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Instauration of Geopark Pilot: Preliminary Approach in Implementation Process of Geoconservation at Isalo National Park, Madagascar

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Abstract

Although Madagascar has long been recognized as a biodiversity hotspot for conservation, very little is yet known about its diverse endemic fossils and the original beauty of its geotopes. The richness and endemicity of geodiversity constitute nonrenewable natural resources, which deserve to be valorized and protected. Protection of natural heritage resources, aligned with geotourism, can provide a sustainable way for the population to rise out of poverty. The main purpose of this work is the instauration of Geopark, a long-term project in Madagascar National Parks to support geotourism and sustainable development. Given its outstanding landscape and its unique bio- and geo-diversity, we adopt Isalo Park as a pilot site, and suggest that this specific area is suitable for a Geopark. Following our field investigation, inventory and geodiversity assessments within the park are now underway, which will contribute to the implementation of Isalo Geopark.

Keywords

Geoconservation, Geotourism, Geosites Value, Isalo National Park, Madagascar

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1. Introduction

During the last two decades, the conservation of geological heritage and geodiversity took some momentum in developing countries, where they may achieve a double objective.

On one side, in developing countries as Madagascar, economic growth depends largely on natural resources as most of the population are uneducated or under educated. They are forced to depend largely on natural capital such as the earth's resources (e.g. water, land, minerals, oil) and biodiversity [1]. Conservation efforts and initiatives of Madagascar National Parks organizations met within some of geosites of Isalo National Park are vulnerable for catastrophic geological events such as flooding and rain runoff, which may produce and enhance mass wasting (rock falls and landslides) erosion and sinkholes.

Mining, deforestation and any other heavy anthropic activity might have a strong impact on country and in some cases those activities might tend to severe land degradation, natural geological transformation, and heavy sedimentation caused by the transported materials (see **Figure 1**). Consequently, there was the possibility that the land resource base became less productive, decreasing the wealth and economic development of the nation. This reality led to become aware of the need for management and protection of these geotopes and reveal priority to enhance the value of geoheritage [2] [3].

On the other side, developing a project of conservation of geological heritage and geodiversity meant to diversify the job offering and economy of a country. It meant to think to another idea of tourism, the so-called geotourism, slower and conscious, which permitted to visitors to know not only the biodiversity and beauty of a country but also the sub-stratum under those beauties.

Madagascar, an Island located in about 400 km off-shore of the main land of Africa, did have several potential Geoparks. The country did have some National Parks, which were generally protected by local government via the Madagascar National Park (MNP) (formerly known as ANGAP).

1.1. Geoconservation in Madagascar

Landscapes are usually considered to include the assemblage of land cover formed by biodiversity, agricultural, human element and the landscape form. These natural heritage resources mainly attract tourists and are generally protected. They are considered as a tool for representing key areas of the landscape worthy of protection and stewardship action. During the last two decades, the use of term "geodiversity" for geoconservation was widely used and mainly highlighted by Duff 1994 [4]; Sharples 1995 [5]; Black 1988 [6] and Wimbledon *et al*. 1995 [7], in order to promote geoheritage. Other terms such as geomorphosites ([8]-[11] and [3]), geotopes ([12] [13]) and geosites ([14]-[17]) are closely connected to the geodiversity which has taken an important place in promoting natural world heritage. Geodiversity was defined by Gray (2004) [18] as representing the present and past diversity of geological (rocks, minerals, fossils), geomorphological (land form, physical processes) and soil features.

Figure 1. Land degradation due to mining of precious stones.

It includes their assemblages, relationships, properties, interpretations and systems. To enhance the action plan for geoconservation, many workshops, symposiums, conferences and projects were organized to promote the geodiversity. The Geopark concept has grown rapidly during recent years in African countries. One of the major achievements was the creation of the Association of African Women Geoscientists [19].

Starting in 2002, many colloquiums were organized. The main shared objective is to endorse the understanding of Earth Sciences among women on the African continent by encouraging and mobilizing support for education, training and research [19]-[21]. Last year the five-day 6th Conference of AAWG held in Cameroon (23 - 27 April 2012) had the theme: Geoscience and African Integration. In addition, after the workshop “An Introduction to Geoparks” (3rd August 2004 in Windhoek) organized by the Geological Survey of Namibia and Unesco [22], the first International Conference on African and Arabian Geoparks: “Aspiring Geoparks in the Africa and Arab World” El Jadida, Morocco, on November 2011, had been followed by the 24th Colloquium of African Geology (CAG-24) in Addis Ababa (Ethiopia) during which one of the challenge is the creating Geoparks in Africa and discussions around some of the promising projects in Africa. In front of these situations, although the Unesco, 2010 supported Global Geopark Network (GGN) is represented by 88 members, many Africa countries had just start to initiate the instauration of Geopark. This baseline geoconservation studies in Africa should in the first, serve as a model, and in the second prompt us to promote the implementation of the geoheritage valorization, preliminarily in Isalo National Park for the instauration of Geopark in Madagascar The purpose is to allow new approaches more sustainable and more attractive for geotourism in order to preserve and improve the splendor of a natural heritage which includes the richness of geodiversity.

1.2. Geographical and Geological Setting

Isalo National Park is located in the province of Toliara (South Madagascar) along the national road RN7, more

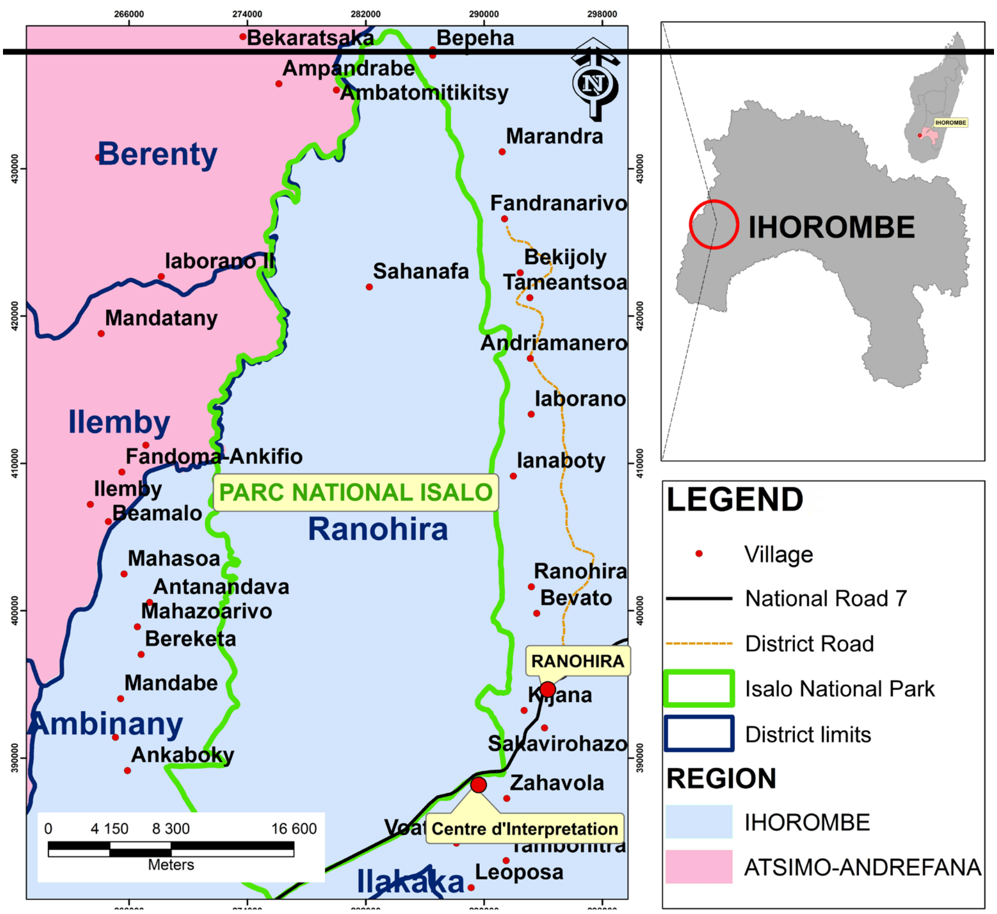

Figure 2. Geographic location of the study area: Isalo National Park.

precisely in the region of Ihorombe, district of Ihosy and approximately 700 km South West of the capital Antananarivo and 29 km North-North-West of Ranohira (see **Figure 2**). The park was created in 1962, but the landmark had previously been well known to the Malagasy. Isalo Park covers 86,570 Ha and delimited by the Malio River on the west and by Menamaty River to the East. The southern side is crossed by the RN7 while its north side is bordered by the ruiniform massif of Isalo (see **Figure 3**). Isalo National Park is within the southern part of Morondava basin, which is characterized by a semi-arid climate, with small precipitation and a high thermal contrast 15˚C - 32˚C.

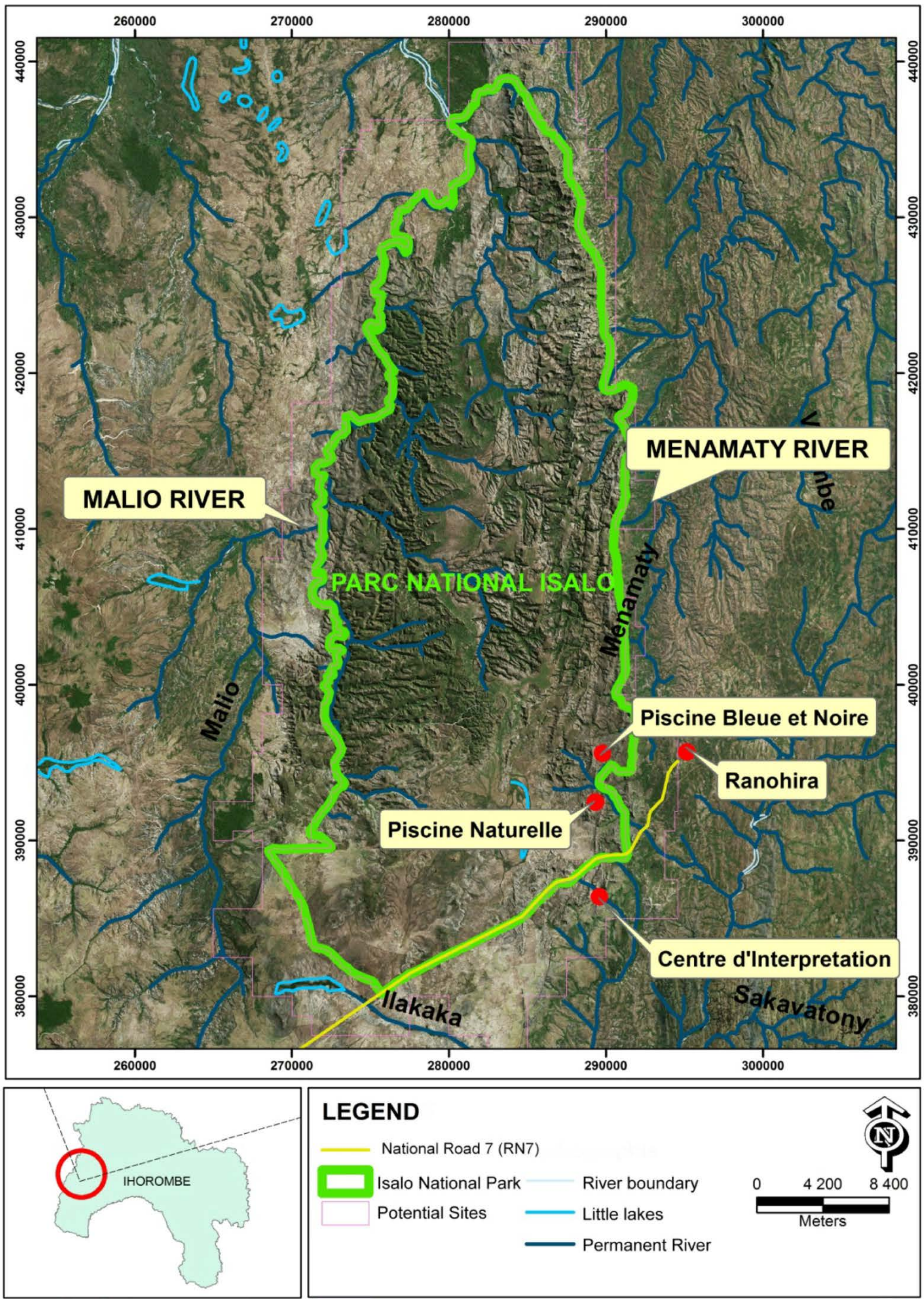

Figure 3. Isalo National Park hydrography.

Figure 4 shows that the main geological formation of the park is the Isalo group. The uppermost of the Karoo Supergroup of Madagascar is predominantly viewed by vast amount of clastic material of coarse sandstone mountains [23] ranging from 5000 to 6000 m thick deposited during Triassic to early Jurassic [24]. Sculpted by wind and water that showed an extraordinary landscapes of monoclinal and tabular beds, dipping gently to the west, these sandstone rocks, cut by deep canyons, very linked with rare endemic plants (see **Figure 5**) and fauna are sacred to the Bara and Sakalava Tribes [25]. One can distinguish in the landscape three geomorphological landforms: the ruin-shaped mountains, the tabular mountains and the sandy domes [26].

2. Methods

Taking account the all relevant interests of methods process advanced by many authors that aiming to valorize and protect the geoheritage ([1] [27]-[32]), the first step of the action plan consists to select the study area. The selection depends mainly of the geotouristic attraction values of the site. Given the current state of our knowledge, there is no particular legislation concerning the structure on geoconservation in Madagascar. In fact, in order to ensure the management of geosites, the second step is to include them into the protect areas (park) administered by a government structure. This is the reason of an active partnership with Madagascar National Parks (MNP), a main actor of the conservation. Among the several National Parks, Isalo National Park is one of the most visited National Parks in Madagascar (**Figure 6**). It was chosen as a pilot site for Madagascar's geoconservation, not only because of its geomorphological beauty but also because of its location and its unique geo- and eco-systems which people can appreciate geological dynamic process.

The collecting data method is based on preliminary consultation of all scientific or literature sources of geographical, geological, cultural and social information contributing Isalo geoheritage. These are represented by reports, publications, maps and photos that reveal history of Isalo geosites. GIS applications is the main tool to improve representation of cartographical data (see **Figures 2-4**) in order to promote the knowledge and the usage of geosites/geomorphosites to the general public. Several fieldworks have been organized in goal to add more in detail the potentiality of the selected geosites. In the first time, these trips tend in order to localize, to verify and to complete all collected bibliographical data in Isalo National Park. In the second time, other geosites totally ignored before this work have been considered for a research and study detailed. The finality is to obtain a preliminary inventory of all interesting geosites and geomorphosites around the way in the park.

Isalo a National Park suitable for a Geopark: preliminary geosites inventory.

Table 1 and **Table 2** exposed the description of Isalo National Park and their criteria for suitability as a Geopark [33] [22].

There are currently several tours crossing the Isalo National Park of which originality is represented in **Table 2** and **Figure 7**. Visitors can choose between easy and medium level circuits. It is possible to combine individual circuits by staying overnight at a campsite in the park. A good number of materials (articles, databases available, websites...) are focused on methodology of geosites value.

These important task for geosientists demonstrate that geodiversity conservation recognized as geoheritage request, economic value, scientific value based on rarity, representativeness, integrity and diversity [29] [34] and the combination of aesthetic, cultural and ecological value called "additional value" according to Pereira, 2006 [35] and Pereira and Peireira 2010 [36]. Indeed, the aim is to state if the potential geological heritage of Isalo National Park region can attract more tourists in order to bring the possibility of sustainable development in surrounding communities. Given the linkage between geosites' values and the plan of expected results, **Figure 8** is the synthesis of geosites'values relevant to the current issues of Madagascar [1].

Geosites inventories are significant for geodiversity identification because conservation, contributing both to the enhancement of geoconservation and the sharing of knowledge about rock formation and past life [37]. The Museum is one possibility that should safeguard our geoheritage. In and around Isalo Park, (Ranohira to Sakaraha region) a well preserved, diverse assemblage of flora and fauna fossils has been excavated. Fossils of endemic species that succeeded mostly through the Mesozoic and Cenozoic offered testimony to the fact that these hills were once inhabited by a large number of invertebrate and vertebrate fauna. These fossils have helped paleontologists to explain and solve the mysteries of the evolution of pre-historic life valorization without preliminary inventory, may conduct a misinterpretation of geoheritage [38]. **Table 3** gives a preliminary inventory of geosites' values for potential geoheritage recognized at Isalo Park.

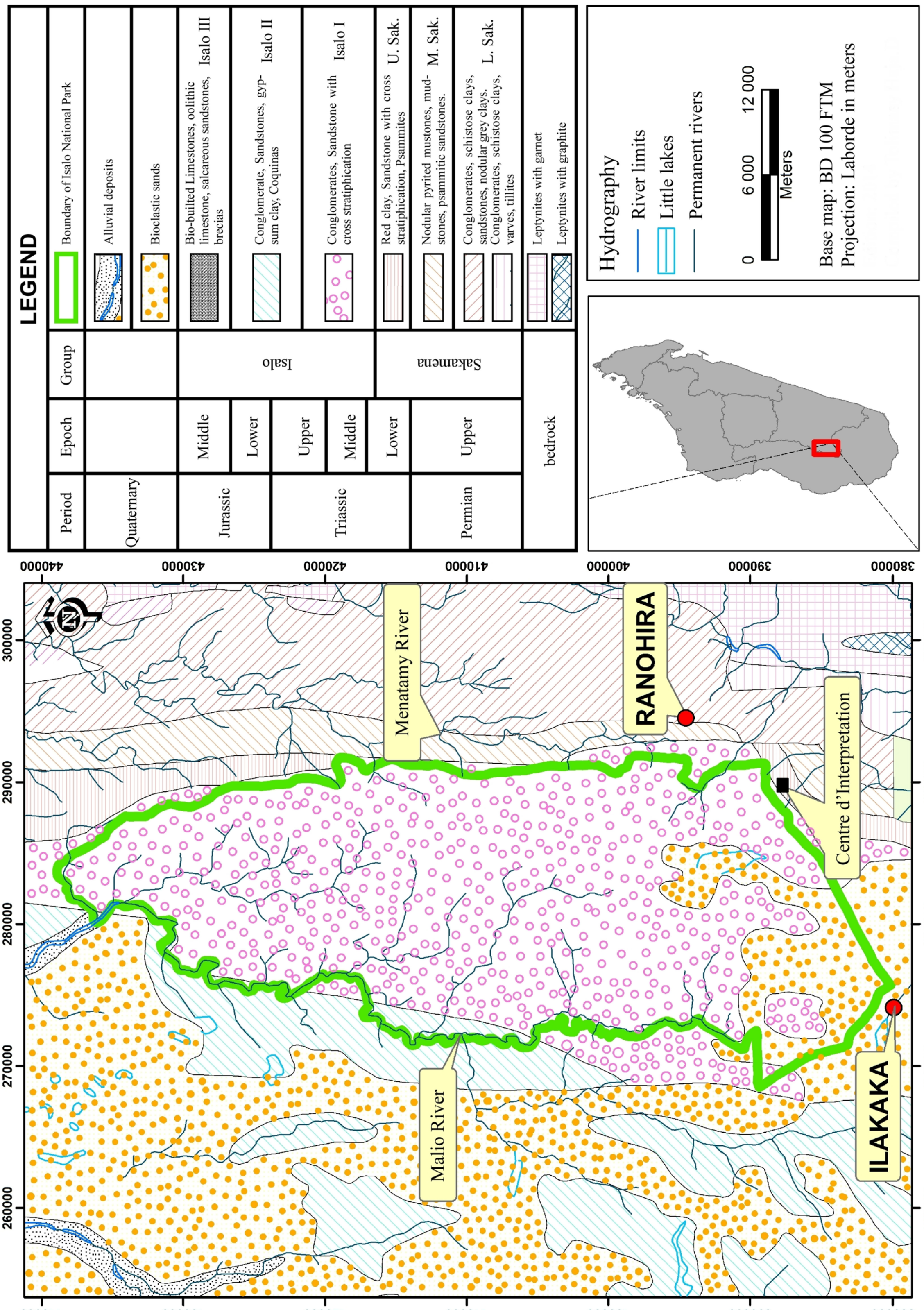

Figure 4. Geological map of Isalo National Park.

Figure 5. One of the best endemic plant *Pachypodium rosulatum* in the Isalo National Park.

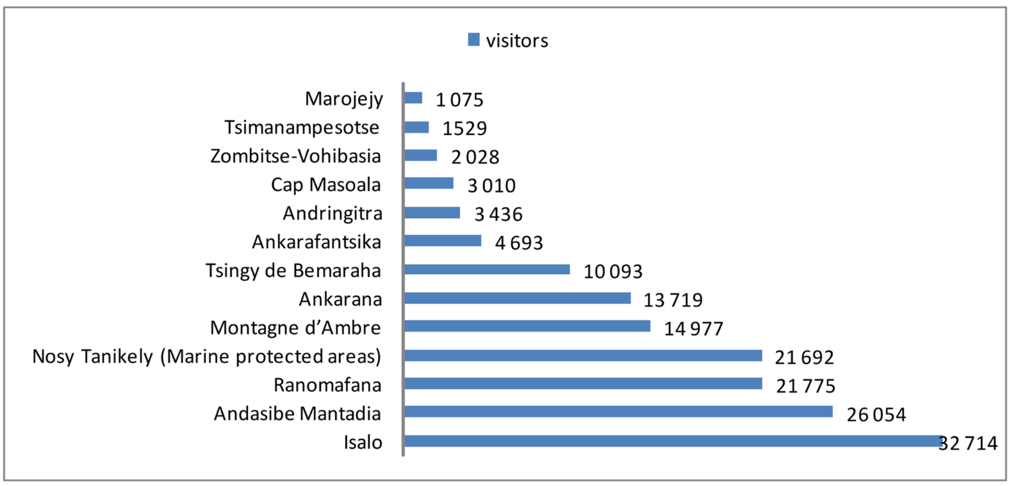

Figure 6. Number of visitors in the most frequented parks during 2011. The data is obtained from Madagascar National Park.

2.1. Sharing of Knowledge about Rock Formation and Past Life in Isalo Center

Physically accessible because situated in Zahavola locality, The "Centre d'Interprétation Isalo" (**Figure 9**) is a future museum situated about only 9 kilometers in the southern part of Ranohira village along the RN7, direction Toliary. The center holds a permanent exhibition focused on the geology, fauna, flora and cultural influence by the local people. The action plan for instauration of the Geopark project includes the renovation of this center with the main goal of geoconservation.

Figure7. Touristic points and several tours crossing the Isalo National Park (modified from Madagascar National Parks brochure).

Contributing both to the enhancement of geoconservation and the sharing of knowledge about rock formation and past life, the Museum is one possibility that should safeguard our geoheritage. In and around Isalo Park, (Ranohira to Sakaraha region) a well preserved, diverse assemblage of flora and fauna fossils has been excavated. Fossils of endemic species that succeeded mostly through the Mesozoic and Cenozoic offer testimony to the fact that these hills were once inhabited by a large number of invertebrate and vertebrate fauna; these fossils have helped paleontologists to explain and solve the mysteries of the evolution of pre-historic life.

2.2. Geotourism and Legend Records

Local human population without any historic, geological, paleontological and geomorphologic education may use many legends in order to try to explain what they see, where they live and why. Usually different legends provide what may be considered the "noble or legendary origin" of a population, a city, a nation or a landscape.

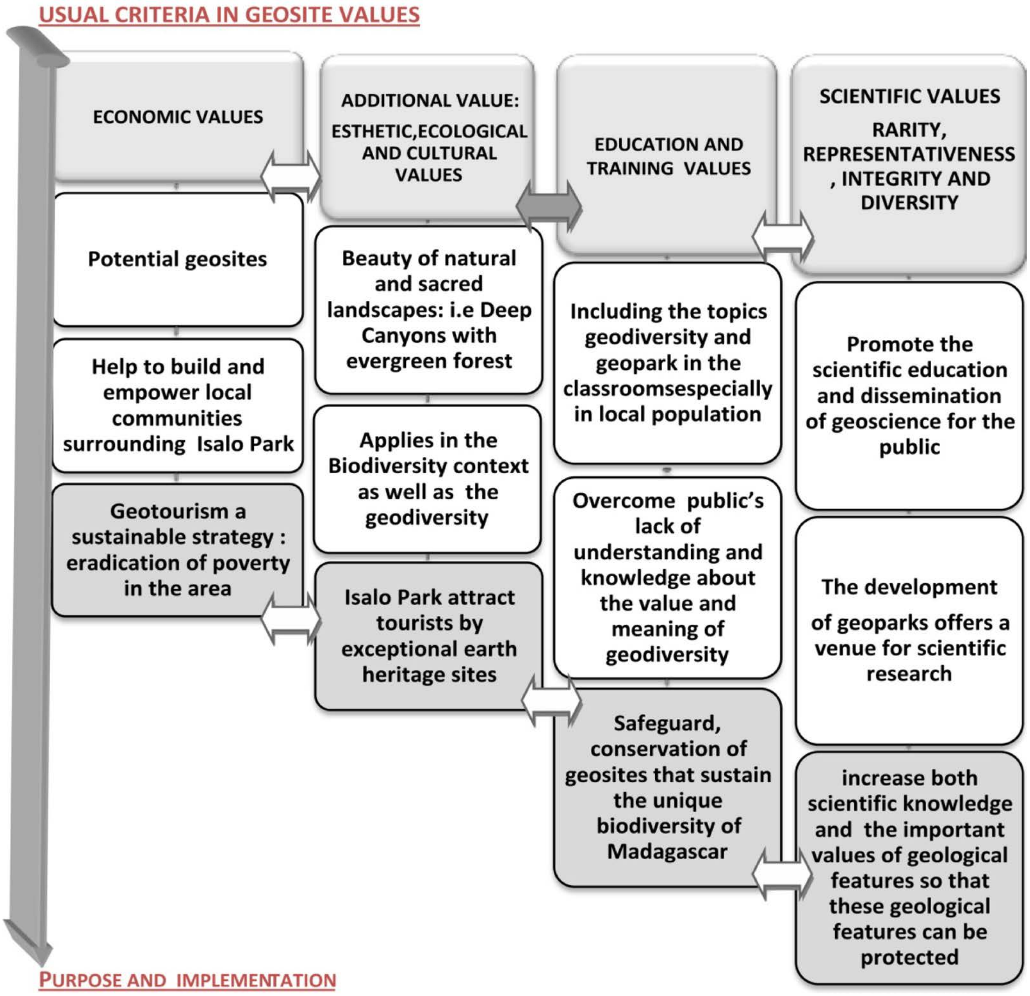

Figure 8. Synthesis graph of geosites values relevant to the current issues to Madagascar.

Figure 9. "Centre d'Interprétation Isalo" the center for visitors and researchers situated around the park.

Table 1. Description of Isalo National Park (source: mnp, 2011 [33]) and their criteria suitable for a Geopark (source: schneider & schneider, 2005 [22]).

		Description	Criteria adopted as pilot site of specific area suitable for a Geopark
Catégorie UICN		II (National Park)	Existing infrastructure
Creation		19th July1962	
General geography	Locality	29 km NNW Ranohira, approximately 700 km southwest of Antananarivo	
	District	Ihosy	
	Region	Ihorombe	
	Country	Madagascar	
	Primary administrative	Toliara	
	Latitude	−22.31614	
	Longitude	45.29625	
	Elevation	514 m to 1268 m	
	Area	86,570 Ha; average length of 59 kilometres; and an average width of 22 kilometres	
Climate		Dry tropical Mean temperature: 17˚C in June and 25˚C in February (warm temperature)	Promoting geotourism for a better community and better life, *i.e.* fight against drought and low income because of dry climate
		Low Level of Socio-Economic Development	
Geology	Sedimentary rock	Sandstone of Isalo range prominent western skyline, dissected cuesta with flat-topped mountains, scattered in an intricate maze of valleys	Potential geoconservation occurring in the area: —Geosites —Paleosites —Minerals and gemstones
	Basin	Southwest of Morondava Basin	
	Geologic -tectonic	Geodynamic model for the early and late Karoo rifting and the Mesozoic plate drift of Madagascar	
	Mineral and gemstone	Saphir, corundum	
Landscapes		Big savannas, gallery forests Natural geological shape that make the famous Isalo (the Boot, the Queen of Isalo, the Wolf and the Tsingy of Isalo…) Canyon; karstic; desertic Waterfalls, lakes, natural swimming pool	
Fauna		Strong majority of the endemic species: —77 species of birds live in Isalo among which the *Pseudocossyphus bensoni*, an endemic species of Madagascar that is well protected —14 species of nocturnal lemurs, 8 of which are introduced and 7 endemic to Madagascar —Reptilian, amphibian, carnivores, insectivorous and gnawing	Specially adapted fauna and flora and its links to geology
Flora		More than 400 floristic species Endemic to Madagascar like the *Pachypodium rosulatum*, family of the Apocynaceaes, the *Catharantus ovalis* a medicinal plant that isn't found anywhere else in the world but in the Ihorombe and on the plain of the Zomandao The savanna of the Isalo is colonized by typical palms of this region: the *Bismarkia nobilis* "*Satrana*" that resists fire	
Cultural sites		Palace wall, the royal bath, the royal tombs as well as traditional Bara tombs Sacrifial rites (prayer *joro* and *Tsipirano*) "Bilo" ritual exorcism Legend records	Density of cultural sites

Table 2. Tours (Circuits) crossing the Isalo Park (Sources put out from http://www.madacamp.com/Isalo_National_Park and MNP [33].

	MALASO (See Figure 10)	NATURAL SWIMMING POOL	CASCADE OF THE NYMPHS, BLACK AND BLUE SWIMMING POOL CIRCUIT	CANYON OF THE MAKIS AND RATS	BIG CIRCUIT	CREST CIRCUIT	ANTSIFOTRA CIRCUIT (See Figure 11)	ANJOFO CIRCUIT	GREEN LAKE LAC VERT D'ISALO
Itinerary	.Medium circuit, 42 km by car (4 hours), thereafter a 2 km trek	Medium circuit, 3 km by car from Ranohira to Mangily and thereafter 3 km trek	Easy circuit, 4 km by car, thereafter 2.8 km trek (3.5 hours)	Medium circuit, first 17 km by car, thereafter 1.7 km trek (2.5 hours)	Hard circuit, 40 km by car and 80 km on foot. This tour compiles all sites	Medium circuit, 3 km by car and thereafter 4 km on foot (2.5 hours).	Medium circuit, 29 km by car (5 hours) and thereafter 5 km on foot	Medium circuit, 29 km by car (5 hours) and thereafter 5 km on foot	Medium circuit, 20 km by car (4 hours) and thereafter 1 km on foot.
Geological sites	**Tsihitafototra canyon -Tsingy of Isalo in the savanna, Ampasimaiky cliffs and The Wolf rock formation-**	**Palm-fringed pool, constantly fed by a warm waterfall.**	**Black or Blue Swimming Pool, Waterfall. bath in the dark waters Namaza Canyon**	**Granites rock, Waterfall of turquoise water, Canyon**	**Natural swimming pool.**	**Tsingy de l'Isalo - sharp limestone karst pinnacles.**	**. waterfall**	**waterfall.**	**Lake**
Biodiversity		Plain of Tapia trees, big savannas	Rare birds, butterflies and lizards	Unique flora of the forest. Colonies of lemurs, birds, butterflies and lizards.	Birds and lemurs (day as well as night active) in forest Sahana	Vegetation with *Pachypodium*, *Aloe* and *Kalanchoe*	Riparian forest where lemurs live	Rain-vegetation with orchids, birds and lemurs	Tapia forest- an riparian forest with palms
Habit and custums	Malaso circuit draws its name from the zebu thieves which use the natural labyrinth of the Isalo for their activities.	Several tombs of the Bara and Sakalava people.		royal village-palace wall- the royal bath- the royal tombs as well as traditional Bara tombs	Archaeological sites: Portuguese Cave,			Sacred locations	
Aesthetic view	Unlimited view of vast extent of Isalo. Window of Isalo a natural rock formation in shape of a window through which the sunset can be seen.	Panoramic views diverse ecosystems passing eroded cliffs with strange shapes Analatapia campsite	Panoramic view over the green canyon	Panoramic views rice fields gorges, the Canyon of the Makis and Rats;The huge Ihorombe plateau. swim in the canyon	unforgettable panoramas	Natural geological shape,for which Isalo is famous: - The Queen of Isalo,- The Boot- The Wolf		unforgettable panoramas	

Table 3. Priliminary inventory of geosites values of potential geoheritage recognized at Isalo.

Criteria		Sub criteria	Potential geoheritage
Economic value		Potential geosites	Landscapes; rivers; lakes; swimming pool; waterfall; canyon; valley; domes; mountains; caves
			Geosites for hiking and trekking
		Gemstones	Sapphire, corundum
		fossils	Vertebrate invertebrate and plants
		Rocks	Eroded sandstone
		Museum	Center of Isalo interpretation
Additional value	Aesthetic value	Landscapes	Eroded cliffs with strange shapes (Wolf, Queen…)
			Landscapes panoramic view: wide monoclinal, tabular mountains; deep and short canyons; sandy domes; natural labyrinth of Isalo
	Ecological value	Lakes	Natural and colorful lake (green)
		Waterfall	Warm waterfall; waterfall bath; waterfall in the colorful water (dark; turquoise)
		Swimming pool	Natural and colorful swimming pool (black and blue)
		Savanna	Endemic flora and fauna
		Forest	Evergreen forest, riparian forest; endemic flora and fauna
	Cultural value	Spiritual	Tombs: royal village; exorcism.
		Folklore	People Bara and Sakalava
		Archeological	Portuguese Cave
Educational and training value: protection and valorization of geoheritage		Regional	Awareness of local population
		Professional	Training of Isalo Park staff on geoheritage
		Classroom	Teacher's training
		University	Field work
Scientific value		Geoscience	Geoprocesses of basin formation
			Sedimentology: deposit process of sandstone; mechanism of transportation, erosion and diagenesis; silicoclastic sedimentary rock (sandstone, siltstone, conglomerate)
		Geological History	Isalo formation
		Stratigraphy	Karroo supergroup: stratotype; sequence type
		Geotectonic	Fault, diaclase
		Paleontology	Biostratigraphy; paleoecology (paleoclimate, energy)
		Geomorphological processes	Formation of deep Isalo sedimentary basin Fluvial processes Tectonic processes

Moreover, such legends may explain to people what they have found inside rocks or in their territory (fossils, unknown archeological or geomorphological features).

Consider, for example, the double origin (noble or legendary and real) of Rome, the capital of Italy. According to an old legend Rome was founded by Romolus, together with his brother Remus, two orphans descendant of Aeneas (a very important hero during the ancient war in the Troy city) raised by a wolf female, on 21st April 753 B.C. Ancient Romans citizens really appreciated the legendary version of the origin of the city of Rome because they loved to associate their origin with the even more ancient Hellenic culture. The image of a wolf growing two children serves as the symbol of Rome as capital of Italy. Actually, first settlements of Rome are dated to the Bronze Age (about 1400 B.C.) and belonged to ancient shepherds and farmers.

As for what concern the presence of fossils, there is a noticeable example regarding ammonites. First ammonites found in England (in the area of Whitby, Yorkshire) were explained by the local population with the

Figure10. Panoramic view in Malaso tour: Isalo's window (source: Madagascar Nationa Parks).

Figure 11. Figure showing the wide eroded sandstone mountain of antsifotra tour (source: Madagascar National Parks).

reference to "snakestones" [39]. Snakestones were created by the Abbess Saint Hilda which, according the legend saved the village from snakes by turning the snakes into stones. This legend was born to explain why the rocks around Whit by were so rich in ammonites, including the genera named *Hildoceras* Hyatt 1867 and *Hildaites* Buckman 1921 (lower Toarcian, Venturi 1972 [40]; 1973 [41]; 1981 [42]; Gabilly 1973 [43]; Di Cencio 2007 [44]), whose names derive from Saint Hilda.

The better example in Madagascar is the legend of the two beauties in such a natural setting, the mountain waterfalls in Andringitra National Park: According to local legend, the waterfalls are named "Riandahy" (the King) and "Riambavy" (the Queen). The story is told that the King and Queen after years of being infertile gave a sacrifice and swam in the waters and soon after had a baby. These waterfalls are still regarded as sacred by the locals, who believe that swimming in the waters (waterfalls over 250 m) will help infertile couples conceive.

The examples above mentioned are only a little sampling of the legends which ancient and primitive populations have used to explain the world they live in. The entire body of legends represents a richness usually not used in tourism projects. This richness is often connected with the geological and paleontological heritage of a place, much too complex to explain for a non-geologist population without the use of legendary keys.

Furthermore, the contribution of oral traditions and folks permits a true and equal collaboration between local populations, who have better known the legends of a place, than have tourists and touristic operators. Only in this way, indeed, the diffusion of legends, diversities among folks from different places and preservation of historic memory are guaranteed. Last but not least, diffusion and persistence in time of legends of the world represents an undoubtedly cultural and literally patrimony whose preservation should be considered a moral duty for every person.

3. Conclusions

Given the richness of natural heritage in Isalo Park, particularly the geosites, this work is a preliminary result as baseline steps demonstrating the relevance of preliminary inventorying of geoheritage features in National Park Isalo. Taking account the current issues of Madagascar, as a tool for geoconservation, the methodology being advanced are based firstly on the criteria assessment of geosites, in order to recognize their potentiality to attract more tourists because of the developed new awareness of the importance of geosites for a wide public.

Geoheritage is connected tightly to cultural additional value: a thorough census of Isalo geotopes will consider the presence of oral traditions and folk legends about historic, geological, geomorphological and paleontological features, in order to give complete information to tourists and scientists. The next step of the Geopark project will be used to focus group methodology for reconstitution of Isalo geoconservation and legends for nourishing the future Museum Isalo Center (Centre d'Interprétation d'Isalo).

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