally low conservation value due to wide distribution of human settlements and livelihood activities within the boundaries of these corridors. However, the riverine forest along the Lilau River is of high conservation value, hence should be protected.

For the implementation of corridors, the following is recommended:

- LNP should develop irrigation schemes in areas of high soil fertility outside but in the proximities of the recommended corridors. This will promote a gradual self-resettlement of people towards the proximity of irrigation schemes. The increased access to irrigation schemes will compensate local communities for the cultivated land lost to conservation. Irrigation schemes will reduce the rate of conversion of natural habitats into cultivated fields associated with low land productivity in rain-fed crop production systems, which will contribute to the persistence of viable corridors.
- Irrigation schemes should be equipped with necessary human-wildlife conflict mitigation measures, where necessary
- To ensure that corridors are functional even for species that do not tolerate degraded habitats, natural resource protection measures within corridors in the buffer zone should be the same as those applied in the core area of the park. However, palm milking and collection of wild fruits should be allowed due to the importance of these activities for the subsistence of local people
- The establishment of corridors will result in restricted use of land and other natural resources. Therefore, should sufficient land not be available for subsistence use as a result of the corridors, the LNP should consider compensating local communities for the land lost to establish corridors by expanding the width of the buffer zone. This will minimize conflicts between

park management and local communities, which have a key role in the implementation of functional corridors but are heavily dependent on multiple natural resource use

- Within recommended corridors, the expansion of agriculture and settlements should be discouraged and controlled, and subsistence activities of local communities supported by the park through the establishment of irrigation systems and human wildlife conflict mitigation strategies
- The park should establish field ranger's camps in the proximity of each of the recommended corridors to ensure effective patrolling and reduction of anthropogenic threats to biodiversity
- Environmental education campaigns should be promoted by the Community Information Centre, stressing the need of community involvement in the protection of corridors due to their ecological and potential socio-economic importance
- Dense riverine woodlands of tall trees should be protected due to their potential biodiversity value, role in protecting hydrological processes and as a contribution to the implementation of REDD (Reducing Emission from Deforestation and Forest Degradation) in Mozambique
- Although local communities are aware of the need and generally agree to collaborate in the protection of corridors, the communities that will be directly affected by the restrictions in the use of natural resources and increase in HWC should be consulted to discuss the ecological, social and economic implications of establishing corridors. Wide community participation will create positive attitudes and increase community involvement in the protection of corridors.
- The LNP should considerer moving the confluence between the barrier fence and the Limpopo River about 25 km northwards to leave Matafula, Hassane and Vundla villages in the buffer zone south of the fence, to relieve these villages from human-wildlife conflicts that will follow the completion of the erection of the barrier fence
- Considering the degree of uncertainty on the functionality of the proposed corridors as well as on the socio-economic impacts associated with their implementation, a continuous monitoring of animal movements, HWC, and attitudes of local communities in relation to corridors is necessary as a basis for

management interventions to revert negative situations in the framework of adaptive management

- In collaboration with local communities and the private sector, the LNP should consider identifying opportunities to establish game farms or hunting concessions in the Eastern side of the Limpopo River to generate income that will support park management and the socio-economic development of local communities, while reducing human-wildlife conflicts.

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CONTEXT AND BACKGROUND

Around the globe protected areas are a cornerstone for biodiversity conservation (Dudley 2008). The role of protected area is to separate elements of biodiversity from processes that threaten the persistence of a representative sample of the natural heritage of a region (Margules and Pressey 2000). However, natural landscapes, including within protected areas, are undergoing drastic change due to anthropogenic pressures that result in habitat loss and fragmentation. Fragmentation decreases the size of habitat blocks, increases the isolation among these blocks and increases edge effect (Bennett 1998). Landscape fragmentation also hampers critical ecological processes, including animal movements to access key resources outside the boundaries of protected areas during critical periods of the year, such as the dry season. The long term effect of increased landscape fragmentation is the decline of biodiversity, ecosystem resilience and ecosystem services. For example, several large mammal species within the Masai Mara Reserve and Amboseli National Park in Kenya have declined in abundance during the past 30 years due to rapid intensification of land use in the surrounding regions, which blocked animal movements across the landscape seasonally to obtain required resources (Hansen and DeFries 2007).

As areas of natural habitat are reduced in size and continuity by human activities, the frequent recommendation for protecting biodiversity is to increase connectivity and establish ecological corridors that connect natural habitats (Dudley 2008). Ecological corridors will play a vital role in the conservation of biodiversity through improving natural dispersion of species and improved resilience of ecosystems to human induced or natural changes in the landscape.

The Limpopo National Park (LNP), covering an area of 10 000 km^2, was proclaimed in November 2001 by the Decree number 38/2001, dated 27th November 2001. The objectives of the LNP are as follows:

- To maintain the wilderness character of the park, and to manage it within a framework of minimum intervention
- To ensure the integration of the LNP into the greater TFCA planning and development framework

- To ensure the participation of local communities in the development and management of the LNP
- To manage and develop the LNP in the interest of the people of Mozambique
- To promote responsible tourism as a mean of generating income for the LNP and as a mean of driving sustainable socio-economic development

In the context of having a spatially explicit delineation of the park into different areas where different management and development activities can take place towards achieving the objectives of the park, it has been zoned during the preparation of the LNP management and development plan in 2003. During the zonation process, a buffer or support zone covering an area of 2 349 km^2 (20.9% of the park) has been demarcated, where human settlements, traditional subsistence livelihoods including crop and livestock agriculture, and sustainable economic development including opportunities for community-based tourism, could continue to take place.

The buffer zone has not been fenced to create an opportunity for interaction between humans and wildlife, but also to prevent the blocking of access to riverine resources by wildlife and the movement of wildlife through the TFCA. Nevertheless, the management and development of the buffer zone should result in a gradient of decreasing intensity of land use and decreasing anthropogenic land degradation towards the boundary of the core area of the park.

The LNP is part of the Great Limpopo Transfrontier Park (GLTP), which in Mozambique also includes the Banhine National Park and the Zinave National Park as well as the interstitial zone between the parks; Kruger National Park (KNP) in South Africa and Gonarezhou National Park (GNP) in Zimbabwe. The objective of the GLTP is to manage the Limpopo ecosystem holistically to ensure connectivity of habitats, landscapes and ecological processes, towards the maintenance of biodiversity and associated cultural values. According to MITUR (2003), the movement of animals through the greater transfrontier park area should be facilitated though this needs to be accompanied by the necessary actions to ensure their welfare.

With the growth of human population and the resettlement of villages from the core area to the buffer zone, land use will likely expand and intensify in the buffer zone,

hindering access to riverine resources by wildlife and blocking migration routes. Additionally, areas with high conservation value might be degraded. Therefore, in the context of sustaining wildlife populations within the LNP as well as ensuring landscape linkages towards achieving the objectives of the transboundary objective of the LNP, human settlements and livelihoods activities in the buffer zone should not prevent animals from accessing the river or from crossing it towards the Banhine NP, Zinave NP and the interstitial zone between the three parks. This requires the identification of sections of the buffer zone where human livelihood activities will be more restricted than in other areas, to serve as conservation corridors that will maintain key ecological processes.

The need of identifying conservation corridors has been highlighted in the report of the participatory zoning of land and other resources (Nhalidede and Dimande 2004), in the Management Plan of the buffer zone (MITUR 2010) and in the Strategic Plan for Tourism Development (Governo de Moçambique, Ministério do Turismo, Direcção Nacional das Áreas de Conservação, 2010). The identification and implementation of corridors becomes an urgent priority for the park because the barrier fence under construction will restrict access to dry season range by large mammals, particularly elephants and buffalo, which will have the Limpopo River as the only potentially available alternative. Additionally, the name “Limpopo National Park” suggests that the Limpopo River should be accessible for both conservation and tourism development initiatives implemented by the park. The implementation of corridors will also open opportunities for sustainable consumptive and non-consumptive wildlife utilization outside national parks, which will benefit park management and the social and economic development of local communities.

Legal framework for the establishment of protected areas and ecological corridors

There is no specific legislation on ecological corridors. However, in general, establishment of protected areas, including ecological corridors, is supported by the following national, regional and international legislation:

Environmental Law

According to the Environmental Law (Law N^{o} 20/97 of 1th October 1997), to ensure the protection and preservation of biodiversity, and the maintenance and improvement of ecosystems with high ecological and socio-economic value, the Government can establish areas of environmental protection. Protected areas can be local, national, regional or international, depending on the objective of the establishment. Protected areas are subject to classification, conservation and enforcement measures in accordance with the needs of biodiversity protection, as well as the social, economic, cultural and scientific value of the area. According to this Law, conservation measures should indicate the activities that are allowed and those that are not allowed in a given area and its surroundings, and should state the role of local communities in the management of the area. Activities that threaten the persistence of biodiversity are not allowed.

Forest and Wildlife Law and its Regulation

According to the Forest and Wildlife Law (Law N^{o} 10/99 of 7th July 1999), the Cabinet has the competence of creating, modifying and extinguishing protected areas. The Cabinet also establishes the buffer zones around protected areas, where multiple resource use can be allowed, with restrictions stated in the management plan, which must be developed with the involvement of local communities. The Regulation of the Forest and Wildlife Law (Decree 12/2002 of 6th June 2002) states that around protected areas a buffer zone should be established to form a transition zone between the core area and the area of multiple resource use, with the objective of reducing the impacts of human activities in the protected area.

SADC Protocol on Wildlife Conservation and Law Enforcement

The primary objective of this Protocol is to establish within the Region and within the framework of the respective national laws of each State Party, common approaches to the conservation and sustainable use of wildlife resources and to assist with the effective

enforcement of laws governing those resources. Directly related to the establishment of corridors, the protocol promotes the conservation of shared wildlife resources through the establishment of transfrontier conservation areas; and calls for the need of facilitating community-based natural resources management practices for management of wildlife resources.

Convention on Biological Diversity

With regard to *in-situ* biodiversity conservation, of special relevance to the establishment of corridors and development of buffer zones, CBD states that each Party shall:

- Establish a system of protected areas or areas where special measures need to be taken to conserve biological diversity;
- Develop, where necessary, guidelines for the selection, establishment and management of protected areas or areas where special measures need to be taken to conserve biological diversity;
- Regulate or manage biological resources important for the conservation of biological diversity whether within or outside protected areas, with a view to ensuring their conservation and sustainable use;
- Promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings;
- Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas;
- Integrate consideration of the conservation and sustainable use of biological resources into national decision-making;
- Protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements.

OBJECTIVES OF THE MISSION

Preliminary work has identified 6 potential areas for the implementation of ecological corridors in the LNP (dashed areas in Figure 1), which is the basis for the formulation of this study. The primary objective of the mission is to determine and advise on the feasibility of each of potential corridors, including consideration for the following factors:

- Value and practicality of corridor for Wildlife Migration and access to Limpopo River water source
- Land conservation value within PNL
- Land Use to the East of the Limpopo River
- Current and Future Land Use by Communities within the corridor
- Effect on and acceptance by Communities within the corridor vicinity
- Feasibility of implementation and control

The secondary objective is to identify areas that require protection from buffer zone development due to its high conservation value. This should include consideration of the following factors:

- Biodiversity and Conservation value
- Current and future land use within the Buffer Zone
- Effect on and acceptance by communities in the vicinity of the area
- Feasibility of implementation and control

Figure 1. Proposed areas for the implementation of corridors marked as dashed areas in the buffer zone. Yellow dots indicate villages. Munguambane corridor: dashed area in Ndlala village; Matsilele/Salane corridor: dashed area just north of Salane village and dashed area in Matsilele village; Sihogonhe corridor: dashed area just south of Sihogonhe village; Tchowe corridor: dashed area ranging from Mapai to Panhame

village; Chipeluene corridor: dashed area just south of Hassane village and Matafula corridor: the dashed area in the Matafula village.

METHODOLOGY

Study area

The study area covers the buffer zone along the Limpopo River. The climate is warm, with a dry winter and a mean annual temperature exceeding 18^{o}C. Rainfall decreases from 500 mm per annum in the south to <450 mm at Pafuri in the north. The dominant geological feature of the LNP is the extensive sandy cover along the northwest/southeast spine of the park. However, clayey and fertile soils are predominant along the Limpopo River. From south to north of the buffer zone, the landscape is predominantly mopane shrubveld on calcrete. Other landscapes that occur in the buffer zone include *Salvadora angustifolia* floodplain (south of Mapai) and Limpopo Levubu floodplains (from Mapai to Pafuri) (Stalmans *et al*. 2004).

The first delimitation of the buffer zone included a band of 5 km along the Limpopo and Elefantes Rivers. The extent of the buffer zone was initially complained by the communities, arguing that this space would not be enough to satisfy their subsistence needs. To meet the interest of the rural communities, a participatory zoning of land and other resources was done during 2003 and 2004. A key recommendation of the study was to include the southeast part of the park to the buffer zone to accommodate communities that were planned to be relocated from the core to the buffer zone. As a result of increased community densities, to manage an expected increase in Human wildlife conflict a barrier fence would be constructed to form a triangle with the Elefantes and Limpopo rivers, downstream of the dam to Massingir until the community of Hassane in the district of Mabalane. The selected area for this study starts at the first community northwards from the confluence between the fence and the Limpopo River, called Hassane in the Mabalane District until Ndlala in the Chicualacuala District. This region covers almost 22 out of the 44 communities of the whole buffer zone.

Criteria for selecting priority ecological corridors

Given the difficulty of assessing the functionality of ecological corridors in rapid assessments, we used the structural connectivity of habitats and landscapes as a proxy to functional corridors assuming that connected habitats and landscapes will link populations and ecological processes. Based on these general guidelines we defined the following specific criteria for the comparative analysis and prioritization of corridors for implementation:

Ecosystem integrity. Ecosystems with greater integrity, such as large patches covered by intact vegetation, will be more resistant and resilient to change and disturbance that threaten biodiversity than fragmented habitats and landscapes. Accordingly, patches with less "ecological footprint" should be given priority in the implementation of conservation corridors.

Corridor width. Large areas are more likely to contain a high diversity of habitats, flora and fauna species and ecological processes. The effectiveness of corridors in enhancing movement between patches increases with increasing corridor width because wide areas have less edge-to-area ratio, provide high quality interior habitat, hence elements of biodiversity in these areas are less exposed to human pressure from the surrounding areas. In Tanzania, Newmark (1993) documented effective use of corridors of about 8 km in width by large mammals.

Habitat heterogeneity. Priority for implementation of corridors should be given to areas with high habitat diversity in terms of vegetation structure and composition, topography and hydrological attributes because habitat heterogeneity means distinct microhabitats, hence more diverse plant and animal communities and their ecological interactions.

Human settlements and livelihood activities. No re-settlement of people is foreseen for the implementation of corridors. Therefore, the priority for the implementation of corridors should be given to areas without or with less human settlements or livelihood activities. This will minimize competition in land use between biodiversity conservation and socio-economic development of local communities and will minimize human-wildlife conflicts (HWC). HWC have negative impacts on food security and poverty

reduction programmes, threaten human lives and create negative attitudes among local people in relation to wildlife conservation.

Land use types outside national parks. If land use change reduces habitats in the unprotected portion of the ecosystem, ecosystem function and biodiversity may be degraded within the protected area (Hansen and DeFries 2007). Additionally, the establishment of protected corridors should neither result in land use conflicts with other stakeholders, human-wildlife conflicts nor transmission of diseases between wildlife and livestock. Accordingly, priority corridors for implementation will be those that promote the link between the core area with land uses outside the park that are compatible with biodiversity conservation.

Current use of corridors by wildlife. The use of areas by wildlife is an indication of its ecological functionality, which should be maintained through appropriate management actions. Accordingly, current routes of large mammals to access water from the Limpopo River should be given priority in the implementation of corridors over areas with no records of use by large mammals.

Methods of data collection

To identify priority areas for protection as conservation corridors, a combination of desktop study, ecological and socio-economic methods was used to obtain relevant data. Data collection spanned 10 days, from 8th to 18th of May.

a) Desktop study

The collection of secondary data consisted on reviewing existing relevant documents, including the management and development plan of the LNP, LNP wildlife census reports, report of the participatory zoning of land and other resources, buffer zone management plan, reports and maps produced during the preliminary assignment conducted by LNP to identify potential conservation corridors and reports on human-wildlife conflicts. Information on the current and or future uses of land in the eastern side of the Limpopo River was obtained by analyzing the land certification maps at the Provincial Directorate of Agriculture. This information included the location, size and

land use of each plot where land use right (DUAT) has been given to individuals, communities or companies.

b) Ecological methods

Analysis of aerial photographs and aerial inspection of the proposed corridors. To obtain a broad characterization of the landscape in terms of (i) connectivity in vegetation cover in the landscape; (ii) spatial heterogeneity in vegetation structure; (iii) occurrence of water sources for wildlife (pans and streams), (iv) land use types (presence and spatial coverage of cultivated fields and human settlements in both sites of the Limpopo River, livestock grazing); we combined the analysis of aerial photographs and flights over the study area using the LNP Bantam microlight aircraft. Sightings of wildlife were also registered. The GPS coordinates of all relevant features were recorded.

Field data collection. Data collection on the ground was conducted to confirm the broad landscape features obtained from the aerial survey and to get detailed site-specific data. Data collection covered the 6 proposed conservation corridors, from Hassane village at the southern end of the study area to Ndlala village in extreme north. Within each corridor the following data were recorded:

- Land use type (villages, cultivated fields and evidences of livestock grazing)
- Habitat diversity. The diversity of habitats in terms of vegetation structure was recorded by driving through the buffer zone and identifying changes in the density and height of woody vegetation. To describe vegetation composition, transects 1 – 1,5 km long were walked from the road eastwards to the riverine vegetation and westwards to the upland vegetation. Along each transect, the predominant woody and grass species were recorded as well as evidences of vegetation use by livestock and by humans. Transects were walked for the assessment of composition when a visual change in vegetation structure was noted when driving through the main road.
- Use of corridors by wildlife. Along each transect, sightings of wildlife and of signs of wildlife occurrence such as dung and spoor were recorded. Cultivated fields were visited to detect evidences of crop damage by wildlife. Additional information on the use of the corridors by wildlife and of human-wildlife

conflicts was obtained through interviews with people living in the nearest village.

- Topographic and hydrological features. The spatial variation in topography was described. The presence of seasonal rivers or drainage lines was also registered within each proposed corridor.

c) Socio-economic methods

Open interviews and semi structured interviews were the main methods applied to collect data from LNP staff members and community members, respectively. Interviewed staff members included project manager, wildlife manager, community support operation manager, re-settlement officer, technical advisor, extension officers and field rangers. With the interview to LNP staff, information about conservation guidelines, planned corridors, technical advice to rural communities and current projects in the buffer zone was collected.

Semi-structured interviews were applied to reach members of local communities in random sample regardless of gender, age and occupation. However, in order to respect local hierarchies and because the actors were not previously informed, almost 70% of interviews were carried out with local authorities, such as community leaders, village secretaries, park committee members and leaders of irrigation associations, accompanied by a small group of ordinary community members, both men and women. In order to get representative sample of the socio-economic features, perceptions and opinions on the corridor issue, at least 2 communities were visited within each corridor. The average running time for the interviews was about one hour. A total of 15 interviews were conducted (Table 1).

Table 1. Information on human population of the villages located within proposed corridors (see in Figure 1 the location of villages in relation to the location of corridors)

Corridor Name	Villages within the corridor	N° of families	N° of persons	GPS coordinates	Main respondents and (number of participants)	Association of producers
Matafula	Hassane de Mabalane	201	319	23°26′ 23.1” 32°22′ 37.6”	Member of Park committee (4)	Yes
	Matafula	96	284	23°22′ 09.3” 32°19′ 10.1”	Member of Park committee (5)	
	Mvudla	77	121	23°22′ 00.9” 32°18′ 58.2”	Community leader (4)	
Chipeluene	Muchacha	78	187	23°13′ 10.7” 32°13′ 56.8”	3 community members with previous permission of the leader	
	Chipeluene	47	148	23°08′ 05.9” 32°14′ 07.9”	Community leader	
Tchowe	Panhame	73	270	23°01′ 28.1” 32°03′ 50.6”	Leader of irrigation association (9)	Yes
	Tchowe			22°53′	Community	

				58.8” 32°00′ 28.5”	leader (7)	
Sihogonhe	Lisenga	101	560	22°43′ 16.8” 31°54′ 54.6”	Community leader (3)	Yes
	Sihogonhe	81	144	22°44′ 51.1” 31°52′ 26.3”	Community leader (2)	Planed
Matsilele/Salane	Matsilele	134	337	22°42′ 52.5” 31°49′ 44.4”	Community leader (7)	
	Mbeti	126	349	22°39′ 37.7” 31°47′ 41.7”	Leader of irrigation association (6)	Yes
	Salane A	115	536	22°36′ 53.8” 31°42′ 10.0”	Community leader (4)	
	Salene B				4 community members, with previous permission of the leader	
Muguambane	Chitsuitsuine	96	322	22°32′ 04.3” 31°35′ 24.2”	Community leader (1)	
	Munguamban	63	582	22°29′	Community	

	e			08.4” 31°33′ 03.5”	leader (8)	
	Ndlala	20	220	22°28′ 18.7” 31°28′ 09.3”	Community leader (5)	

The first part of questionnaire dealt with general information about the interviewer, such as name, age, occupation and family size. The second part dealt with question about economic activities, including issues on agriculture, livestock, collection of Non-Timber Forest Products (NTFP), tourism and labor, importance of forests and other natural resources for livelihoods. In the third part, interviewers were asked to give comments about the relationship and cooperation with the park, awareness about establishment of corridors in the buffer zone, areas used by wildlife as corridors, wildlife species most frequently seen, seasonality of corridor use by wildlife, costs and benefits of wildlife presence or passing for local communities. Interviews were conducted in the Portuguese language with translation to Changana or directly in Changana. Direct observation of daily activities of respondents complemented the information collected through interviews.

Corridor feasibility analysis

Based on the ecological and socio-economic criteria described above, each potential corridor was judged on its own merits in contributing to the desired conservation goals of: (i) facilitating wildlife movements from the core area of the park to get access to water and green forage in the Limpopo River; (ii) facilitating wildlife migration to the Banhine NP, Zinave NP, Gonarezhou NP or to the interstitial zone between parks; and (iii) creating opportunities for sustainable wildlife utilization, while reducing human-wildlife and land use conflicts. The feasibility of implementation was analyzed in terms of costs, opportunity costs, weaknesses, strengths, threats and opportunities of each corridor with regard to the achievement of the objectives of establishing corridors in the LNP buffer zone. However, the actual feasibility will depend upon the capacity of LNP

in financial and human resources, and political support to implement the recommendation of this study.

Study limitations

- The short duration of the field data collection prevented in depth analysis of use of proposed corridors by wildlife, human-wildlife conflicts, identification of biodiversity rich areas and in depth analysis of social issues that might affect the feasibility of implementation of corridors
- The lack of previous notice to the villages about this mission made it difficult to get a wide community participation in meetings for the interviews. The consequence is that most of the socio-economic information was collected from community leaders and not from a representative sample of ordinary community members that will be affected by the land use restrictions in the corridors
- Collection of ecological and socio-economic data on the ground was conducted only within the buffer zone, i.e. West of the Limpopo River, which makes impossible to draw conclusions about the concerns and expectations of local people living in the East of the Limpopo River
- The information on the rights of land use (DUAT) is incomplete with regard to current and future land use in the East of the Limpopo River because small plots used for subsistence agriculture and settlements do not appear in the 1:250000 map used by the Provincial Directorate of Agriculture. Additionally, land used under customary rights does not need to be necessarily registered at this institution.
- Some information might have been lost during the translation of the interview. Additionally, a translator was a PNL staff member, with potential of not being neutral in relation to the answers given by community members.

RESULTS

General characteristics of the buffer zone

In the whole area of 6 corridors there are around 22 communities, out of which 15 communities were visited and interviewed. The estimated human population size in all 6 corridors is around 1500 people, from about 600 families.

Rain-fed agriculture is the main livelihood activity. Cultivated areas are concentrated in the clayey fertile soils on river banks. The main crops are maize, beans, fruits and a variety of vegetables including tomatoes, lettuce, garlic and onions. Crop yields are low and are mainly for family consumption. Access to market is very limited, even in years of good harvests. The park gives technical assistance to producers organized in associations.

Extensive livestock production is widespread in the buffer zone, with cattle, goat and poultry being the most reared species. Few community members reported having pigs and sheep. While the production of cattle is oriented for the local market and wealth retention, the rest of the animals are important in the household's diet. The investment in livestock production is limited to the construction of cattle or goat pens near the houses. Veterinary assistance is from the Provincial Directorate of Agriculture, but is not frequent.

Non-Timber Forest Products are very important for local communities, particularly during years of drought and hunger. The most eaten fruits include: *Diospyros mespiliformis* (ntoma), *Berchemia discolor* (nhiri), *Manilkara macaulayae* (nwambo), *Drypetes mossambicensis* (xakwari), *Ficus sycomorus* (nkwua), *Sclerrocarya birrea* (Canhu), *Adansonia digitata (*ximhua), *Boscia albitrunca (*chicutso*), Strychnos madagascariensis* (nkwakwa), *Euclea divinorum (*nhlangula), *Xanthocercis zambeziaca* (nhlaru). The extraction of wine from wild palms (*Phoenix reclinata* and *Hyphaene petersiana*) is an important livelihood activity, generating income for many families, particularly in the northern half of the buffer zone (eg. Munguambane corridor and Matsilele corridor). Although the milking of the palm requires the cutting of the whole above ground part of the plant, the observed rapid natural regeneration observed during

field work suggests that current palm milking practices will ensure the long term availability of this resource. To prevent competition and conflicts among community members in palm milking, community leaders divide the land in plots for each community member.

Tourism is currently not an important economic activity, mainly due to poor infrastructure and lack of attractive services for tourists. However, the northern half of the buffer zone has a high potential for tourism development, being currently used as a route used by travelling tourists from South Africa to the beaches of the Mozambican coast. To promote tourism development in the area, the following tourism infrastructure will be developed in the area: (i) community lodge and camping site in Pafuri (near of corridor 1), under the financial support from the Government of Italy, (ii) camping sites in Salane and Chicumbane (Matsilele corridor), using the 20% of park revenue allocated to local communities.

Almost all interviewers mentioned a good interaction with staff members of PNL. Local communities obey with the rules of the park in terms of restricted use of natural resources. Local communities are happy with the park because it helps preserve the natural heritage for younger and future generations that would otherwise be lost due to unsustainable use of natural resources. In addition, the park supports the socio-economic development of local communities with 20% of its revenues from tourism as well as through park's partners such as French Development Agency (AFD). Park revenues have also contributed to the purchase of building materials for schools in almost all the villages located in the buffer zone. Through AFD support, irrigation schemes were established in selected villages. However, to cope with drought related hunger, communities request more irrigation schemes. Communities that benefit from irrigation schemes show interests in expanding the cultivated area and in diversifying crops, to produce surplus food for sale. Community members consider irrigation schemes as the most important contribution of the park to community development.

Despite the overall success in the implementation of irrigation schemes, some handicaps and problems were listed by respondents:

- Lack of experience in working in associations

- Personal inhibitions when members have to invest in advance. For example purchase parts to enlarge the system
- Restrictions on irrigation system performance, such as the number of hectares that the pump can irrigate and length of the available pipes
- Great technical requirements at the time that the system is damaged or not working (filters, electrical system, etc.)
- Lack of knowledge on crops with higher performance and better market prices. Currently farmers concentrate activities in few crops, using traditional techniques
- Lack of experience and technical skills in the management of public funds by the leaders of the irrigation schemes.

Local communities are aware and agree with the idea of reducing the use of natural resources in areas that will function as conservation corridors, allow wildlife access to water and forage during the dry season. Local leaders have played a key role in building community awareness and sensitization among community members with regard to the conservation of corridors, following the land zoning processes conducted by park staff in 2003-2004 with wide community participation. However, local communities raised concerns about the escalating frequency of human-wildlife conflicts.

In terms of wild large mammal species passing through the corridors, in most of the corridors community members frequently see elephants moving to the river and causing crop damage, particularly during the dry season. Buffalo are regularly seen in the far north (Munguambane corridor). During the rainy season crocodiles and hippopotamus are widely distributed throughout the Limpopo River. However, during the dry season, the distribution and conflicts caused by these species are restricted to areas where pools along the Limpopo River remain. Human-crocodile conflicts consist on the killing and eating of goats and cattle and injury of people by crocodiles, whereas hippopotamus damage crops in the river banks. Vervet monkeys, common duiker and warthogs are reported as the other species causing some crop damage, although conflicts with these species are relatively easy to control or mitigate.

Description of each proposed corridor

The document "corridor alignment" elaborated in January 2011 recommended 6 corridors to be analyzed deeply based on ecological and socio-economic criteria. In this section a description of the main ecological and socio-economic attributes of each corridor, based on updated information collected during the field trip in May 2012, is presented.

Munguambane Corridor

Name:	Munguambane Corridor
Location:	S22°29´08.4" / E031°33´03.5" S22°28´18.7" / E031°28´09.3" (Figure 2)
Width:	5km Neck / 10km River
Main settlements	Chitsuitsuine, Munguambane, Ndlala
N^{o} of families and population	Estimated based on interviews and PNL data: 180 families and around 1100 persons, of which 220 persons live in Munguambane on the centre of the corridor and the remaining on the edges
Main ecological Attributes:	• This corridor is characterized by high habitat diversity in terms of vegetation structure and composition, potentially providing resources and habitat conditions suitable for a wide diversity of fauna species. The upland area is covered by intact woodland of medium-sized trees. Predominant woody species include *Acacia* spp, *Euphorbia* spp, *Terminalia prunioides*, *Xanthocercis zambesiaca*, *Colophospermum mopane*, *Adansonia digitata*, *Drypetes mossambicensis*, *Lannea stuhlmannii*, *Manilkara macaulayae* and *Salvadora australis*. Good quality browse dominated by shrubs and small trees of *Grewia* spp., *Dichrostachys cinerea* and *Acacia* spp. Poor grass cover. • The proximities of the river are covered by a large patch of riverine forest, consisting of tall *A. xanthophloea, C. imberbe, Philenoptera violacea*, *Diospyros mespiliformis* and *Ficus*

sycomorus in good conservation status but under an emerging threat from cultivation. Abundant and widely distributed palm (*Phoenix reclinata*) used for the production of a local beer. The riverine forest is rich in bird species. This forest should be given priority for protection (S22°33´40.3" / E031°39´05.3" and (S22°28´54.7" / E031°33´25.1")

- The topography is highly diverse, with hills, plateaux and floodplain grasslands. This results in spatial heterogeneity in vegetation structure and composition, hence in diverse habitat conditions for fauna and flora species
- There are records of recent use of the corridor by elephants and buffalo in the proximity of Ndlala village, where there is less people living. These species are also seen passing through the proximities of Pafuri village to drink from the Limpopo River. Other wild animals causing crop damage include warthog, vervet monkey, baboons and porcupine.

Main Socioeconomic attributes

- Agriculture is rain-fed and minimal because many people obtain a reliable income from working in South Africa or through exchanges of products with South Africa. However, *A. xanthophloea* forest, with high conservation value is being invaded by small scale agriculture due to its high soil fertility and the availability of water for manual irrigation.
- Livestock production is widespread and practiced by most of the people, with cattle and goats as the main reared species
- The milking of palms is the main anthropogenic disturbance to natural vegetation, but it is a very important livelihood activity. There are reports of people purchasing livestock from money obtained through selling of palm beer
- Settlements are not concentrated in large villages, but rather distributed widely along the road. This reduces the width of

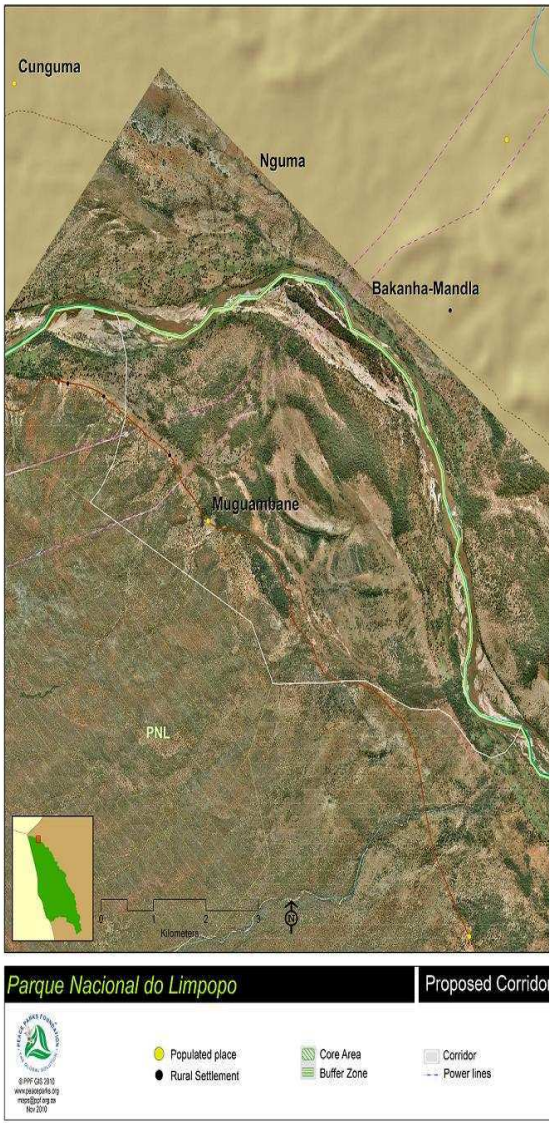
	patches of natural habitats undisturbed by human presence and use of natural resources. There are also human settlements in the Eastern side of the river. • Land use rights (DUAT) in the Eastern side of the Limpopo River have been given for the implementation of game farms, ecotourism activities and cattle farms
Relevance	Pafuri is the driest area of the country. Therefore, establishing a corridor in this area will contribute to the conservation of species of flora and fauna that are less prevalent or are not represented in wetter areas of the PNL, such *Euphorbia* spp. In addition, a sample of the reverine forest described above and the riverine forest at Crooks corner need to be protected This corridor is relevant to link PNL with the Gonarezhou NP, Zinave NP and the interstitial zone between the parks Pafuri has a high potential for eco-tourism associated with the diverse topography and ecosystems, occurrence of wildlife, history, cultural attributes and proximities to the Pafuri gate of the KNP. There is a plan of building a lodge and a camping site, funded by the Government of Italy and implemented by IUCN and CESVI. The implementation of this corridor will increase the tourism potential of the area and income to be generated will make evident the socio-economic relevance of implementing this corridor.
Feasibility:	Although this corridor has many people living within its limits, most of them do not depend on agriculture or harvesting of natural resources, but rather on income from family members working in South Africa. Hence, implementation costs associated with HWC and restrictions in the use of natural resources will not be of concern Community lodges and camping sites will generate income and increase the importance of wildlife conservation for local communities. This will increase the feasibility of the corridor Apart from customary use, land use rights in the Eastern bank of the

Limpopo river have been given for the establishment of game farms and ecotourism enterprises, which are land uses compatible with the biodiversity conservation objective of the TFCA, specifically of the adjoining Gonarezhou National Park in Zimbabwe. This increases the feasibility of this corridor

The feasibility of this corridor is threatened by the scattered distribution of settlements. To increase corridor feasibility, new settlements should not be allowed in Munguambane village, where a riverine woodland with high conservation value is threatened by cultivation and in Ndlala, where large mammals are regularly seen moving towards the river

People invading the riverine woodland for cultivation should be discouraged to continue and compensated through an irrigation scheme away from these areas of high conservation value

Success in the implementation of this corridor will be constrained by the shortage of park staff to strengthen natural resource use restrictions and to provide technical assistance to local communities in the implementation of livelihood activities that are compatible with biodiversity conservation



Aerial photographs of the proposed Munguambane corridor, showing the location of Munguambane village

Palm milking East of Munguambane village.

Riverine woodland dominated by *A. xanthophloea*, undisturbed by humans. Geographical coordinates: S22°29´08.4" / E031°33´03.5"

Subsistence agriculture invading reverine woodlands of high conservation value East and South-East of Munguambane village. Geographical coordinates: S22°28´54.7" / E031°33´25.1" and S22°33´40.3" / E031°39´05.3". These forests should be protected from expansion of cultivation

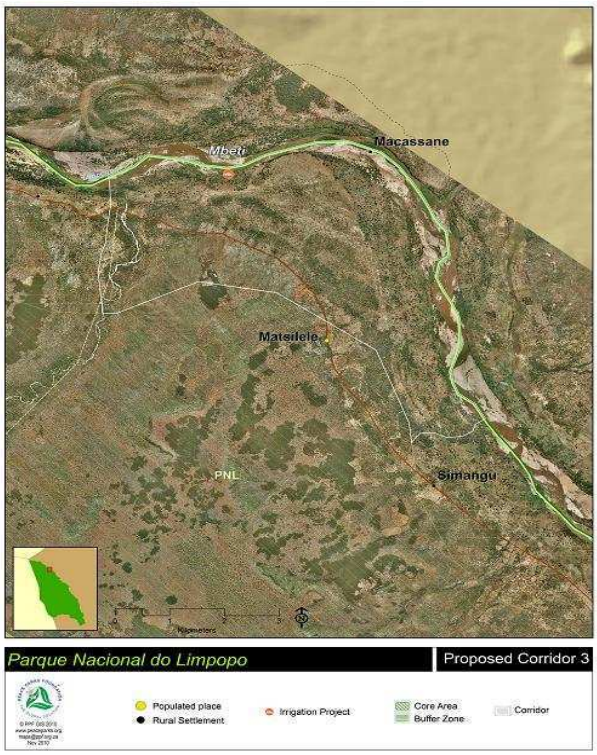
Figure 2. Location and ecological and socio-economic features of the proposed Munguambane corridor

Matsilele Corridor

Name:	Salane/Matsilele Corridor
Location:	S22°36´53.8" / E031°42´10.0" S22°38´40.1" / E031°45´48.0" (Figure 3)
Width:	>7 km
Main settlements	Matsilele, Mbeti, Salane and in the future Makandazulo
N^{o} of families and population	Estimated based on interviews and LNP data: 375 families, around 1220 persons. Additional 340 persons from 54 families will be brought with the resettlement of Makandazulo. About 260 families (about 670 persons) living at Matsilele and Mbeti villages will be directly affected by the implementation of this corridor
Main ecological Attributes:	• Large areas of pristine vegetation characterized by short trees and shrubs of *Acacia* spp. and *Grewia* spp., providing abundant food for browsers. Other common shrubs include *Salvadora australis* and *Gymnosporia* spp. Large trees on the uplands consist mainly of *C. mopane*, scattered baobab trees (*Adansonia digitata*), *Sclerocarya birrea*, *Drypetes mossambicensis* and *Commiphora granulosa*. In the riverine vegetation, *Acacia xanthopholea*, *Philenoptera violacea*, *Kigelia africana*, *Diospyros mespiliformis* and *Xanthocercis zambesiaca* are the predominant woody species. • This corridor includes the Lilau River (S22°38´40.1" / E031°45´48.0") with dense and intact riverine woodland on the edges dominated by tall trees of *Acacia* sp., *Acacia nigrescens*, *Philenoptera violacea*, *Xanthocercis zambesiaca*, *Ficus sycomorus*, *C. mopane*, *Diospyros mespiliformis*, *Combretum imberbe*, *Kigelia africana*, *Afzelia quazensis* and *Garcinia livingstonei*. Abundant and palatable browse species, mainly *Grewia* spp., *Acacia* spp. and *Ziziphus mucronata*. Abundant *Panicum maximum* beneath tall trees of the riverine woodland. • There are no records of use of the corridor by large mammals. Common duiker and vervet monkey are species that cause some

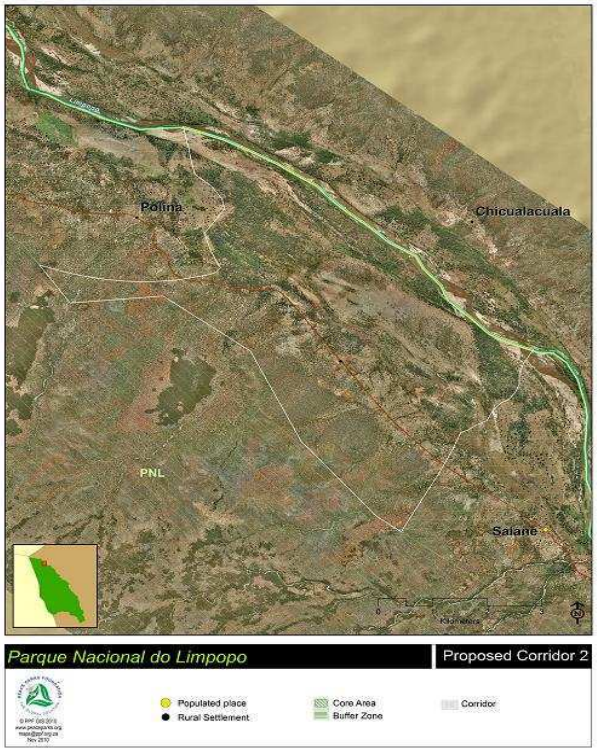
	crop damage in the area. There are conflicts with crocodiles due to the killing of goats and injuring of people gathering water from the river
Main Socioeconomic attributes	• This is the most populated corridor. However, the main problem is that settlements in both sides of the river are not organized in large villages, but rather distributed patchily along the proposed corridor, which results in habitat fragmentation and narrow patches of intact vegetation. Some settlements are located within the area indicated by villagers as a historical wildlife migration route, including the proximities of the Lilau River. This might explain the lack of use of this potentially important corridor despite the intense wildlife activity in the central zone of the park. The area identified for the resettlement of Makandazulo A and B villages lies at the northern end of this corridor, which will require community use of a significant portion of the corridor and natural resources. The Eastern bank of the River is under less pressure from human land use than the buffer zone • The high potential for agriculture of this area results in conversion of riverine woodlands into cultivated fields in both sides of the river, including by a community irrigation scheme under implementation at Mbeti on the northern edge of the corridor, supported by the LNP community programme. There is also a private irrigated system near Matsilele village • The grass layer is under heavy pressure from livestock grazing • Palm milking is widespread and an important source of income for local families • There are still no concessions for use of large plots of land in the Eastern side of the river, only customary use of land is envisaged for the near future • There is a community initiative of establishing a camping side near Salane village, using the share of 20% of park revenues
Relevance	The corridor is not relevant to link LNP with GNP and ZNP. However, the riverine woodland along the Lilau river has an extremely high

	conservation value in terms of providing habitat for resident species and potentially functioning as a natural migration route for wildlife to access water and dry season forage along the Limpopo River.
Feasibility	• The scattered distribution of settlements reduces the availability of continuous undisturbed vegetation patches for biodiversity conservation. This, combined with the planned resettlement of Makandazulo A and B, makes this area not feasible with regard to the achievement of the objectives of the park in establishing corridors • The implementation of two irrigation schemes (private scheme and association of Mbeti) makes this area not feasible for the implementation of corridor due to potential socio-economic costs associated with human-wildlife conflicts. However, moving the irrigation scheme southwards would help conserve the riverine woodland threatened by the expanding cultivated fields of the association • Pristine and biodiversity rich area such as the riverine woodland of Lilau River needs implementation of actions for protectionThe planned establishment of a community operated camping site will increase the importance of conserving the biodiversity of this area. However, the selected site does not have high aesthetic value to be attractive for tourists due to proximity to the village and cultivated fields. Therefore, the camping site should be shifted southwards, to the proximities of Lilau River, which is an area less disturbed by human activities, proposed for the establishment of a corridor.



Irrigated agricultural fields of the Mbeti association to the North-East of Matsilele village. A forest of high conservation value is being destroyed by the expansion of cultivation. GPS coordinates: Geographical coordinates: S22°38´46.5” / E031°46´06.8”

Private irrigation system to the East of Matsilele village. Geographical coordinates: S22°42´52.5” / E031°49´44.4”



Aerial photograph of the proposed Matsilele/Salane corridor showing the location of Matsilele and Salane villages

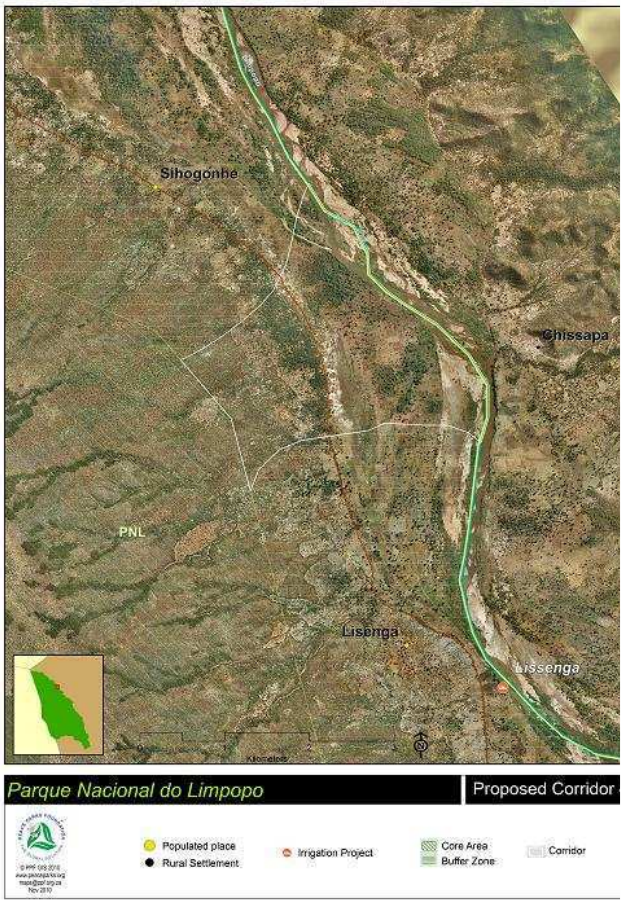
Dense riverine woodland of high conservation value along the Lilau river. Geographical coordinates: S22°38´40.1” / E031°45´48.0”. This forest should be protected

Figure 3. Location and ecological and socio-economic features of the proposed Matsilele corridor

Sihogonhe Corridor

Name:	Sihogonhe Corridor
Location:	S22°44´51.1" / E031°52´26.3" (Figure 4)
Width:	<3 km
Main settlements	Lissenga, Sihogonhe
N^{o} of families and population	Estimated based on interviews and LNP data: about 180 families and 700 persons
Main ecological Attributes:	• The woody vegetation consists mainly of *X. zambesiaca*, *C. imberbe*, *Gimnosporia* spp., *C. mopane*, *L. stuhlmannii*, *A. digitata*, *Berchemia discolour*, *T. prunioides* and *Boscia albitrunca* in the uplands, whereas in the proximities of the Limpopo river, *A. xanthopholea* and *P. reclinata* are the commonest woody species. Browse is abundantly available in the form of *Acacia* spp. and *Grewia* spp. of different heights. Scarce grass cover and soil erosion, associated with overgrazing by livestock • There are no records of recent use of the area by elephants or buffalo. Regularly seen terrestrial large mammals include kudu, nyala and common duiker
Main Socioeconomic attributes	• Settlements are spread out throughout most of the potential corridor, reducing the width of blocks of undisturbed vegetation. There are no settlements in the Eastern side of the river. • Both river banks are used for cultivation • There are records of HWC associated with crop damage by hippopotamus and goat killing by crocodiles during the rainy season when water levels rise in the river • There are no concessions for use of large plots of land in the Eastern side of the river
Relevance	This corridor has a low conservation value because scattered settlements, cultivation and grazing reduce the availability of natural habitats This corridor is not relevant and can be easily replaced by nearby

	corridors with higher potential to contribute to park's objectives in implementing corridors
Feasibility:	The area of this corridor is under heavy pressure human land use, including settlements, cultivation and livestock grazing. The costs of reducing threats, mitigating land use conflicts or compensating local communities for the land lost to conservation would be high or the poor remaining biodiversity. Therefore, this corridor is not feasible



Aerial photograph of the proposed Sihogonhe corridor , showing the location of Sihogonhe and Lisenga villages

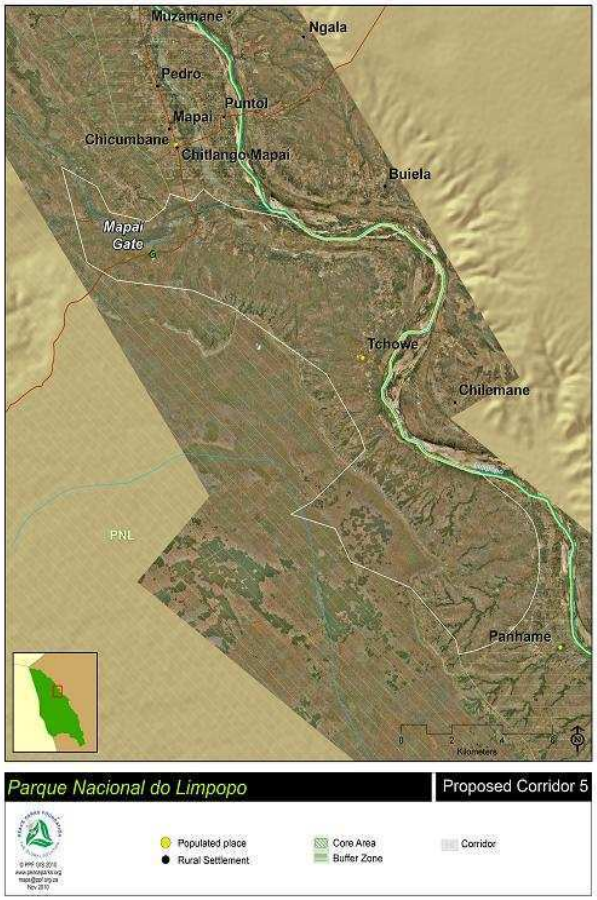
Between the Lisenga and Sihogonhe villages there are many scattered human settlements, which limits the availability of areas with high biodiversity conservation value within this corridor

Figure 4. Location and ecological and socio-economic features of the proposed Sihogonhe corridor

Tchowe Corridor

Name:	Tchowe Corridor
Location:	S22°58´12.5" / E032°02´30.3" (Figure 5)
Width:	>10km
Main settlements	Panhame, Tchowe
N° of families and population	Estimated based on interviews and LNP data: 73 families and around 270 persons, but close to the densely populated village of Chicumbane with 118 families and 702 persons
Main ecological Attributes:	• Large and intact mixed *C. mopane*, *Acacia* spp., *T. prunioides* woodland and discrete patches of *Androstachys johnsonii* in the upland regions of the landscape. Some signs of illegal charcoal production. The riverine woodland along the Limpopo River and seasonal drainage lines, the vegetation is dominated by tall trees of *A. xanthophloea*, *A. nigrescens*, *Acacia* sp., *Albizia* sp., *C. imberbe*, *Philenoptera violacea* and *X. zambesiaca*. Abundant palatable browse species such as *Grewia* spp. and *D. cinerea*, but low grass cover as a result of heavy grazing pressure from cattle. Common grass species including *Panicum* sp., *Enteropogon macrostachyus*, *Chloris virgata*, *Bothriochloa* sp. and *Aristida congesta* • Sightings of vervet monkey, common duiker, steenbok and fresh elephant dung
Main Socioeconomic attributes	• The few settlements in the West of the river are organized in villages, leaving large areas of land unoccupied by humans. However, in the Eastern side of the river, the landscapes is human-dominated, partly due to the influence of the Mapai Estação village • Both banks of the river are used for cultivation, including the irrigated fields of the association crop growers of Panhame, supported by the Park. Cultivated areas are concentrated in areas with fertile alluvial soils • There are reports of recent of crop damage by elephants

	• The predominant land use in the East of the river is game ranching
Relevance	This corridor is important in facilitating access to water and dry season habitat for wildlife coming from the centre of the LNP
Feasibility:	The naturalness of large vegetation patches in the western side of the river makes this corridor feasible to link the core area of the park with key resource areas along the river. However, the linkage with Banhine National Park will be potentially blocked by the settlements and extensive cultivated fields in the Eastern side of the river The concentration of cultivated fields in the irrigation scheme will facilitate the implementation of land use restrictions within the corridor. Implementation costs are mainly associated with a likely increase in crop damage by wildlife and in the need of restricting the use of natural resources by nearby communities. The Panhame irrigation scheme needs to be electrically fenced to prevent crop damage by elephants



Aerial photographs of the proposed Tchowe corridor, showing the location of Tchowe and Panhame villages at the northern and southern edges of the corridor

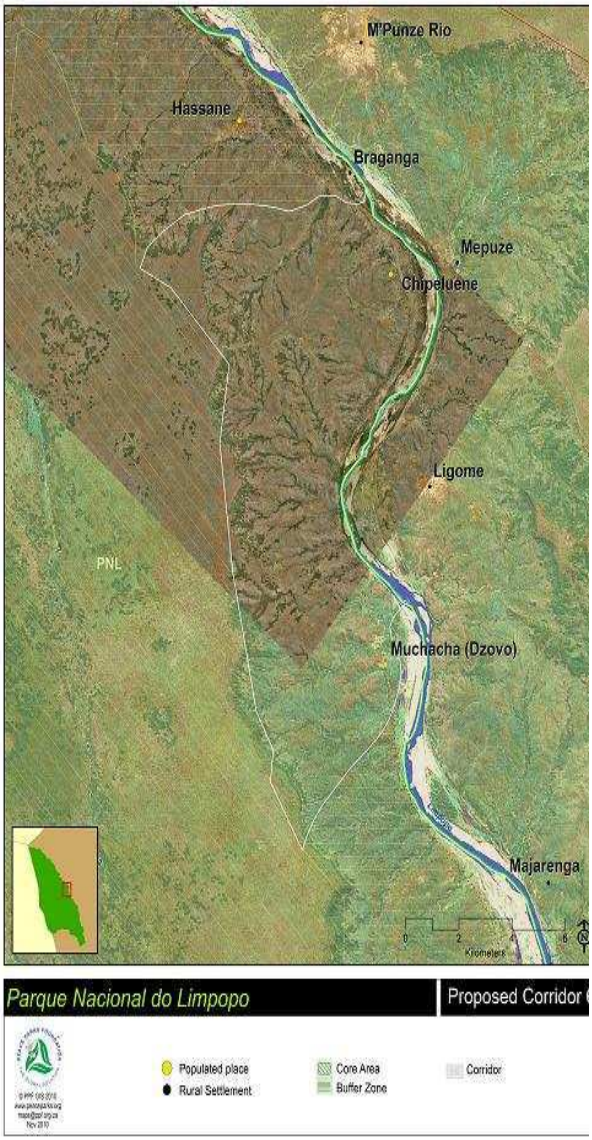
Between Panhame and Tchowe villages there is a drainage line currently used by elephants in their movements to the Limpopo river. Geographical coordinates: S22°58´12.5" / E032°02´30.3").

Figure 5. Location and ecological and socio-economic features of the proposed Tchowe corridor

Chipeluene Corridor

Name:	Chipeluene Corridor
Location:	S23°18´08.6" / E032°16´03.0" S23°12´08.6" / E032°13´21.6" (Figure 6)
Width:	>10 km
Main settlements	Muchacha and Chipeluene
N^{o} of families and population	Estimated based on interviews and LNP data: 120 families, about 350 persons.
Main ecological Attributes:	• There are large blocks of highly diverse and intact vegetation, dominated by palatable woody species such as *Acacia* spp., *Grewia* spp. and *Combretum* spp. of different heights. Extensive and intact *C. mopane* woodland. Drainage lines undisturbed by human uses, with tall trees of *Acacia nigrescens*, *P. violacea*, *D. mespiliformis*, *F. sycomorus* as the dominant species. Highly palatable grass species, such as *P. maximum* and *Urochloa mossambicensis* on the banks of the Limpopo River and edges of the drainage line. Seasonally flooded areas retaining green forage during the dry season, with *A. xanthophloea* as the dominant woody species, whereas *Ischaemum* sp. and *Setaria* sp. area the dominant species in the grass layer. • There is topographic variation within the corridor, with hills covered by short grass, sparse and short trees, whereas the bottomlands are covered by tall grass and tall trees. • Sightings of fresh elephant dung and spoor, common duiker and steenbok. Results of the transboundary elephant research programme undertaken by SAVE THE ELEPHANTS also show some elephant movements within this corridor.
Main Socioeconomic attributes	• There is a small village (Muchacha) in the buffer zone, but there are no settlements in the East of the Limpopo River. • There are no cultivated fields in neither side of the Limpopo river, except near Muchacha village, where there is some cultivation and evidences of human-elephant conflicts due to

	crop raiding, worsening the crop yields already low due to erratic rainfall. There is a small scale private irrigation system just south of Muchacha village • The heavy grazing pressure from livestock is the most important threat to habitat integrity • Wild palms are abundant in low lying areas and used by local people to produce a local beer • Most of the land use rights given to the East of the river are for game ranches
Relevance	This corridor has a high conservation value, is highly relevant and irreplaceable in facilitating access to water by wildlife as well as wildlife migration to the Banhine National Park and the interstitial zone between the two parks. The relevance of this area for biodiversity conservation in the GLTFCA had been previously documented during the study on "conservation setting priorities" (Smith and Ntumi 2008).
Feasibility	Due to its large width, intactness, diversity in habitat structure and composition, low number of people that will be directly affected, limited risk of human wildlife conflicts, this is the most feasible corridor. Outside the buffer zone, sustainable consumptive and non-consumptive wildlife utilization projects can be developed, which will reduce human-wildlife conflicts and generate income to sustain park management and the socio-development of local communities, including compensation for the restrictions in customary land use, i.e. the potential threats associated with HWC will be transformed into opportunities for income generation Game farms established in the Eastern side of the River will complement conservation efforts ongoing within the LNP, which increases the feasibility of the corridor



Aerial photographs of the proposed Chipeluene corridor, showing the location of Muchacha and Chipeluene villages. A large block of pristine habitat occurs between these villages.

Drainage line currently used by elephants in their movements to the Limpopo river. Geographical coordinates: S23°12´08.6" / E032°13´21.6"). The drainage line is located between the Muchacha and Chipeluene village

Changes in vegetation structure and composition along a catena gradient, with vegetation on uplands dominated by short *C. mopane* trees, whereas on the bottomlands the vegetation is dominated by tall *A. xantophloea* trees and regularly flooded grassland

Figure 6. Location and ecological and socio-economic features of the proposed Chipeluene corridor

Matafula Corridor

Name:	Matafula corridor
Location:	S23°18´16.2" / E032°16´37.0" (Figure 7)
Width:	**>7** km
Main settlements	Hassane, Matafula and Vundla
N^{o} of families and population	Estimated based on interviews and LNP data: 375 families, about 720 persons
Main ecological Attributes	• The structure of the woody vegetation is intact in the west of the Limpopo River in a length of about 7-8 km. The vegetation consists mainly of mixed *C. mopane* and *Acacia* spp. woodland, plus discrete patches of *A. johnsonii*. Woody vegetation in riverine areas is dominated by tall trees of *D. mespiliformis*, *P. violacea*, *F. sycomorus* and *X. zambesiaca*. • The grass layer is dominated by palatable species such as *Panicum* spp. and *U. mossambicensis*. Reeds (*Phragmites* sp.) dominate the herbaceous layer in the river bed
Main Socioeconomic attributes	• There are human settlements and cultivated fields in both sides of the river • High grazing pressure from livestock • Observation of crops recently damaged by elephants and hippopotamus. There are also reports of elephant sightings and human-elephant conflicts in Geres and Makarale, located in the Eastern side of the Limpopo River • Land use rights in the East of the river have been given mainly for private cattle farming. Communities North-East of Combomune village have also demarcated community lands and formalized use rights
Relevance	The barrier fence under construction will block access to dry season water sources by wildlife in the southern section of the buffer zone. It is expected that when the pans of the sandveld dry out during the dry season, wildlife will follow the barrier fence in search of water. This will likely result in an increase in wildlife at the fence confluence with the

	Limpopo River. The location of this corridor, about 8 km from the confluence of the fence with the Limpopo river makes it relevant to facilitate wildlife movements to access water at Limpopo river.
Feasibility:	With the erection of the barrier fence, wildlife will concentrate in this area of dense human settlements and cultivated fields causing HWC and reducing the feasibility of this corridor. To protect Matafula, Mvudla and Hassane from HWC, the confluence between the barrier fence should be shifted about 25 km northwards to leave these villages south of the fence. This would allow wildlife access to riverine resources and migration to BNP and the interstitial zone through Chipeluene corridor, where risks of HWC are minimal

Aerial photographs of the proposed Matafula corridor, showing the location of Matafula village towards the centre of the corridor

Pools and reeds in the Limpopo river bed used by cattle and elephants

Crops damaged by elephants just north Matafula village. Geographical coordinates: S23°18´16.2" / E032°16´37.0"

Figure 7. Location and ecological and socio-economic features of the proposed Matafula corridor

Corridors recommended for implementation

Based on the criteria for prioritizing corridors (width, intactness/ecosystem integrity, vegetation heterogeneity, land use, human-wildlife conflicts, etc.) and on the descriptions of the ecological and socio-economic attributes of each corridor, the following corridors are recommended for implementation:

Munguambane corridor

The northern location of this corridor makes it unique in providing the link between LNP and GNP in the context of the GLTFCA. Results of the Greater Limpopo Transboundary Buffalo Project show transboundary buffalo movements throughout this region, highlighting the relevance of this corridor for the achievement of TFCA objectives.

Since agriculture is not essential for the subsistence of local people, it would be possible to control the expansion of cultivated areas in the future. However, a problem could be the lack of control and technical advice of the park in the region, mainly due to long distance from park headquarters and limited number of PNL staff based locally, including field rangers and extension officers. This may lead to communities not complying with the restrictions in the use of land and other natural resource within the boundaries of the corridor. Livestock grazing is the most widespread threat to habitat integrity. Due to the difficulty in preventing livestock grazing, the results of the ongoing carrying capacity study of the buffer zone should be used by the park to promote sustainable use of rangelands in the area.

An emerging cultivation is threatening the persistence of a riverine forest within the corridor. Peasants are attracted by the fertile alluvial soils and by the availability of water for manual irrigation. This indicates that cultivation, to some families, is an important economic activity, but it is a threat to biodiversity conservation. Therefore, to reduce agricultural expansion within the corridor, the park should consider the development of an irrigation scheme in the south of Chitsutsuine in the southern edge of the corridor.

Another important activity is the extraction of palm wine for sale. The implementation of the corridor should not restrict this key livelihood activity for local communities. Accordingly, the community support program of the LNP needs to monitor the trends in number of people involved and distribution of palm milking activity and sensitize local communities to continue with the current traditional palm milking practices that appear sustainable.

This corridor has a high potential for promoting socio-economic development of local communities through eco-tourism. The economic benefits from the lodge and camping site to be constructed soon, over the long term will stimulate community participation in the protection of the corridor, which will in turn play an important role in maintaining the area attractive for tourists.

In this corridor evidence of human-wildlife conflicts is also low. According to the answers of the interviewees, the passage of wildlife does not interfere with economic activities, either by the "small" extension of crop area, or because wildlife passes in areas of low population density, such as the Ndlala village with only about 20 families towards the northern edge of the corridor. The Munguambane village located towards the center of the corridor does not suffer from human-wildlife conflicts. The limited conflicts are recorded on the banks of the Limpopo River, mainly involving crocodiles and hippopotamus, whose movements and spatio-temporal distribution is not influenced by the availability of corridors.

Chipeluene Corridor

From the ecological point of view this corridor is the best available option for linking the LNP with BNP and with the interstitial zone between the parks due to the prevalence of intact and large patches of suitable habitat for a wide range of wildlife species, coupled with evidences of current use of the area by elephants to access water from the Limpopo River. From a socio-economic point of view this corridor has also the best conditions for implementation, with settlements concentrated in villages and low number of people to be directly affected by the implementation of the corridor. These characteristics make this irreplaceable to achieve the objectives of the LNP in establishing corridors.

Rain-fed agriculture and extensive livestock production are the main economic activities for community members. However, cultivated areas are concentrated near Muchacha village; the Eastern bank of the Limpopo River is not under pressure from human settlements and livelihood activities. Therefore, the implementation of this corridor will not result in overwhelming HWC or in restrictions to access of natural resources for many people. Nevertheless, 187 persons representing 78 households living in the Muchacua village towards the center of the corridor will be directly affected, while other 148 persons from 47 families living in Chipeluene village will be indirectly affected by the establishment of the corridor.

Local communities agree to comply with the restrictions in the use of natural resource within the corridor and recognize the need of setting aside wildlife migration routes. Traditional authorities have always established measures to prevent the blockage of wildlife corridors, such as the organization of settlements in villages to leave large areas without settlements or subsistence activities, to serve as wildlife corridors. The main concern is hunger associated with drought and the increasing frequency and severity of HWC, which worsen crop yields and hunger. Interviewees stated that if there were no restrictions in the use of forest resources, they would make charcoal for selling as an alternative to face hunger when crop production fails due to erratic rainfall.

Establishing an electrically fenced irrigation scheme just south of Muchacua would promote the abandonment of cultivated fields threatened by HWC in Muchacha and encourage the shift of cultivation fields towards the irrigated area protected from HWC by fence. The introduction of irrigation systems would improve the income of rural households, which will be an external incentive encouraging conservation measures within the corridors. The training of local communities on other techniques to mitigate or control HCW needs to be strengthened to prevent crop damage by wild animals.

This corridor is outside the current route of tourists, which is generally from South Africa through Pafuri and Mapai to the beaches. Hence, opportunities for non-consumptive tourism are limited. However, there is high potential for establishing game farms in the Eastern side of the river in the future, which would benefit park management and local communities.

Based on the described characteristics, costs and opportunities, Chipeluene corridor is the most feasible among the analyzed corridors towards the achievement of the PNL objective of facilitating wildlife access to water and dry season habitat along the River, link the core area of the LNP with the BNP and the interstitial zone between these parks.

Tchowe Corridor

Large patches of natural vegetation remain, making the habitat prevailing in this area suitable for a wide range of wildlife species, in terms of providing resources and security from human impacts. Nevertheless, both banks of the Limpopo River are used for cultivation, including the Panhame irrigation scheme supported by the PNL community support programme. Cattle grazing is also widespread. The eastern bank of the river is densely populated and influenced by the large Mapai Estação village.

The implementation of this corridor would directly affect about 450 persons living in Panhame and Tchowe villages at the southern and northern edge of the corridor, respectively through crop damage and injury and killing of people by wildlife. However, between these villages there are no human settlements. The number of persons that will be potentially affected by the establishment of this corridor in the Eastern bank of the river is unknown, but it is higher than the number in the Western bank.

In Panhame, community members stated that to cope with hunger associated with drought and poor crop yields, if there were no restrictions in the use of forest resources, they would make charcoal for selling. Evidences of illegal charcoal making by local communities were recorded during field data collection. This indicates that strengthened forest resources protection measures during the implementation of corridors will negatively affect the livelihood of local people, likely resulting in negative attitudes in relation to the conservation of corridors. Therefore, protecting the Panhame irrigation scheme from crop damage by elephants through an electric fence would, to some extent, compensate for the more restrict use of forest resources. The soils of the Tchowe area are fertile; hence establishing an irrigation scheme would stimulate positive attitudes and involvement of local communities in the conservation of the corridor. The potential

for tourism development is very low because this corridor is located out of the rout of tourists.

This corridor is recommended to facilitate safe movements of wildlife to access drinking water and dry season forage along the Limpopo River. However, it is not feasible as a migration route to Banhine NP and the interstitial zone between the two parks because its implementation would result in severe HWC in the Eastern bank of the Limpopo River. However,

Priority forests for protection

Apart from the conservation of corridors that cover large areas of intact and diverse vegetation, specific sites that retain high conservation value should be given priority for the implementation of protection actions. These include:

- Riverine vegetation along the Lilau River (S22°38´40.1" / E031°45´48.0")
- Riverine vegetation East and South-East of Munguambane village (S22°28´54.7"/ E031°33´25.1" and S22°33´40.3"/ E031°39´05.3"), and
- Riverine forest at the border between Mozambique, South Africa and Zimbabwe, i.e. Crooks corner

Environmental impacts assessment issue to be considered in the implementation of corridors

In Mozambique, according to the Environmental Law (Law n° 20/97, dated 1st of October), Environmental Impact Assessment (EIA) is a legal requirement for all activities that will modify components of the environment, including biodiversity components, and if the implementation of the activity requires the re-settlement of people or will result in restrictions in the use of natural resources. The implementation of corridors will not directly modify ecosystem components, involve the re-settlement of people or result in insufficient land resources for the sustainable livelihoods. However, the restrictions in the use of natural resources within corridor boundaries, particularly land for cultivation, will require the development of measures that will serve as alternative sources of livelihood for local communities, such as irrigation

schemes to intensify crop production, and the development of tourism infrastructures. These new developments will have the following potential impacts on the environment:

Development of tourism infrastructure: according to the regulation for environmental impact assessment (Decree n^{o} 45/2004, dated 29th of September), the establishment of lodges requires EIA only if the capacity is equal or greater than 150 beds or covers an area of 10 ha or more. Camping sites require EIA only if the planned capacity is for more than 650 persons or cover an area equal or larger than 5ha. However, the proposed community lodge and camping site at Pafuri and the camping site at Salane will not reach these upper limits. Accordingly, no EIA will be required, but the investor/community must implement sound environmental management practices during the construction, operation and removal stages of the infra-structure.

Agricultural development: all irrigation schemes covering at least 350 ha or rain-fed agriculture occupying more than 1000 ha require EIA. This is not the case for the proposed development of irrigation schemes to promote socio-economic development of communities living within or on the edges of conservation corridors, because these will cover less than 100 ha in total. Apart from having negligible environmental impacts, these schemes will have significant positive impacts in improving food security, which will stimulate community involvement in the protection of corridors. However, conflicts among community members might occur if the irrigation schemes are too small to accommodate most of the people with cultivation related livelihoods directly affected by the establishment of corridors. Accordingly, a registration of the number of persons directly affected and interested need to be done before deciding on the capacity of the irrigation scheme to be installed at each recommended site. Being small irrigation systems, the impact related to the extraction of water from the river for irrigation is negligible because it will not affect basic needs of water consumption by local people. However, water use for irrigation might reduce the depth of pools that sustain aquatic fauna during the dry season, which can temporally affect the distribution of hippopotamus, crocodiles and fish species.

The Regulation for EIA also states that vegetation clearing for whatever reason resulting in deforestation of an area greater than 50ha needs EIA. This will not be the case for the additional irrigation schemes recommended because these should be established in areas

already in use for agriculture or in areas of secondary vegetation. Nevertheless, taking into account that vegetation clearing for agriculture and development of tourism infrastructure will take place within a protected area; care should be taken to avoid the destruction of rare, endemic or threatened species of flora and fauna and to avoid soil erosion. In addition, vegetation clearing should be restricted to the minimum area required.

Electric fence: fences erected to protect crops from damage by wild animals can cause blockage of animal migration routes. Severe impacts of large mammals on woody vegetation and soils will occur in the proximities of the fences. However, the electric fence will be erected only in the surroundings of the irrigation systems; hence it will have limited likelihood of interfering with wildlife movements and space use patterns. Additionally, the socio-economic benefits that will be obtained from protecting crops and irrigation pumps from damage by wild animals outweigh the ecological costs of interfering with animal movements.

Other environmental impacts that need assessment and monitoring include:

- Increased use of natural resources in the periphery of corridors due to restrictions within corridors
- Potentially unsustainable palm milking due to the restrictions of cultivation within the corridors
- Increased interactions and transmission of diseases between wildlife and livestock

GENERAL RECOMMENDATIONS FOR THE IMPLEMENTATION OF CORRIDORS

Short term

- LNP should develop irrigation schemes in areas of high soil fertility outside but in the proximities of the recommended corridors. This will promote a gradual self-resettlement of people towards the proximity of irrigation schemes. The increased access to irrigation schemes will compensate local communities for

the cultivated land lost to biodiversity conservation. Irrigation schemes will reduce the rate of conversion of natural habitats into cultivated fields associated with low land productivity in rain-fed crop production systems, which will contribute to the persistence of viable corridors. However, in the selection of sites to establish irrigation care should be taken to avoid the destruction of forests with high conservation value.

- Irrigation schemes should be equipped with necessary Human-Wildlife conflict mitigation measures including: (a) an electric fence where necessary and subject to fund availability, (b) teams to drive problem animals away, and (c) training of community members on techniques to mitigate the conflict
- To ensure that corridors are functional even for species that do not tolerate degraded habitats, natural resource protection measures within corridors in the buffer zone should be the same as those applied in the core area of the park. However, palm milking and collection of wild fruits should be allowed due to the importance of these activities for the subsistence of local people
- The establishment of corridors will result in restricted use of land and other natural resources. Therefore, where additional land for subsistence activities is required, the LNP should consider compensating local communities for the land lost to establish corridors by expanding the width of the buffer zone. This will minimize conflicts between park management and local communities, which have a key role in the implementation of functional corridors but are heavily dependent on multiple natural resource use
- The park should establish field ranger's camps in the proximity of each of the recommended corridors to ensure effective patrolling and reduction of anthropogenic threats to biodiversity
- Environmental education campaigns should be promoted by the Community Information Centre, stressing the need of community involvement in the protection of corridors due to their ecological and potential socio-economic importance
- Dense reverine woodlands should be protected due to their high biodiversity conservation value and their role in protecting hydrological processes. This would contribute to Reducing Emission from Deforestation and Forest Degradation (REDD+) in Mozambique

- Although local communities are aware of the need and generally agree to collaborate in the protection of corridors, the communities that will be directly affected by the restrictions in the use of natural resources and increase in HWC should be consulted to discuss the ecological, social and economic implications of establishing corridors. Wide community participation will create positive attitudes and increase community involvement in the protection of corridors. Meetings must also be organized with communities in the Eastern bank of the Limpopo River, which were not included in this study.

Long term

- The LNP should considerer moving the confluence between the barrier fence and the Limpopo River about 25 km northwards to leave Matafula, Hassane and Vundla villages in the buffer zone south of the fence, to relieve these villages from human-wildlife conflicts that will follow the completion of the erection of the barrier fence. Another, and less costly, option would be to move the confluence between the barrier fence and the Limpopo River to the south of Mahawane village, i.e. south of Matafula corridor. However, the ecological and socio-economic feasibility of this option would need to be assessed because the area south of the current confluence was not covered by this study.
- Considering the degree of uncertainty on the functionality of the proposed corridors as well as on the socio-economic impacts associated with their implementation, a continuous monitoring of animal movements, HWC, and attitudes of local communities in relation to corridors is necessary as a basis for management interventions to revert negative situations in the framework of adaptive management
- In collaboration with local communities and the private sector, the LNP should consider identifying opportunities to establish game farms or hunting concessions in the Eastern side of the Limpopo River to generate income that will support park management and the socio-economic development of local communities, while reducing human-wildlife conflicts.

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