MINISTRY OF TOURISM
NATIONAL DIRECTORATE OF CONSERVATION AREAS

LIMPOPO NATIONAL PARK

STUDY ON THE POTENTIAL OF LAND USE AND LOAD CAPACITY FOR THE POPULATION AT THE SUPPORT ZONE OF THE LIMPOPO NATIONAL PARK IN MOZAMBIQUE

1.2. Study of Soils in the Support Zone of the Limpopo National Park (Scale 1:250 000) – Final Report

RURAL CONSULT

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1. Introduction

Such is well known that land resources are limited and finite. In a context where the human population continues to grow, the land resources become increasingly scarce. Two of the major problems arising from this scenario are the emergence of conflict between different types of land use and the degradation of land resources, which can lead to deterioration of the quality of life for people who depend on these resources for their livelihoods. Hence, it is time for more rational ways to use these resources, which accommodates the interests of different stakeholders and enable the satisfaction of human needs both in the present and the future. This, in turn, requires the use of proper scientific methods to identify and evaluate the suitability and potential of land resources for different types of use, in order to allocate these resources to its adequate area of use, as to meet the needs of communities and resource conservation.

In this context, the districts of Massingir, Mabalane and Chicualacuala intend to inventory and assess the potential of land resources, particularly in the Support Zone of the Limpopo National Park (LNP), in order to identify the alternatives of sustainable use, in order to meet the needs of the communities living there as well as others who may be resettled in the area. The completion of this effort requires the adoption and use of scientifically appropriate approaches conventionally termed as Agro-ecological Zoning. In this particular case, the Agro-ecological Zoning will include the integrated analysis of the load capacity of the LNP´s Support Zone.

One of activities to be carried out in the process of Agro-ecological Zoning is the study of soils. The study of soils can identify the types of soils found in the region, understand the extent and geographical distribution, know their morphological characteristics and determine their quality and suitability for various alternative uses. This report presents the results of the study of soils undertaken under the Agro-ecological Zoning of the LNP´s Support Zone.

1.2 Objectives

The objective of this study is broadly defined and unfolded into more specific actions.

1.2.1 Overall objective

This study of soils aims to provide information on areas with potential for different types of agricultural use of land resources, in view of the characteristics and suitability of soils at the LNP´s Support Zone, which could facilitate the better planning of use and conservation of these resources. This information will be integrated with other disciplines in the process of Agro-ecological Zoning and integrated analysis of the load capacity of the area under reference.

1.2.2 Specific Objectives

The overall objective of the study of soils unfolds into the following specific objectives:

1. Identify and analyze the spatial distribution of the main groups of soils of the LNP Support Zone;
2. Carry out a morphological characterization (including physical and chemical features) and classification of the major groups of soils in the region;
3. Produce the soil map of the study area and its explanatory legend and
4. Determine the suitability of general agricultural use of soils in the area.

1.3 Location of study area

The Limpopo National Park´s (LNP) occupies the eastern portion of LNP, along the Limpopo River, extending from Pafuri to the junction of the Limpopo and Elefantes Rivers, in a length of about 320 km and average width of 10 km from the right bank of the Limpopo River to the interior. This is the portion of the LNP area that houses most populated community and probably with greater potential in terms of resource base, particularly land, of the livelihoods of communities living there.

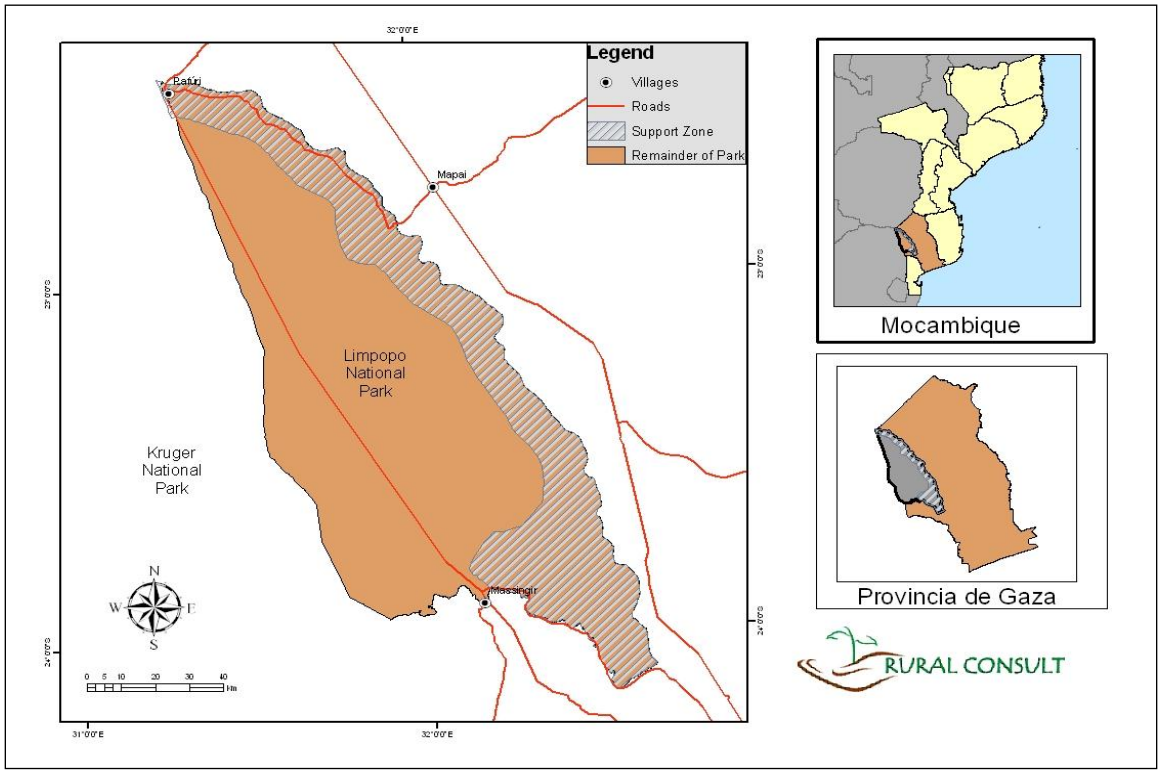

Figure 1. Location of study area.

2. Methodology

2.1 Introduction

The study of soils in the Limpopo National Park´s Support Zone aims, specifically, at identifying and mapping the soils of this area, in a scale of 1:250 000, in the context of the study of Agro-ecological Zoning and integrated analysis of the load capacity of this area, to support life for both communities who live there and others that may be resettled. As can be seen by the scale (1:250 000), this is a recognitions study, which allows the identification of areas with potential for different uses, in terms of the suitability of the main groupings of soils found in the study area .

To this end, a general approach was adopted for soil survey, given the level of aggregation meeting the scale to which the soils are mapped here (1:250 000), the existing information base (level of detail of previous studies, spatial images – images of satellite and digital terrain models, etc.), as well as the physical characteristics of the study area. Thus, the methodology entailed the review and analysis of the existing secondary data and information, sampling design, soil survey in the field analysis and interpretation of data, delivery of results, including soil maps.

2.2 General procedures for the study

In this sense, the general procedure to carry out the study unfolds into the following steps:
Step one. Collection and analysis of baseline information on the existing study site. Such specific information consisted of reports of previous studies on land resources and their use, including their maps (e.g. Information on the geology, geomorphology, soils, vegetation, hydrograph, land use, etc.). At this stage, further analysis of satellite imagery and digital terrain model was undertaken on the study area.

Step two. Production of preliminary soil map based on the interpretation of satellite images and digital terrain model, digital geological map and topographic maps. This exercise allowed the identification of the major soil units found on site, focusing on the relation between geology, geomorphology, vegetation and soils. The preliminary soil map served as the basis for the selection and dimensioning of sampling areas for the identification of soil types and their respective characterization in the field.

Step three. Field survey. The field survey of soils consisted of observations (surveys) in transects with equidistant points (5 x 5 km) within the sampling areas. Outside the sampling areas, control and validation observations were made for the limits of soil units of the preliminary map. Adequate points in the soil units were identified, definitively set in the field, in representative areas where profiles to describe morphologically the soils were opened, based on the description manual of soils used in the country. From these profiles, soil samples were taken for laboratory analysis, which provided the basis for the taxonomic profiling of soils as well as recommendations of its use.

Step four. Interpretation of soil data and production of the final soil map of the study area.

Step five. Preparation of recommendations on alternatives for use and soil management in the study area.

2.3 Materials and Method

In order to carry out the study of soils, different materials were used so as the method commonly used in soil surveys for the level of detail that this study requires.

2.3.1 Materials

Consultation of existing documentation

As mentioned earlier in this document, documentation was consulted relating to various studies conducted in the area, in order to be acquainted on the biophysical features of the location, characteristics and potential of natural resources as well as its current use.

Development of preliminary soil map

In order to develop the preliminary soil map, an analysis of the spatial database of the study area was done, including geological map (scale 1:250 000, Sheets 83, 84, 88, 89 and 93-94), soil map (scale 1:1 000 000), topographic map (scale 1:250 000, Sheets 83, 84, 88, 89 and 93-94), digital terrain model (SRTM) and satellite imagery (Landsat TM of 24 July 2004 Sheets 83, 84, 88, 89 and 93-94) in the scale of 1:250 000. To analyze this database, mildware GIS (Arc-Map Arc-view version 3.1) was used. The mildware DNR Garmin was used for uploading the GPS (GPS Map60csxGarmin) and downloading the observation points of the field.

Field survey

For the soil survey in the field were used various materials and equipment. Observation (surveys) of soils was made by using conventional probes, Munsell colour charts, diluted solution of hydrochloric acid (HCl 10%) k for carbonate testing of soils, clinometers and GPS. The holes for soil profiles were opened with the help of shovels and pickaxes. The profile knifes registration forms for the description of profiles, tape measures of 1.5 meters, Munsell colour charts were used in the description of soil profiles. The thickness of horizons identified in the soil profiles were measured with a tape measure. A dilute solution of HCl (10%) was used for carbonate testing of soils in the field.

The topographical features of the observation sites and soil profiles were determined with the help of the clinometers. Adequate plastic bags were used for the packing of soil samples

collected in the representative soil profiles and observation points and in some soils of the study area. The identification of soil samples was registered with appropriate labels.

Lab analyses

Laboratory analyses were performed at the Soil Laboratory of Eduardo Mondlane University, where appropriate equipment and materials were used.

2.3.2 Method

Development of the preliminary soil map and sampling points

The interpretation of satellite imagery was based on visual technique, using a GIS package, to display the image. For such, there was the appropriate combination of bands 1, 2 and 3, which represent the wavelengths of the visible portion of the electromagnetic spectrum, including blue, green and red (Lillesand and Kiefer, 1994:6). The allocation of the bands is usually done considering the **RGB** order (Red, Green, and Blue). In this case, the bands 1, 2 and 3 provide better understanding of the characteristics of soil and coverage in general. Then, it was followed by the interpretation of satellite imagery, using the tone and texture as main distinguishing features of the different units of interest. These units consist of different types of vegetation and land use. Here, it was considered the assumption of the correlation between the factor of soil formation "**living organisms** = *plants, organisms and man*" and soil type.

The product of interpreting satellite imagery was then combined with the interpretation of digital terrain model (RSTM) and geological map to produce Terrain Mapping Units, which were taken as preliminary soil units. Note that these units constituted the preliminary soil map of the study area and was based on the topographic map with scale of 1 250 000. Sampling points were defined based on a grid of 5 x 5 km. The overlay grid of the soil map resulted in preliminary map of observation points. Thus, the observation points were geo referenced and imported into the GPS, enabling its exact location on the field.

Field survey

The field survey was preceded by a field visit to the area of study. This allowed the realistic understanding of site features, which helped in improving the limits of the soil units identified during interpretation of satellite imagery and digital terrain model, before beginning field work. Given the size and geometrical configuration of the area, the field visit to the study area took four days.

The soil survey work in the field was carried out by three teams of three persons each. Of the three persons, one was chief pedologist; another was the assistant and helper. 140 observation

points were made in the field, of which 27 are complete profiles and the rest are surveys. The 27 profiles were opened in representative locations of the soil units found in the field.

The observations of soils were made by the method of surveying. At each observation point was made the description of soil features in the different layers/horizons, the number of which depended on the nature and depth of the soil. The description also included the external features of the soil and the site environment of each observation point. The external soil features include topography, micro relief, and slope, signs of erosion, rocky outcrops, vegetation and land use. Regarding internal features, it was described the colour, soil texture, consistency, spots, rough matter, existence of carbonates, drainage and depth of groundwater, if it existed within the features control section (0-120 cm).

For the description of soil profiles, holes were opened measuring 1.0 x 1.0 x 1.5 m such that the side to be described was placed opposite to the irradiation of the sun at the moment of description. The horizons found in profile were identified and described, with special attention to the diagnostic horizons. The horizons were properly marked in accordance with the method of Soil Survey Staff (1992). Here also, the external and internal features of the soil were described as well as the local environment of the profiling site. From the point of view of internal features (morphological), the profile was described in terms of the following parameters:

- Thickness of horizons;
- Colour of soil
- Soil texture
- Soil consistency
- Cor do solo;
- Rooting depth;
- Abundance e size of roots;
- Abundance e size of pores;
- Abundance e size of rough matter;
- Existence of spots and/or specks;
- Existence or not of carbonates;
- Existence or not of clay particles on the structural elements;
- Existence of physical impediments;

- Existence of groundwater.

The field work lasted 21 days, which was determined by the workload, given the access conditions to the observation points and the complexity of the area, in terms of number of units soils preliminarily identified and their spatial distribution.

Lab analyses

The lab analytical data is an important component of the study of soils. However, it should be noted that not all of chemical, physical and mineralogical measurements are always necessary. Obviously, the purpose of the study is to determine the type of analyses to be made. For this study the following analyses were made:

- **Soil texture.** Determined by the pipette method, which is based on the use of sodium hexametaphosphate and soda carbonate mix as a dispersant.
- **Soil acidity** (expressed in pH). The pH was determined in the water at a concentration of 1N and measured through the titrimetric method, in a relation a soil: water of 1:2.5.
- **Organic Matter**. The organic matter was measured by the Walkley and Black method. This method consists of indirect measuring through the carbon oxidation with potassium dichromate in medium acid.
- **Bases of exchange (Ca, Mg, K, Na)**. These were first extracted from the soil based on the extraction method with a buffered solution of ammonium acetate at pH 7. Subsequently, Ca and Mg were measured by flame photometer, K and Na were determined by the method of complexometry (EDTA), using calcon and black eriochrome T as indicators.
- **Hydrogen + Aluminum**. These were determined by the method of titration with 0.025N NaOH after filtration.
- **Cationic exchange capacity (CEC)**. This was calculated by adding more Al cations and H.
- **Assimilable phosphorus.** The assimilable phosphorus was determined by the method of Olsen, using a stripper solution of Sodium Bicarbonate having pH 8.2, with UV spectrophotometer.
- **Electrical Conductivity.** Measured in saturated paste of soil with the electronic method, in a relation soil: water 1:2.5.
- **The carbonate** was measured simply by the level of effervescence shown by the soil when subjected to HCl diluted to 10%.

Data processing

The soil data collected in the field, properly coded, were introduced in the mildware known as Soil Database (SDB) and Excel for processing. The SDB allows information from soil profiles to be well systematized, which facilitates the identification and taxonomic classification. The Excel spreadsheet allowed the determination of quantitative parameters for the different soil classifications.

Soil classification

Once all data for the soils was collected, the classification of soils took place, using two classification systems, namely **FAO**-WRB 2006, and the **National Soil Charter** ***(Legend to Soil Charter of Maputo Province and southern Gaza)***. Such will enable both communication and correlation of the results of this study with those of other studies conducted in the country. For example, the system of the National Soil Charter proves valuable because it is easily understood and used by anyone, even if not versed in soil science. The FAO system is currently, the one which allows international communication on the soil resource. In fact, the system of the National Soil Charter was adopted for mapping soil, while the FAO was used as a translation of the international system.

Preparation of the final soil map

The analysis and interpretation of soil data resulted in the preparation of soil maps. As previously mentioned, the soil mapping system was based on the National Soil Charter and may be reclassified in terms of the FAO-WRB 2006 system. The soil map, at the scale 1:250 000, was prepared using a GIS mildware (Arc-Map Arc-View version 3.1).

3. Results

This chapter presents the main findings of this study. First, the issues arising from the analysis of existing documentation (secondary data) are presented. These are mainly associated with natural physical environment of the study area. It then presents the results related to the soils (primary data), in terms of major groupings and main features of soils found in the study area.

3.1 Natural Physical Environment of Study Area

3.1.1 Climate

There are various systems and methods for the analysis and classification of climate, e.g. Coppen and trewarth, Ready, Tornthwaite, among others. For the present study the method of Torthwaite was adopted. Importantly, in the study area there are two types of predominant climates. A climate type covering the area from Mapai to Pafuri, while the other goes from around Mapai to Massingir. According to the climate classification method of Tornthwaite, the climate of the Mapai to Pafuri area is **Arid** and the one from Mapai to Massingir is **Semi-arid**. Both are mega thermal with null excess of water and small thermal concentration (**DA'da'**).

To characterize these climate zones, the observed historical weather data from the meteorological stations in Pafuri and Massingir was used. In the Massingir data, inexistent information was on evapotranspiration, average day and night temperatures, which in this case were extracted from the Chokwe Meteorological Station data (Chokwe is the nearest station to Massingir). Note that the data are quite old (period 1971-1981) and more recent and systematized data was not found on the study area. Table 1 show the climatic data and water

balance of the Pafuri to Mapai area, which derived from historical data from the Meteorological Station of Pafuri.

Table 1. Weather information and water balance at Pafuri area.

Month	Avg-T	Max-T	Min-T	T-day	T-night	Avg-HR	U	P	ET	Bal
	oC	oC	oC	0C	oC	%	m/seg	Mm	Mm	Mm
Jan	26.4	35.3	21.5	30.8	25.4	64	2	**77.7**	175.5	**-97.9**
Feb	26.1	34.7	21.5	30.4	25.4	66	1.9	**63.2**	146.2	**-83**
Mar	27.2	34	20.4	29.6	24.6	66	1.9	**36.3**	143.7	**-107.4**
April	25.4	33.3	17.7	28.1	22.7	65	1.9	20.1	124.3	**-104.2**
May	21.7	30.2	13.2	24.8	19	64	1.3	4.9	88.4	**-83.5**
June	19	28.3	9.7	22.4	16.2	64	1.6	6.5	73.5	**-67**
July	19.2	28.9	9.4	22.7	16.2	63	1.8	0.7	84.5	**-83.8**
Aug	21	30.7	11.4	24.6	17.9	59	2.3	3.3	121.2	**-117.9**
Sept	24.5	33.4	15.7	27.7	21.4	58	2.7	6.9	158.2	**-151.3**
Oct	27	35.4	18.6	30	23.7	59	2.9	15.9	197.7	**-181.8**
Nov	27.8	35.5	20.2	30.5	24.6	63	2.5	**45.9**	188.2	**-142.3**
Dec	28.4	35.8	21.1	31	25.2	62	2.1	**75.5**	152.7	**-77.2**

Year	24.48	32.96	16.7	27.7	21.9	62.8	2.1	356.9	1654.1	

T=temperature; HR=Relative humidity; U=Wind speed; P=Rainfall; ET =Evapotranspiration

As can be seen from this table, this area has an average annual rainfall of about 357 mm, thus very low, and an average annual evapotranspiration of 1654 mm, being relatively high. The data shows that the area has two distinctly different seasons, a rainy season which lasts from November to March and a dry one from April to October. It is noteworthy to mention that the evapotranspiration is somehow greater (almost double) than precipitation throughout the year, implying the existence of a large permanent water deficit in the area. This indicates the absence of a crop growth period, as shown in **Figure 2**. In accordance with Kassam et al. (1982), growth period is defined as that during which precipitation exceeds half the evapotranspiration. However, one must take into account that this is an average situation, therefore it provides for the possibility that in one or another year, there could be some growth period even if very short. So this is an area with major limitations for the production of dryland annual crops.

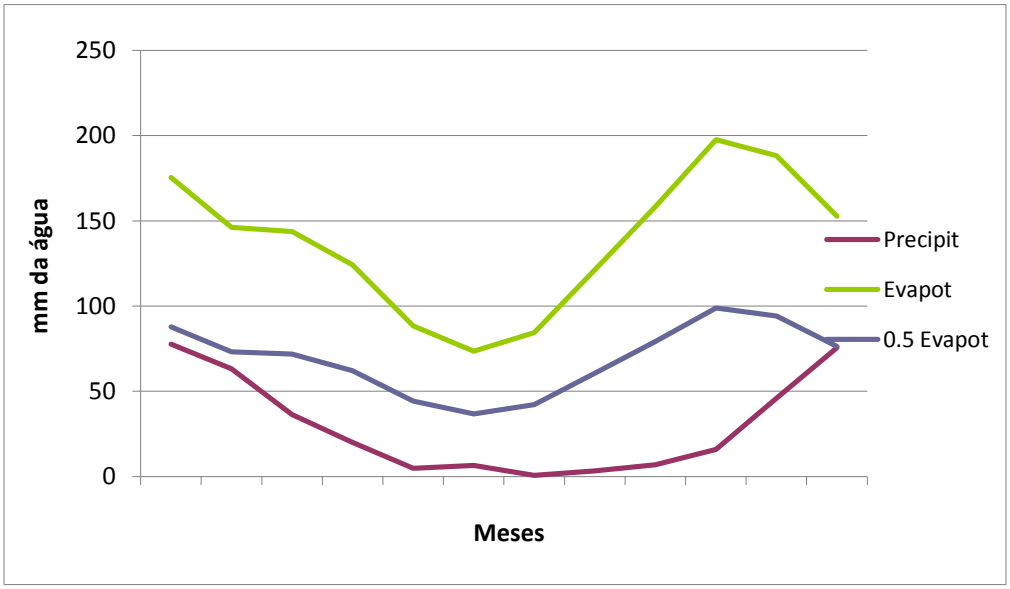

Figure 2. Average Monthly Rainfall, Evapot e 0.5 Evapot. (Pafuri).

The average temperature in this area is about 24.5°C, with the highest and lowest of 33°C and 17°C respectively. During the day, the average annual temperature reaches 27.7°C, while at night the annual average is 21.8°C. These temperatures are quite high, implying that the levels of evapotranspiration of crops are also relatively high. Such means the presence of high levels of water requirements for crops in this area. In a situation of high water deficit (P-ET), crops may easily experience a strong water stress, which could obstruct their development. These temperature also imply that in cases of possible irrigation, the supply of irrigation water will be

relatively high, which may translate into increased energy needs for water pumping (larger pump size and short intervals of irrigation).

The relative humidity does not exceed 66%, with an average of 62.75%, so quite low when compared with the tropical and subtropical zones. However, it is favorable to the development of many crops and unfavorable to the development of disease-causing agents (fungi) to crops.

Table 2. Weather information and water balance at Massingir area.

Month	Avg-T	Max-T	Min-T	T-day	T-night	Avg-HR	U	P	ET	Bal
	oC	oC	oC	0C	oC	%	m/seg	Mm	Mm	Mm
Jan	28	34.1	21.9	*27.4*	*24.3*	75	2.5	**95.1**	*167.5*	**-72.4**
Feb	27.5	32.9	22.0	*27.5*	*24.5*	79	2.5	**85.7**	*137.5*	**-51.8**
Mar	26.6	32.2	21.1	*26.8*	*23.8*	78	2.1	**62.8**	*130.4*	**-67.6**
Apr	24.8	31.1	18.5	*25.1*	*22.2*	77	2.0	27.8	*58.9*	**-31.1**
May	22.2	29.6	14.7	*23.3*	*20.0*	73	2.0	24.0	*78.2*	**-54.2**
June	19.1	26.9	11.3	*21.4*	*18.3*	72	1.8	4.5	*52.5*	**-48**
July	18.6	26.9	10.4	*21.1*	*18.1*	74	1.8	3.6	*59.4*	**-55.8**
Aug	20.4	28.0	12.7	*22.7*	*19.5*	73	2.1	9.8	*86.3*	**-76.5**
Sept	23.1	30.3	15.9	*24.1*	*20.6*	73	2.3	24.4	*120.8*	**-96.4**
Oct	25.4	32.0	18.9	*25.3*	*21.7*	70	2.6	27.1	*154.9*	**-127.8**
Nov	26.4	32.4	20.3	*26.3*	*22.8*	71	2.3	**87.2**	*155.8*	**-68.6**
Dec	26.7	32.5	20.9	*27.4*	*24.0*	73	2.4	**73.9**	*170.6*	**-96.7**
Year	24.1	30.7	17.4	*24.9*	*21.7*	74	2.2	525.9	1372.8	

T=temperature; HR=Relative humidity; U=Wind speed; P=Rainfall; ET =Evapotranspiration

NB: All the data refers to Massingir (1971-1981) except the day and night temperatures and Evaporation (ET).
Source: SIR M MacDonald & Partners Ltd e Hunting Technical Services Ltd (1983)

The climatic data from the Massingir area is shown in Table 2. To refer that all data was observed in Massingir, in the period from 1971 to 1981, with the exception of evapotranspiration (ET),

average day and night temperatures, which were extracted from the average meteorological data related to Chokwe Station (Nearest station to Massingir).

This area has an average annual rainfall of about 526 mm, therefore covering an area larger than Pafuri, and an average annual evapotranspiration of about 1373 mm. The data of the table also shows a climate of two seasons, namely the rainy and dry. The rainy season lasts from November to March, while the dry season runs from April to October, and in this respect it is similar to the climate of the Pafuri area. Moreover, the evaporation is also significantly greater than the precipitation throughout the year, implying that the water deficit is also constant in the area. However, it is important to note that the growth period starts in November, but has an interval in December and resumes in January, terminating in March. There is no humid period during which the precipitation exceeds evapotranspiration, as illustrated by **Figure 3.** This feature climate obviously imposes a limitation for the production of dryland annual crops.

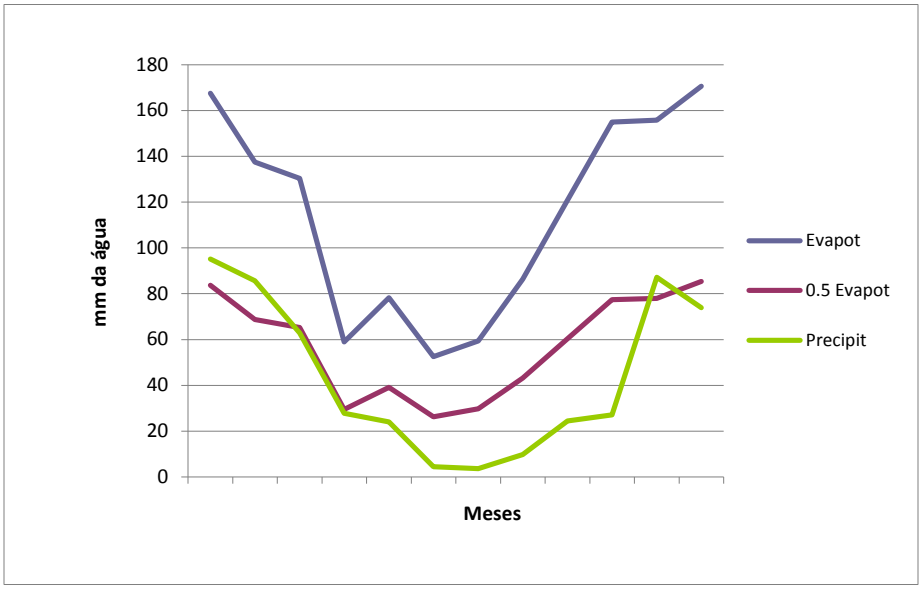

Figure 3. Average Monthly Rainfall, Evapot e 0.5 Evapot (Massingir).

The average annual temperature in this area is around 24.1 ° C, with a maximum and a minimum of about 30.7 ° C and 17.4 ° C respectively. During the day, the average annual temperature reaches 24.9 ° C, while at night annual average is 21.7 °C. Here too, though to a lesser extent than in Pafuri, the temperature values are relatively high, implying that the levels of evapotranspiration of crops are also quite high. The implications for agricultural production are similar to those above for the situation of Pafuri. The relative humidity does not exceed 79%, with an annual average of 74%. However, it is favorable for the development of many crops and unfavorable for the development of disease-causing agents (fungi) to crops.

From the point of view of its influence on soil formations, the climate of the study area, due to its large water deficit, determines that there is a predominance of physical weathering of rocks, and few chemical weathering. In many instances, where some chemical weathering occurs, it

happens that some of the solutes precipitate again, forming, for example, secondary limestone. In general terms, such enable the soils of the study area to be very little evolved in terms of differentiation of pedogenetic horizons of their profiles.

3.1.1.1 Conclusion

The climate description of the study area leads to the following conclusions:

- The area has a climate from semi-arid to arid;
- The average annual temperature is relatively high;
- The average annual rainfall is relatively low;
- The average annual evapotranspiration is relatively high;
- There are two seasons, including rainy and dry;
- There is a large water deficit in the area in terms of the difference between average annual rainfall and average annual evapotranspiration;
- The relative humidity is quite low;
- The average values of precipitation and evaporation indicate that virtually no growth period exists that can sustain a full cycle of annual food crops and thus
- **The dryland agricultural production is generally very difficult, almost impossible, except for cases of alluvial areas which may benefit from residual moisture, capable of sustaining crops in some years.**

3.1.2 Geology

From a geological point of view, the LNP´s Support Zone is part of the sedimentary basin of southern Mozambique. Thus, according to the Geological Map of Mozambique in scale 1:250 000, the various geological formations in that area are mainly sedimentary in nature. Three geological settings occur in the area, namely the Alluvial Zone, Sedimentary Basin Zone and the Volcanic Rocks Zone. Thus, the geology of the area can be described on the basis of these two geological settings.

Alluvial Zone

The alluvial zone consists of two geological units, including the Sand , Silt and Gravel Aluvium Mantle (Qa) and the Gravel Fluvial Terrace Sand Mantle (Qt), both belonging to the recent Quaternary period (Holocene age). These geological formations exist throughout the course of the Limpopo, Elefantes and Chinguedzi Rivers.

Sedimentary Basin Zone

Such geological setting dominates almost the entire interior area of the LNP´s Support Zone. This includes geological units as the intermediate ***(TeAcs)*** and upper ***(TeAuc)*** conglomerate gritty members; basal ***(TeAbl)*** and upper ***(TeAul)*** limestone members ; eolian sand ***(Qe)***, mantle of fluvial clayey outwash ***(QPl)*** and arkosic sandstone (consolidated feldspathic sands) partially conglomerate ***(Tez)***. With the exception of the mantle of fluvial clayey outwash and aeolian sand, part of the Quaternary period, all of these geological members are from the Tertiary period.

The upper conglomerate gritty member extends from the South to the North portion and adjacent to the ***Qa*** and ***Qt*** units. In Northern portion, these units are separated by the basal upper limestone member until the Pafuri region. Following the upper conglomerate gritty member towards the interior, from Limpopo and Elefantes rivers is found the intermediate conglomerate gritty member. This unit also exists within the upper conglomerate gritty member in the form of small pockets, in the central part of the study area. Mainly, the intermediate conglomerate gritty member occupies much of the Southern portion of the area. Adjacent to this area towards the interior, the upper limestone member is found, which is also quite significant in this area.

The mantle of fluvial clayey outwash exists as patches, more or less isolated within the aeolian sand units, which occupy most of the Western portion of the Limpopo River, from North to South. This unit ***(Qe)*** exist in the higher and flattened parts, with some intervals (very few) of drain lines or small depressions. The arkosic sandstone exists bordering the drainage incisions and small valleys.

Volcanic Rocks Zone

This geological setting is found in the Northern portion of the study area, near the border with the Republic of South Africa. The main unit that exists in the Volcanic Rocks Zone is *balato* ***(JrLb)***, which belongs to the Jurassic period. The same exists in a small portion at the South of the study area, near the border with the Republic of South Africa.

Therefore, the geological formations of the study area are, basically, comprised of sedimentary rocks, some more or less consolidated and others unconsolidated (clastic). The sedimentary rocks are more or less consolidated, predominantly from the Tertiary period, while the unconsolidated belong to the Quaternary (latest). Obviously, the geological configuration described above, largely determines the geomorphological nature (which causes the morphogenetic processes) as pedogenetic (which determines the type of soil) of the study area.

3.1.3 Geomorphology and Physiography

In geomorphologic terms, according to the Geomorphological Charter (scale 1:1 000 000), the study area belongs to the so-called Littoral Zone of Accumulation Plains (Zone C), more specifically called the Limpopo Plain Accumulations Area.

The interpretation of digital terrain models (SRTIM and Shaded Hills for Africa and Europe), combined with the geological map, revealed that, in the study area, one can distinguish three main scenic areas, namely, Alluvial Plains (lesser altitudes), Slopes shaped as heavily dried wavy areas (intermediate altitude) corresponding to sedimentary formations of the Tertiary period and finally Flattened Surfaces relatively high (higher altitudes) from Pleistocene period. These scenic areas are briefly described in the following section.

Alluvial Plains

This type of landscape is found along the Elefantes, Limpopo, and Shingwedzi rivers. This physiographic unit is located in dimensions ranging from 30 to 100 meters. It is divided into several sub-units, such as natural dykes, complex of terraces and small decantation basins. The alluvial plains are covered by soils derived from recent alluvial sediments, predominantly fine-textured, at the decantation basins, and textured soils more or less thick, in the natural dykes.

Wavy Slopes of Tertiary Formations

This landscape is a transition between the Alluvial Plains and Flattened Surfaces of Pleistocene period. This is a surface based on the sedimentary formations of Tertiary period (calcareous sandstone, conglomerate sandstone, calcareous marl, etc.) and to the Northwest, there are small patches of the rhyolite complex, which develops along the border with the Republic of South Africa.

COBA (1986) asserts that this physiographic unit encompasses heterogeneous areas with very active morphogenesis, it is a slope, eroded and with high stoniness. In some areas, with smooth slopes, there are more or less evolved soils, whereas along some drainage lines there are soils derived from colluvial deposits. This physiographic unit can be subdivided into four sub-units such as:

a) Colluvial Depressions

These areas are concave, with little representation, located along some drainage lines. The soils of these areas are derived from colluvial materials from the higher surrounding areas, relatively deeper and with finer textures.

b) Smooth Slopes

These are nearly flat areas with slopes that do not exceed 5%. They exist in the lower part of the pediment consisting of small hills and interfluves, particularly in the area of contact between the Tertiary slopes and alluvial zone. Here there are relatively deep soils of medium to fine texture of limestone material.

c) Area of wavy or smoothly wavy relief

These areas are eroded, and with heterogeneous soils and higher content of rocky fragments (stoniness). The soils of these areas derive from sedimentary materials more or less consolidated and others unconsolidated. When derived from consolidated materials of calcareous nature (calcareous limestone, marl), they tend to exhibit relatively fine textures. However, when derived from non-calcareous materials (non-calcareous conglomerate limestone, irregular gravel), they have coarser textures.

d) Very steep areas

These areas are very dissected with a high density of drainage lines forming interfluves and convex channels with slopes between 15 and 25 percent. These areas have very shallow soils with many rocky fragments of round gravel type.

Flattened Surface of Pleistocene period

This landscape corresponds to the highest level of sedimentary formations in the region, reaching the dimensions ranging from 150 to 300 meters. Some authors (eg. COBA, 1983) believe that it is part of a large flattened surface of unconsolidated formations, mainly sandy of Pleistocene, which, upon their deposition, covered the entire region to the eastern border of the rhyolite complex and subsequently removed in the areas crossed by the Elefantes river and its main tributaries, uncovering the underlying formations.
It is a permeable surface where the pedogenesis tends to dominate over the morphogenesis, except the steep areas where erosion is most active. Soils in this physiographic unit are predominantly sandy.

So this geomorphological configuration acts as a modifying agent (through morphogenetic processes) in the relation between geology (which provides the source material) and soil, which specific characteristics are the result of pedogenetic processes on such source material, in time and space.

3.1.4 Vegetation

The general outline of the vegetation of the study area is presented by Peter and Barbosa (1955). In their description, these authors point to the existence of diverse floristic formations, depending on different geomorphic and edaphologic conditions in this area. This study provides a summarized general characterization and not strictly technical, as this does not fit the context.

Such characterization results from general observations made during the soil survey in the field. For example, they refer to the existence of edatic deciduous suplained forests, riverine forests or galleries, medium and high, bushy, hydrophilic in the rainy season and xerophilous in the dry season (phycimimosipholy of Acacia spp, Albizzia spp, Combretum spp, *Tamarindus indica*, African Cordyla, etc. on the banks of some river banks of torrential regime, such as the Lilau River). There is a long period of drought, especially in the lowlands, subplains, sub littoral and Coastal areas (Peter J. Gomes, LA Grandvaux Barbosa, 1955 – *A Vegetação – em Esboço do Reconhecimento Ecológico Agrícola de Moçambique*).

Field observations during the soil survey, determined that the alluvial zone, in uncultivated areas is dominated by gallery forest, with species such as *Acacia Xantopholeae, Acacia nigrensis, Cordyla africana, Tamarindus indica* and a range of herbaceous and woody creepers. The peripheral part of the alluvial zone is dominated savanna bush with *Cassia spp*., some gramineous lays and some palm species.

In the area of undulated slopes of the Tertiary formations, there are semi-open, deciduous and woody forests dominated by Xanatse *(Colophospermu mopane)* in association with herbaceous subshrubs; shrubby savannah, dominated by different gramineous layers, *aloe spp.* and a variety of shrubs, woody savanna, dominated also by different gramineous layers, among other tree species, *Combretum spp*. and Xanatse (*Colophospermu mopane*). In some cases there is a mixed savanna (shrub and tree).

The flattened white yellowish zone generally has a combination of bushy forests and woodlands. In the forests there are different species of trees which comprise of two or three layers with species as *Terminalia cericea*, marula tree (*Sclerocarya cafra*), xanatse (*Colophospermum mopane spp*), and herbaceous and woody creeps. The bushy woodlands have few large trees, but predominantly a combination of shrubs, herbaceous and woody creeps. In areas with sandy soils which are very thin and orange, there are species commonly known as *simbiri*.
These forest formations respond and influence the different soil conditions of the study area.

3.1.5 Hidrology

The LNP´s Support Zone is drained mainly by the Limpopo and Elefantes rivers, with its main tributary, the Shingwedzi river in particular. The Limpopo and Elefantes rivers run throughout the year, but the former has shown a significant reduction in the flow during the dry season that

lasts from April to November. The Elefantes River has less reduction in the flow as it is regulated by the Massingir Dam. The small tributaries of these rivers are predominantly seasonal and torrential in nature, therefore they have some flow during rainy season.

The hydrological configuration of this area, largely determines the spatial distribution of community centers. There is a tendency of communities to be located near the rivers, as these are the main source of water for human consumption, animal and crops. It is also along the basins of the rivers where the best soils for agriculture (in terms of fertility and water retention capacity) can be found.

3.1.6 Access routes

The study area can be accessed by a paved road that runs from the town of Chokwe to the Massingir village. From Massingir there is a dirt road that is easily passable during the dry season, but with some difficulties during the rainy season. The difficulty in the rainy season is associated with the existence of areas with low and miry clay soils that do not allow the movement of vehicles, even with four-wheel drive. This road branches into several others in the area, to give access to diverse communities living here from Massingir to Pafuri.

3.2 Soils

Soils are the central focus of this study. In this section, the results of the soils study are shown in greater detail. It should be noted that the mapping basis of soils for this study is the Legend to National Soil Charter in the scale of 1:250 000. The criterion to identify the different soil units of this legend is geology and geomorphology. In the present study these two aspects were complemented by vegetation coverage and land use, when differentiating soils. No reiterate that the mapping units herein generally show an average purity of 70%, meaning that the proportion of 30% in each of the units consists of a set of inclusions (complex or miscellaneous of different soil types). As afore-mentioned in sections of this report, there is a strong correlation between geology, geomorphology/physiography and soils. Thus, the soils of the study area will be described according to their location in the geological and physiographic mosaic of the area.

3.2.1 Soils of alluvial area

The alluvial area is subdivided into landforms such as natural dike, complex of terraces and decantation basin. As such, the soils in this area observe this standard of subdivision. A general feature of soils in the fluvial area is that are soils originating from recent fluvial sediments (Holocene and tend to have a stratification of layers differentiated in their properties, indicating deposition of sediments at different times. Below is a general description of the alluvial soils in the area, according to their physiographic location.

Natural dyke soils (Soil groups Fs, 39072 ha)

The natural dyke is the highest platform of the fluvial area, and in many cases, marks the boundary between the riverbed and the complex of river terraces. Thus, the soils of this physiographic unit, representing 10.29% of soils in the study area, have a relatively light texture.

The topography of the area is almost flat, with a slope that does not exceed 1.5%. The representative profile of these soils (GL004P) presents a sandy to silty loam texture, throughout its depth, which varies in different layers. The dominant colour of the soil is brown when dry and dark brown when wet. These are well to excessively drained soils and without rocky fragments.

These soils from neutral to slightly basic reaction, presenting a pH ranging from 7 to 7.8. The organic matter content is low to medium, ranging from 0.23 to 2.09%. They have a high relative content of plant nutrients (saturation bases of 80 to 95%), while the nutrient retention capacity of these soils varies from low to medium (the cationic exchange capacity of the adsorption complex thereof ranges from 3.7 to 3.22 cmol (+) / kg of soil). The soil is not saline nor sodic.

Pursuant to the Legend to Soil Charter of Maputo Province and southern Gaza, these soils belong to the soil group **Fs**, which are described as stratified alluvial soils of medium to coarse texture. In the FAO-WRB 2006 system. They are classified as **Haplic Fluvisols (arenic).**

To emphasize that the combination of the nature of reaction (pH), organic matter levels, base saturation, cationic exchange capacity, and soil texture infer that these soils have a low to medium fertility, which makes them suitable for production of some annual crops (peanut, cowpea, cassava, etc.) and some semi-permanent one such as pineapple, provided there is enough water for these crops. Their light texture suggests that these soils are easily workable, with both manual hoes as well as modern tools.

Terrace complex soils (Soil group Fa2, 2546 ha)

Immediately after the natural dyke from the river, there is the terrace complex. This subunit of the fluvial area occupies the intermediate platform, i.e. lower than the natural dyke, but higher than the decantation basin. In fact, this comprises the overflow mantle. The complex is located on an almost flat topography, which slope does not exceed 1.5%. The soils of this physiographic unit represent approximately 0.70% of soils in the study area.

The representative profile of the soils of this unit (GL005P) presents a texture ranging from silty-clay-loam to clay throughout its depth, varying in different layers. The soils have a brown colour when dry and dark brown when wet. They have an average, slightly strong structure of angular anisoform type. They are slightly hard, friable, plastic, sticky and without rocky fragments.

The pH ranges from 7.1 to 8.1, from mildly to moderately basic. The content of organic matter in these soils, ranges from 1.35 to 3.96%, so a level which is considered low to high. Their relative

content of basic nutrients in plants is very high (base saturation ranging from 90 to 92%) as well as its nutrient retention capacity (cationic exchange capacity from 32 to 41 cmol (+)/kg). There are neither salts nor sodics. They do not present effervescence to HCl (10%), therefore, do not have carbonates.

These soils are very fertile, with the capacity to support a sustainable farming system, based on different annual (maize, beans, vegetables, etc.) and perennial crops (fruit trees such as banana, mango, papaya, citrus, avocado, etc.), subject to compliance aspects of improved agricultural management.

Considering the Legend to the Charter of Soils of Maputo Province and southern Gaza, these soils may be included in the soil group **Fa**, which are alluvial soils of fine texture. However, this study made a subdivision of this group in **Fa1** and **Fa2**, to meet the situation of least heavy fine textured soils, or existence of a coarse or medium layer after 50 cm, and another much heavier fine textured soils, without the existence of thick textured layer, respectively. This case comprises of a least heavy fine textured alluvial soil, thus group **Fa2**. In the FAO-WRB 2006 classification system, they belong to the class of **Mollic Fluvisols (eutric, siltic).**

The main limitation of these soils for agricultural use relates to their susceptibility to flooding. So its exploitation should take into account the periodic information on weather conditions. When they are exploited for irrigated agriculture, it is necessary to observe aspects of proper drainage to prevent salinization and consequent degradation of the soils.

Complex terrace soils (Soil group Fa2n, 117 ha)

This soil unit results from the subdivision the **Fa2** unit into **Fa2** and **Fa2n**, to highlight the alluvial soils of fine texture with sodic phase. The **Fa2n** soils unit, unlike the **Fa2** soil unit**,** have a subsoil has extreme concentration of sodium. This unit is found in a significant decantation basin in an area very close to Pafuri (GL04AP). However, in the general context of the study area, it has very little expression, representing approximately 0.031% of soils in the area.

The horizon A is clay loam, greyish-brown, with robust, large structure of prismatic type. It has a hard, firm, sticky and plastic consistency. It does not have effervescence to HCl (10%). At 51 and 71 cm, it has a silty sandy layer resting on clay loam layers. The organic matter content ranges from 0.45 to 3.20%, from low to high. The soil reaction varies from neutral to slightly basic (pH 7.4 to 9.2). The relative content of nutrients are very high (base saturation of 88.24 to 100%) and the nutrient retention capacity is from high to very high (cationic exchange capacity of 20-60 cmol (+) / kg of soil). They are not saline but are extremely high in sodium (PST from 26 to 69%), thus reaching very toxic levels for crops.

In terms of classification, according to the Legend to Charter of Soils of Maputo Province and southern Gaza, they fit into the soil group of **Fa** unit, with alluvial soils of fine texture; but in the

case of this study, these are considered to be in the **Fa2n** soil group, with alluvial soils of least heavy fine texture and extremely high in sodium . In the FAO-WRB 2006 classification system, they are included in the **Mollic Fluvisols (sodic)** unit.

These soils have a severe limitation for agricultural use, coupled with the extreme concentration of sodium that reaches toxic levels for crops.

Decantation or depression basin soils (Soil group Fa1, 15594 ha)

The decantation basin occupies the lower portion of the terrace complex, where the river waters deposit finer and more fertile sediments. In some cases it is associated depression basins or small lagoons, found in one or another site between the smooth slopes and alluvial zone. Here, the heavier soils of the alluvial zone predominate, occupying about 4.11% of the soils of the study area. The topography of soils in the area is plain.

The representative profile (GA024P) of these soils has a silty-clay-loam to clayish texture, dark brown when dry and dark greyish-brown when wet. They have a predominately robust, fine to medium structure, of angular anisoform to prismatic or columnar type. They are mild to hard, friable to very firm, plastic, sticky with rare rocky fragments. They present an organic matter content ranging from 0.2 to 2%, representing a low to medium level. The pH ranges from 8.2 to 8.8, indicating a moderately basic soil condition. The relative content of nutrients is very high (base saturation of 100%), as well as the nutrient retention capacity (the cationic exchange capacity ranges from 48 to 107 cmol (+)/kg). They are not saline but contain moderate sodium (PST of 11.9 to 26.8%) and contain effervescence of HCl (10%), i.e. they have carbonates.

In the Legend to Soil Charter of Maputo Province and southern Gaza, these soils fall also in the **Fa** soil group, being alluvial soils of fine texture, but in the case of this study, they are considered as **Fa1** unit, because these soils are alluvial with much heavier fine texture and without the existence of medium or coarse texture. In the FAO-WRB 2006 classification system, they are included in the **Mollic Fluvisols (eutric, clayic)** unit.

These are also very fertile soils, with potential to farming based on annual food crops. However, it is very important to safeguard the problem of high sodium concentrations, poor drainage and the risk of floods. Here, for example, it is necessary to establish a good drainage system and adopt the habit of incorporating organic matter in the soil using crop residues, grasses or even animal manure, to improve the structure, porosity, and consequently good circulation air and water in the soil.

3.2.2 Wavy slope soils of the Tertiary period

This zone comprises of heavily wavy and dissected physiographic areas in the form of narrow interfluves; wavy areas, gently wavy areas, low colluvial and gentle slopes. In heavily wavy areas, the soils are predominantly very shallow on round and irregular gravel of variable size, in other areas, on gritty material of calcareous nature or on non-calcareous conglomerate gritstone.

In gently wavy areas, there is a combination of shallow soils and moderately deep soils, as well as many rocky fragments of variable form on gritty conglomerate or limestone material. On gentle slopes, the predominant soils are moderately deep to deep of medium to fine texture. In the small valleys, the soils are deep and also predominantly thin in texture. To emphasize that in some cases, the different types of soils of this physiographic unit are found combined, in a manner that they cannot be mapped separately. The following is the characterization of the main soil units of this physiographic area.

Shallow clay soils on round gravel on heavily wavy areas (SI unit, 4881 ha)

These are lytic soils for depths less than 30 cm, overlying the round gravel into a matrix of fine earth, which exist, mainly on the tops of narrow interfluves and hills with slopes over 30%. The soils of this physiographic unit occupy about 1.29% of all soils of the study area. The representative profile (GL002P) presents a molyc horizon A (0-31 cm thick), dark brown when dry and very dark brown when wet. They have a silty clay texture, granular, fine, weak structure, mild consistency, friable, slightly sticky and slightly plastic. They show various rocky, average, regular and round fragments of quartz nature.

It has a slightly acidic reaction (pH 6.4) and a high organic matter content (4.00%). These soils presents a relatively high content of nutrients (base saturation of 86.63%) and a high nutrient retention capacity (cationic exchange capacity of 52.00 cmol (+) / kg of soil). The soils do not have a high concentration of sodium or salt. They do not show effervescence to HCl, implying that they lack carbonates. The horizon C is found at 30 cm, consisting of a mixture of smooth and well round gravel, and smooth stone blocks equally well round in a clayish matrix.

In accordance with the Legend to Soil Charter of Maputo Province and southern Gaza, these soils may be included in the **SI** group, which comprises of shallow soils of fine texture on a mantle of round pebbles. In the FAO-WRB 2006 system, these are classified as **Mollic Leptosols (skeletic, clayic).**

The soils of this unit have severe limitations for agricultural use, as they are very shallow, the topography and stoniness.

Shallow soils of coarse texture on round gravel of very wavy areas (unit SI1, 4090 ha)

These lytic soils are for depths less than 30 cm, overlying the round gravel into a matrix of fine earth, found in areas of steep slopes of flattened much higher areas (dimensions of more than 300 m). These soils differ from the SI group for having a relatively coarse texture. Its dimension represents approximately 1.076688% of soils in the study area.

The representative profile (GL001P) shows an ochric horizon (0-15 cm thick), yellowish-brown when dry, reddish-brown when wet. It has a sandy silty texture, granular, fine, weak structure, mild consistency, very friable, not sticky and not plastic. It has many rocky, average, round and irregular fragments of quartz nature.

It has a slightly acidic reaction (pH 6.0) and low organic matter content (1.42%). It presents an average relative content of basic nutrients (base saturation of 62.68%) and the nutrient retention capacity is also low (cationic exchange capacity of 12.30 cmol (+) / kg soil). The soils do not have a high concentration of sodium or salts. They do not show effervescence to HCl, implying that they lack carbonates. The horizon C is found at 20 cm, consisting of a mixture of round gravel in a sandy-clay matrix.

According to Legend to Soil Charter of Maputo Province and southern Gaza, these soils may also be included in the **SI** group comprising of shallow soils of fine texture on a mantle of round pebbles. In the present study, these soils were distinguished from **SI**, to meet the characteristic of its relatively coarse texture. As such, these are considered as soils belonging to the **SI1** group. In the FAO-WRB 2006 system, they would be classified as **Haplic Leptosols (skeletic, arenic).**

The soils of this unit also have severe limitations for agricultural use, which include very shallow depth, topography, stoniness and coarse texture.

Shallow or moderately shallow soils of Mananga on round pebbles (unit Sm, 10902 ha)

These soils are located along the edge of the Mananga or post-Mananga platform where erosion has removed a portion of Mananga deposits. The slopes are relatively steep (2-5%) and drainage is better than in the highlands of the interior covered by Mananga or Post Mananga. These represent approximately 2.87% of soils in the study area.

They have a layer of 30-100 cm of Mananga overlying the round pebbles, as well as a matrix of Mananga. The gravel may extend to several feet above the changed substrate. The horizon A is ochric (10-20 cm), dark brown to grey-brown, clayish-sandy to silty sandy. It has a weak to moderate structure, fine to average subangular anisoform or robust. It is slightly hard, friable, not plastic nor sticky. It does not show the effervescence to HCl (10%) and its reaction is acidic to neutral (pH 5.0-7.0).

The cambic horizon Bw reaches 40-70 cm, very dark grey or dark yellowish-brown, with bulky or moderate, average structure and angular anisoform type. It is robust, slightly plastic and slightly sticky. The reaction is also acidic to neutral (pH 5.5-7) and does not show effervescence to HCl (10%). The horizon C consists of round gravel of different sizes mixed with a silty-clay-loamy matrix.

In the Legend to Soil Charter of Maputo Province and southern Gaza, these soils may be included in the **Sm** group, which entails shallow soils of fine texture on a mantle of pebbles. In the FAO-WRB 2006 system, they would be classified as **Haplic Cambisoils (skeletic, arenic).**

These soils present a set of limitations for agricultural use, associated with stoniness, wavy topography and, in some cases, their shallow depth.

Post-Mananga red soils on round pebbles (soil unit Sv, 1098 ha)

These soils are reddish-brown with a thickness of 30-100 cm, overlying the round pebbles. In general, they are found in association with P3 or M3 soil unit. (GS51S2) The horizon A is ochric, red or reddish-brown, silty sandy texture, weak, fine structure of subangular anisoform type. It is mild, friable, slightly sticky, and not plastic and does not show effervescence to HCl (10%).

The horizon B is cambic, red, silty-sandy-clay, weak, average structure, of subangular anisoform, slightly robust, friable, slightly sticky and slightly plastic and without effervescence to HCl (10%). The horizon C consists of a mixture of round gravel of different sizes and nature.

In accordance to the Legend to Soil Charter of Maputo Province and southern Gaza, these soils may be included in the **Sv** group, which includes low to moderately deep soils of fine to medium texture on a mantle of pebbles. In the FAO-WRB 2006 system, they are classified as **Leptic Luvisols (skeletic).**

Basalt lytic soils of strongly wavy areas (Unit BI, 43 ha)

These soils are very shallow found in a heavily wavy area, thus creating inselberg, with very steep slopes in the Pafuri area. The representative profile (GL003S) presents a mollic horizon A, brown, clayish loam texture, without effervescence to HCl. The horizon C consists of weathering bedrock fragments in a brown clayish matrix.

In the Legend to the Soil Charter of Maputo Province and southern Gaza, these soils may be included in the **BI** group, which includes very shallow soils of fine texture, developed on basalt rock. In the FAO-WRB 2006 system, they would be classified as **Mollic Leptososls (skeletic, clayic).**

These soils have severe limitations for agricultural use, which include wavy topography and shallow depth.

Shallow soils on non-calcareous rock of wavy and smoothly wavy areas (Soil units Wp, 61785, ha)

This unit is found on erosion terraces, which come in the form of narrow interfluves and sometimes as small rocky or stony hills, in a wavy topography with slopes ranging from 10 to more than 30%. It is believed that these interfluves and hills were formed by dissection, due to the erosive action of rainwater, of terraces based on sedimentary rocks of non-calcareous gritty conglomerate nature. They have a good to moderately excessive drainage and rapid runoff. The main characteristic of these soils is their shallowness and stoniness.

The representative profile (GS041P) of these soils shows a horizon **A** of silty sandy texture and a dark reddish-brown colour (5YR 3/3) when dry and the same colour but with code 5 YR 3/2 when wet. The structure is very weak, small and of a granular type. The soils are mild, very friable, not sticky nor plastic. This horizon has few rocky fragments consisting of fine gravel of predominantly quartz nature. Its organic matter content is very low (0.87) and its reaction is slightly acidic (pH 6.4).

The horizon **B** has a greater thickness (20-60 cm) than the horizon **A,** a silty sandy texture and a dark reddish-brown colour when dry, showing the same colour when wet. It has many rocky fragments fine, medium and coarse size, and quartz in nature. The organic matter content of this horizon is very low (average of 0.4%) and pH of 6.3, therefore slightly acidic. The horizon **C** is found 60 cm deep, the mixture consisting of regolith of the bedrock and some irregular and round gravel on a silty sandy matrix. All horizons do not show effervescence to HCl (10%), therefore, lacking carbonates.

In general sense, these soils have a relative content of basic nutrients which are considered average (bases saturation of 66.39% at horizon A and 63.2% for horizon B) and a low nutrient retention capacity (cationic exchange capacity of 9 cmol (+)/kg of soil at horizon A and 8.6 cmol (+)/kg of soil at horizon B) along its entire profile. They are not sodic or with salts. According to the Legend to Soil Charter of Maputo Province and southern Gaza, these soils fall within the **Wp** soil group, as shallow soils on non-calcareous sedimentary rock. In the FAO-WRB 2006 classification system, they would be included in the **Leptic Cambisols (dystric, arenic)** unit.

The main limitations of these soils for agricultural use include shallow effective depth, stoniness, topography, and in some cases, their texture.

Shallow soils on limestone material of wavy and mildly wavy areas (soil unit Wkp, 9260 ha)

This soil unit is very similar to the **Wp** unit, except that it rests on sedimentary rock of calcareous nature (calcareous conglomerate gritstone and/or marl). The representative profile (GLO23P1) of this soil unit shows a horizon A with thickness, also of 20 cm, silty sandy texture and a greyish-brown colour when dry and dark greyish-brown when wet. It has many rocky fragments comprised of medium and fine gravel of predominantly limestone nature. These soils present an organic matter content of 16.1%, which is low, and an almost neutral reaction (pH 7.3). They show a very high saturation base (98.45%) and a cationic exchange capacity equally similarly high (30 cmol (+)/kg). The soil has a strong reaction to HCl, thus indicating a significant presence of carbonates.

The horizon **B** has a silty sandy texture and a brown colour when dry and when wet. This horizon has more rocky fragments than horizon **A** comprised of medium and fine gravel, limestone in nature. The organic matter content of this horizon is very low (0.65%), while the reaction of the soil is slightly basic (pH 8.2). Here, the soil is also highly saturated in base (99.34%) and cationic exchange (cationic exchange capacity of 32 cmol (+)/kg). The soil of this horizon reacts strongly to HCI at 10% HCl, thus indicating high carbonate content.

The horizon **C** is found 60 cm deep and consists largely of regolith of calcareous sandstone and some round coarse gravel in a silty clay matrix. It has a silty clay texture and a dark brown colour (10 YR 8/2) when dry and light grey (10 YR 7/1) when wet. These soils can be approved as **Wkp** soils from the Legend to Soil Charter of Maputo Province and southern Gaza, as shallow soils on calcareous sedimentary rock. In the FAO-WRB 2006 classification system, they are classified as **Leptic Cambisols (calcaric)** or **Leptic Calcisols (skeletic).**

Similar to the **Wp** soil unit, these have major limitations for agricultural use, due to the shallow effective depth, stoniness and topography.

Mild slope soils of interfluves and hills (soil units M1 and M2)

The mild slopes are found mainly in the lower slopes, foothills and interfluves, thus comprising of more or less flat surfaces, with relatively deep soils of medium to fine texture. These slopes have more expression in the contact zone between the alluvial zone and the erosion terraces. In this area can be found soils developed on robust clayish sediments, imperfectly drained and predominantly high in sodium of the Tertiary period.

One of the features that these soils present in the study area is that they are covered by different thicknesses of the sand layer. For example, when they are found in the plain accumulation area (Southern portion of area), they tend to present in a sand coverage of thickness lesser than 25 cm (M1). When they are found in the most southern part, these present a superficial layer of sand with thickness ranging up to 50 cm (M2). In fact, the Mananga soils may still present with a sandy surface layer with thickness greater than 100 cm. Soils with a thicker sandy surface layer exceeding 100 cm are found mostly in the inner part of the study area. The following is a characterization of the M1 and M2 groups.

Mananga soils with sand coverage of 0-25 cm (Group M1, 11887 ha)

These soils exist in the wavy to almost plain topography, with slopes varying from 2 to 5%. The vegetation is dominated by shrubs of *Acacia spp.* and various gramineous strata. They are clayish soils with black colour, thickness of more than 50 cm, covering the original geological deposits of brownish clay and cretaceous marl. The representative profile (GL039P) presents a horizon A of silty sandy texture, very dark brown when dry and black when dry. There is neither stoniness neither nor spots. The organic matter content is average (2.6%), while the soil reaction is slightly acidic, with a pH value that reaches 6.7.

The horizon B reaches a depth of 15 to 100 cm and its texture is silty-clay-sandy to clayish. It has a very dark brown colour (10 YR 2/2) when dry and black (10 YR 2/1) when wet, a strong, average structure of columnar type. Moreover, it has a robust to very robust consistency and firm to extremely firm when wet. It is plastic and sticky when wet. It displays ballstones of fine and medium, mild and irregular composition. The organic matter content is low, varying from 0.4 to 1.2% and the soil reaction is slightly alkaline (pH 7 to 8.7). it presents a considerable level of carbonates, as evidenced by the moderate to strong effervescence to diluted hydrochloric acid (HCl).

The horizon C starts at 140 cm and consists of ballstone material or greyish-dark or dark brown clay; moderate to strong, medium, prismatic structure; very robust; strong effervescence; abundant fine to coarse and irregular ballstones.

In the Legend to Soil Charter of Maputo Province and southern Gaza, these soils are approved as **M1** soil group, as Mananga soils with surface thickness of the sand layer below 25 cm. In the FAO-WRB 2006 classification system, they are included in the **calcic Solonetz (greyic**) unit.

These soils have medium to high fertility. However, a limitation is associated with the presence of sodium (very robust, sodium toxicity), in some cases, salinity, and poor to imperfect drainage.

Mananga soils with thickness of sand surface layer of 25 to 50 cm (Group M2, 43028 ha)

The Mananga soils covered in sand thickness of 25 to 50 cm also exist in the smoothly wavy topography with slopes varying from 2 to 5%. The vegetation comprises of small trees, predominantly Xanatse (*Colophospermum mopane*). These are clayish soils with greyish-brown colour, depth exceeding 50 cm, covering the geological deposits originating from brownish cretaceous clay. The representative profile (GL23AP1) has a horizon A of silty sandy texture, brown when dry and very dark grey when wet. There is neither stoniness nor spots. The structure is weak, medium, of angular anisoform type, a mild consistency when dry and very friable when wet. It is slightly sticky and slightly plastic when wet.

The organic matter content is very low (0.65%), while the soil reaction is slightly basic, with a pH value reaching 7.7. The relative content of basic nutrients is high (base saturation of 85.38%), and the nutrient retention capacity is average (cationic exchange capacity of 17 cmol (+)/kg of soil). It is neither sodic nor saline.

The horizon B reaches a depth of 21 to 100 cm and its texture is silty-clay-sandy to clayish. It has a dark reddish-brown colour when dry and the colour remains the same even when wet. Its structure is very robust, large of angular anisoform type. It has a consistency of solid to very solid when dry and firm to extremely firm when wet. It is slightly plastic and slightly sticky when wet. It displays ballstones of medium, mild and irregular composition. The organic matter content is low, varying from 0.3 to 0.5% and the soil reaction is basic (pH 9 to 9.3). It shows a very significant content of carbonates, evidenced by moderate to strong effervescence to diluted hydrochloric acid (HCl 10%). It is not saline, but has sodium concentrations (PST 16.3 to 46%).

The horizon C begins at 100 cm and consists of ballstones mixed with reddish-brown clay; the structure is weak to moderate, fine to medium, of angular anisoform type; mild; strong effervescence; dominant, coarse and irregular ballstones.

In the Legend to Soil Charter of Maputo Province and southern Gaza, these soils are soils approved as **M2** group, being Mananga soils covering a sand thickness of 25-50 cm. In the FAO-WRB 2006 classification system, they are included in the **Mollic Luvisols (sodic, calcaric)** unit.

The main limitation of these soils is related to the sodicity (hard, possible sodium toxicity).

Soils of longitudinal depressions and narrow valleys (soil unit C)

The longitudinal depressions and small narrow valleys exist among the rhyolite hills and calcareous and non-calcareous sedimentary rocks, with fine, medium and coarse texture. Often these depressions and narrow valleys connect to alluvial areas. These soils can be subdivided into colluvial soils of rhyolite foothills (Cs), colluvial soils derived from sedimentary rocks with medium texture (Cw2), colluvial soils derived from sedimentary rocks with coarse texture (Cw3), colluvial soils derived from sedimentary rocks with fine texture (Cw1), black limestone colluvial soils (Cc).

Colluvial soils on round pebbles of strongly wavy areas (Unit Cs, 375 ha)

These are clayish soils of rhyolite and basalt foothill and hills, or drainage incisions in these areas, where a clayish colluvium accumulated. The representative profile (GL02AP) presents a horizon A of 0-40 cm, with silty sandy soil texture, dark brown colour when dry and very dark greyish-brown when wet. It has a weak, medium structure of granular type. It is slightly robust, friable, slightly sticky but plastic. The soil has a slightly basic reaction, evidenced by the pH index, which reached a value of 8.3. The organic matter content is average (1.35%), the relative content of basic nutrients is very high (base saturation of 100%) and so is its ability to retain nutrients (cationic exchange capacity of 54.4 cmol (+)/kg). It is neither saline nor sodic. It shows a moderate reaction to HCl, meaning that has carbonate content.

The horizon B has a thickness ranging from 42 to 81 cm, a silty sandy texture and a brownish colour when dry and dark brown when wet. Its structure is weak, medium, of subangular anisoform type. It is hard when dry, slightly friable when wet, slightly sticky and slightly plastic. The soil reaction is slightly alkaline (pH 7.5) and organic matter content is low (0.90%). This horizon shows a soil with a very high level of availability of plant nutrients (base saturation of 100%) as well as retention of these (cationic exchange capacity of 56.2 cmol (+)/kg of soil). It is neither saline nor sodic. It shows a moderate to strong effervescence to HCl.

The horizon C is found at 82 cm and more than 150 cm deep. It consists of mixed limestone regolith with very large fragments (round stones) of rhyolitic and basaltic nature in a silty sandy matrix of greyish-brown colour when dry and dark greyish-brown when wet.

In terms of classification, based on the legend to Soil Charter of Maputo Province and southern Gaza, on the scale of 1:250 000, these can be included in the **Cs** unit, as colluvial soils on round pebbles. In terms of the FAO-WRB 2006 system, they can be classified as **Colluvic Cambisols (siltic)**.

These soils have good fertility and good physical properties. Thus, they can positively sustain crops production, subject to the availability of moisture in the soil.

Clayish colluvial soils derived from sedimentary rocks (Unit Cw1, 4476 ha)

These are very heavy clayish soils, with greyish-brown or black colour, sometimes with cracks. They are found at depression basins in the foothills, near the rivers, mostly in the southern part of the study area. The representative profile (GA029P2) of these soils shows a horizon A of clayish loamy texture, a dark brown colour when dry and very dark brown when wet. It shows a crack that can reach 0.25 m wide. There is no stoniness neither spots nor oxidation/reduction. The organic matter content of this horizon, lies between 2.4 to 3.0%, it is medium, and the soil reaction is slightly basic, with a pH of 7.3. It has a high relative content of basic nutrients (base saturation of 98%) and very high nutrient retention capacity (cationic exchange capacity of 50 cmol (+)/kg of soil). It is not saline but slightly sodic (PST from 5 to 15%).

The horizon **B** has a clayish texture, a very dark brown colour when wet. This horizon is very thick, reaching up to 100 cm. The soils present no stoniness or cementation. The organic matter content lies between 0.5 and 2.0%, being low to medium while the pH ranges from 7.9 to 8.7, thus being moderately basic to basic. It has a very high relative content of basic nutrients (base saturation ranging from 98 to 100%) and high nutrient retention capacity (cationic exchange capacity of about 31-52 cmol (+)/kg of soil). It is not saline, but sodic (PST ranging from 15 to 50%). These levels of sodicity may be of concern in these soils. It shows a slight effervescence to HCl (10%), indicating a slight presence of carbonates.

The horizon **C**, which exists at more than 150 cm deep, is dominated by a high content of mild ballstones of medium and coarse size, which occupies about 80% of its matrix. It shows a silty-clay-sandy texture and very light greyish colour.

Regarding its classification, according to the Legend to Soil Charter of Maputo Province and southern Gaza (1:250 000), these soils fall within the **Cw1** group, as clayish colluvial soils derived from calcareous sedimentary rocks. In the FAO-WRB 2006 system, they are classified as **Sodic Vertisols (calcaric, eutric).**

The main limitations of these soils include imperfect or poor drainage, and sometimes, high concentrations of sodium and flooding. Importantly, the farming sustainability of these soils can only be achieved through the use of an adequate irrigation and drainage system. The drainage issue shall play a very important role in the control of sodicity. Soils with high sodium content tend to present a robust structure, which can obstruct the penetration of plant roots and movement of water and air. Thus, it will be necessary to adopt the habit of incorporating plenty of organic matter in the soil. Some of the soils of this group, which have poor drainage, could be better used to grow rice as long as appropriate crop practices are followed.

Colluvial soils of medium texture derived from sedimentary rocks of wavy areas (Unit Cw2, 1000 ha)

These soils are silty-sandy-loam to deep clayish, with sandy topsoil to silty sandy and light brown colouring. These soils exist in the foothills, in the depressions and in the incision areas of the drainage system of hilly landscapes of sedimentary rocks.

The representative profile (GL006P) presents a molic or ochric horizon A with 0-20 cm thickness, having clayish texture and brown colour when dry and greyish-brown when wet. The soils present a weak, medium structure of subangular anisoform type, mild consistency, very friable, slightly sticky and slightly plastic. The soils do not have rocky fragments or effervescence to HCl (10%). Their organic matter content is moderate to high (3.4%) and its reaction is slightly basic. Its relative content of basic nutrients is high (base saturation of 82.82%) and an average capacity to retain such nutrients (cationic exchange capacity of 13:27 cmol (+)/kg of soil). It is neither saline nor sodic.

The horizon B is very thick, silty-clayish-sandy to clayish, brown to very dark greyish-brown colour. It has a very weak to strong, medium to coarse structure of anisoform subangular type, with a mild to slightly hard consistency, very friable to friable, plastic and slightly sticky. It has many fragments in the lower layers and does not show the effervescence to HCl (10%). The organic matter content varies from low to medium (0.23 to 2.84%), whilst the soil reaction is slightly basic (7.53 to 7.79). The relative content of basic nutrients is high to very high (base saturation of 86.38 to 100%) and retention capacity of such nutrients is medium to high (cationic exchange capacity from 12.87 to 30.96 cmol (+)/kg of soil). It is neither saline nor sodic.

The horizon C exists at 120 cm depth and consists of many, large rocky fragments, mixed with a mass of limestone. It has a silty texture and light brown colour. It displays medium sized brown spots. It has a weak, columnar average structure, slightly hard, friable, sticky and slightly plastic consistency.

Taking into account, Legend to Soil Charter of Maputo Province and southern Gaza (1:250 000), these soils can be classified as soils from the **Cw** unit group, as colluvial soils derived from sedimentary rocks of Cretaceous and Tertiary period. In the FAO - WRB 2006 system, these can be classified as **Colluvic, Fluvic Cambisols (clayic).**

These soils do not have many limitations for agricultural use, except that in some cases there is some stoniness in the subsoil.

Colluvial soils of coarse texture derived from sedimentary rocks (Unit Cw3, 7800 ha)

The colluvial soils of coarse texture are found in the drainage lines of hills, predominantly with sandy texture. Indeed, these soils are very similar to **Cw2,** regarding their geomorphic position, except to the soil texture which, in this case, is coarser. The representative profile (GL016S) presents an ochric horizon A of silty sandy texture and light brown colouring. The structure is very weak, fine of granular type. It is mild, very friable, not sticky and not plastic. There is no stoniness or carbonates (without effervescence to HCl (10%)). It is not saline or sodic.

The horizon Bw is cambic, with silty clayish texture, very light brown colour. The structure is weak, fine and medium of angular anisoform type. It is slightly robust, friable, slightly plastic and slightly sticky. There has stoniness or carbonates (without effervescence to HCl (10%)). It is not saline or sodic.

The horizon C exists at 120 cm and consists of fragments, irregular fresh and slightly changed stones.

In terms of classification, according to the national system (Legend to Soil Charter of Maputo Province and southern Gaza, scale 1:250 000), these soils can be classified as **Cw3** soil group, as colluvial soils derived from sedimentary rocks of Tertiary period with coarse texture. In the FAO-WRB 2006 system, these soils can be classified as **Haplic Cambisols (dystric).**

The **Cw3** soils, due to its predominantly coarse texture, have low to moderate fertility, in terms of nutrient content and retention capacity. Moreover, they tend to have low to moderate water retention capacity.

Colluvial soils derived from Mananga platforms (Unit Cm, 7032 ha)

Clayish colluvium accumulated in depressions formed between the Mananga soil platforms. These soils result from erosion of the Mananga mantle in relatively high regions. These soils are very hard. The representative profile (GA022S) shows a molic horizon A of silty-clayish-sandy texture and very dark brown colour. Their structure is moderate, average of subangular anisoform type. It is slightly hard, firm, slightly sticky and slightly plastic.

The horizon B is silty clayish, very dark grey, with robust s, very hard, very firm, slightly sticky and slightly plastictructure. The horizon C presents bedrock fragments of calcareous type, mixed with other types of rocky fragments and clayish soil matrix. In the Legend to Soil Charter of Maputo Province and southern of Gaza (1:250 000), these soils are classified as **Cm**, which means colluvium soils of Mananga. In the FAO-WRB 2006 classification system, these can be classified as **Mollic Cambisols (calcaric**).

These soils are fertile; however, they have physical properties somewhat unfavorable, regarding the solid consistency and robust structure. This could interfere with good rooting of crops and farming. The poor drainage would interfere with soil aeration. From the chemical point of view, these soils have problems of salinity and/or sodicity.

Unspecified sandy soils derived from arkosic or conglomerate gritstone (Group A, 32035 ha)

In some erosion terrace areas of the Tertiary, there are soils of sandy texture derived from arkosic or conglomerate sandstone (consolidated feldspathic sands). These soils are moderately deep to deep, with greyish or yellowish brown colour. In some places, there are some rocky fragments in the underlying layers/horizons.

The representative profile (GL030S) presents a horizon A of brown-greyish colour, sandy (medium to coarse sand) texture and a simple grain structure. It is loose, not plastic neither sticky. The horizon B is very thick, it has a light brown, sandy texture (medium sand), with additional structure than simple grains. It presents some (rare or few) fragments of fine size and of quartz nature.

In the Legend to the Soil Charter of Maputo Province and southern Gaza (1:250 000), these soils are included in the **A** soil group, meaning unspecified sandy soils. In the FAO-WRB 2006 system, they can be classified as **Haplic Arenosols (greyic).**

These are soils of very low fertility and low water holding capacity, which entail the main limiting factors for agricultural use.

3.2.3 Soils of Flattened and Raised Areas of Pleistocene period

This area is located further inland of the study area, which is the highest within the study area. It is flat, without rocky outcrops or stoniness. Farther northwest, the flattened area is located at a higher altitude, which reaches more than 300 m. In this portion of the area, the flattened and raised area is limited by small very steep areas, which bases form small valleys. In this area, the soils tend to be very shallow and very stony. To the midwest and southern parts, the altitudes are lower, reaching up to 200 and 100 m, respectively. In those parts, the soils are predominantly sandy, with some wetlands in the form of small lakes. The following is the characterization of these soils.

Red soils derived from red gritstone (Unit G, 2512 ha)

These are red sandy soils of coarse granule size with homogeneous subsoil. Some red sandstone, angular and subangular gravel can be found at more than 1 m deep. They exist in high almost flat points, with slopes that do not exceed 2%. These soils are excessively drained.

The representative profile (GLO2P1) presents an ochric horizon A (0-20 cm) of coarse sand, reddish-brown when dry and dark red when wet. The structure is very weak, fine of granular type. Its consistency is very mild, very friable, not sticky or plastic. It does not present stoniness and no effervescence to HCl (10%). It is not saline or sodic. The soil reaction is moderately acidic (pH 5.9) and the organic matter content is very low (0.65%). The relative content of nutrients is medium (base saturation of 45.16%) and a nutrient retention capacity which is very low (cationic exchange capacity of 6.4 cmol (+)/kg of soil). It is not saline or sodic.

The horizon Bw has a very wide thickness, perhaps measured in meters, the texture is sandy to silty sandy, reddish-dark, when dry, reddish-brown when wet. It presents a similar structure and consistency to horizon A, but the structure tends to evolve in the deeper layers. It is mild, very friable, not sticky and not plastic. It does not show effervescence to HCl (10%).
In terms of classification, based on the Legend to Soil Charter of Maputo Province and southern Gaza, on the scale of 1:250 000, these can be included in the **G** unit, as sandy soils derived from red sandstone. In terms of the FAO-WRB 2006 system, they can be classified as **Ferralic Arenosoils (dystric)**.

These soils have a low fertility and very low water retention capacity. These are the major limitations that these soils have in the agricultural perspective.

Orange sandy soils on conglomerate gritstone (Group Aj, 32814 ha)

These soils are very similar to the soils of group G, but they have a sandy texture dominated by medium to coarse sand. The representative profile (GL029S1) has a sandy horizon A (medium sand), a dark reddish-brown colour, and no structure except simple grains, loose, no fragments and no effervescence to HCl.

The horizon B is very thick and has a sandy texture (medium to fine sand) and red colour, also without except the simple grains. It is loose, not plastic or sticky. There has carbonates because they do not show effervescence HCl (10%), nor stoniness.
In the Legend to Soil Charter of Maputo Province and southern Gaza, on the scale of 1:250 000, these can be included in the **Aj** unit for orange sandy soils. In terms of the FAO-WRB 2006 system, they can be classified as **Ferralic Arenosoils (dystric).**
These soils have the same limitations as those soils of group G.

Post-Mananga Soils of coarse texture (Unit P3, 21491 ha)

These soils cover the plateaus and slopes near the main drainage lines in the Mananga area. These are sandy or silty sandy soils, reddish brown, usually reaching major depths. They are very homogeneous and have a cambic horizon, if the texture requirements are fully met. The representative profile (GA27B2) has an ochric horizon, silty sandy texture and reddish-brown colour when dry and dark reddish-brown when wet. The grain structure is simple, while the consistency is loose, non-sticky and non-plastic. It shows no stoniness or effervescence to HCl (10%).

The horizon Bw is silty sandy to silty-clayish-sandy, reddish-brown when dry and wet. It has a weak structure of subangular anisoform type. It is loose to mild, friable, slightly sticky and not plastic. It has neither stoniness nor effervescence to HCl (10%). These soils may be included in the **P3** group on the Legend to Soil Charter of Maputo Province and southern Gaza, on the scale of 1:250 000, as Post-Mananga soils. In the FAO-WRB 2006 system, they can be classified as **Ferralic Cambisols (dystric**).
Its coarse texture suggests that these are soils on the one hand, have low fertility in terms of content and nutrient retention capacity, and on the other very low water holding capacity.

Mananga soils with sand coverage of 50-100 cm (Group M3, 17116 ha)

The soils of this unit are generally similar to soils M1 and M2, and they differ from the other two types in terms of the sand coverage thickness, which, in this case, it ranges from 50 to 100 cm.

These soils tend co-exist with the **Aj** orange sandy soils. The **M3** soils are found in the slightly depression parts of the **Aj** soil. They are soils with a thick sandy layer up to 60 cm and a silty sandy to silty clayish subsoil. The representative profile (GA55S1) has an ochric or umbric horizon with sandy texture (medium sand), greyish-brown colour, simple, loose granular type of structure, not plastic or sticky. It lacks stoniness or effervescence to HCl (10%).

The horizon Bw is silty sandy, yellowish brown, weak, fine structure of granular type. It is very mild, very friable, not plastic, but slightly sticky. There is no stoniness or effervescence to HCl (10%). It is not saline, but slightly sodic.
In the Legend to Soil Charter of Maputo Province and southern Gaza, on the scale of 1:250 000, these soils are classified as **M3** soil group, described as Mananga soils of sandy coverage with 50 to 100 cm thickness. In the FAO-WRB 2006 system, they can be classified as **Haplic Cambisols (arenic, sodic).**

The main limitation of these soils for agricultural use is related to the sandy texture, in the layer of 0 to 100 cm. This leads to low fertility and low water holding capacity.

4. Soil Assessment

Every study of soils only has practical utility if it has any interpretative component, which in this case consists of assessing the suitability of soils for various alternative uses. In this study we used the evaluation method of land defined by the USDA (United States Department of Agriculture), which is known as **"Land Capability Classification"**. This method of evaluation is to assess the suitability of soils for rain-fed agriculture in general. It is important to point out that this method does not take into account the climatic limitations, much less the ecological requirements specific to each type of crop. This allows you to simply evaluate the suitability of soils for dry land agricultural use in general.

4.1 Land Suitability pursuant to USDA Method

The land assessment method of USDA evaluates the suitability of land for dry land agriculture in general terms, thus, it does not consider the specific use, in terms, for example, of a particular crop. On this method, the suitability of land for dry land agriculture is given in eight classes. The suitability classes are as follows:

- **Class I to IV**: classes of arable land, reducing excellent suitability (I), good (II), moderate (III) to marginally suitable (IV);
- **Class V to VI**: classes of land suitability not suitable for agriculture but suited for grazing;
- **Class VII**: class suited to forestry, the land is preferably used for forests and;

- **Class VIII**: class of land unsuitable for commercial use. The land is used for permanent preservation, wildlife and natural reserve;

To indicate the type of limitations for a particular land, the land assessment method of uses the USDA subclasses of suitability. For that adopts the following suffixes:
t: limitation of land set by unfavorable topography and slope, including risk of erosion;
i: limitation of land related to high risk of flooding;
d: limitation of land due to poor drainage conditions;
s: limitation of land associated with the texture of the unfavorable soil and subsoil;
b: limitation of land due to surface stoniness;
c: limitation of land for coarse fragments on the surface;
w: limitation of land due to shallow soil;
f: limitation due to low soil fertility and;
n: limitation due to soil salinity and sodicity.
Importantly, the classes of major agricultural suitability classes are also suitable for non-agricultural uses. For example, a class of arable land is also suitable for grazing, agroforestry etc. and the class of land suitable for grazing is also suited for forestry, etc. and so on.

Table 3 presents the land capability quantification of land suitability, according to the USDA method.

Table 3. Land capability qualification in accordance with USDA method. Legend: Ag=clay soil, Ar=sandy soil, F=silty soil, Li=loam soil, f=thin, g=thick soil, m=solid, s=sub angularan isoform structure, v= vertical properties.

Limitations	Classes							
	I	II	III	IV	V	VI	VII	VIII
1. Topography **- slope % (t)**	0 - 2	2 - 6	6 - 12	12 - 25			25 - 55	> 55
2. Humidity **-flooding (i)** **- drainage (d)**	none good	none moderate	none Light Light imperfect	None Light Imperfect or better	none Severe Bad to better	none Severe Bad to better	Very strong Bad to better	Very strong bad to better
3.Soil physical features **- soil texture** **. surface (s)** **. subsoil (s)** **- coarse fragments (%)** **. surface (b)** **. subsoil (c)** **- stoniness (%)** **. surface (b)** **- rocky outcrops (%)** **. surface (a)**	FAr –Ag FAg<60s 0	ArF-Ag<60s AgArLi<60 0 – 15	ArF-Ag<60v ArF-Ag<60s 15 – 35	Arg-Ag>60 Ag-Ag>60 35-55 55-75	Ag-Agm Ag-Agm 35-55	Ag-Agm Ag-Agm 35-55	Ag-Agm Ag-Agm > 55	Ag-Agm Ag-Agm >< 55 >< 75

- soil depth in cm (p)	0 – 15 0 0 > 150	15 – 35 0 – 0.01 0 - 2 100 - 150	35 – 55 0.01 - 0.1 2 – 10 50 – 100	0.1 0.3 10-25 30-50	55-75 0.3-15 25-50 10-30	55-75 0.3-15 25-50 10.30	> 75 15-75 25-50 10-30	>< 75 >< 75 >< 10
4. Soil fertility **- CTC of clay (f)** **- bases saturation (f)** **- organic carbon (f)**	> 16 cmol/kg > 80% > 1.5 %	< 16 cmol/kg 50 - 80 % 1 - 1.5	< 16 cmol/kg 35 - 50 0.6 - 1.0	. 15-35 0.4-0.6	. 15-35 0.4-0.6	15.30 0.4-0.6	>< 15 >< 0.4	>< 15 >< 0.4
Salinity and sodium content **- Ece dS/m (n)** **- PST (%) (n)**	0 – 2 0 - 8	2 - 4 8 - 15	4 - 8 15 - 25	> 8 > 25	> 8 > 25	. .	> 8 > 25	. .

4.2 Agricultural Suitability of Soils in the Study Area Pursuant to USDA Method

In order to make a general assessment of land suitability, the relevant characteristics of each soil units in the study area were confronted with the quantitative specifications of the evaluation criteria of USDA method, as shown in Table 3. The evaluation results are shown in the last row of Tables 4a - c which follow below.

Table 4a.

Limitations	**Soil Unit**							
	Fa1	Fs	Cm	Cw2	M1	M2	Cw3	P3
1. Topography **- slope % (t)**	0 - 1	0 - 2	0 - 2	0 -2	2 - 5	2 - 5	2 - 5	2 - 5
2. Humidity **-flooding (i)** **- drainage (d)**	Moderate Light imperfect	Moderate Good	Moderate Light Imperfect	None Moderate	None Moderate to imperfect	None Moderate to good	None Good	None Good
3. Soil physical features **- soil texture**								

. surface (s) **. subsoil (s)** **- coarse fragments (%)** **. surface (b)** **. subsoil (c)** **- stoniness (%)** **. surface (b)** **- rocky outcrops (%)** **. surface (a)** **- soil depth in cm (p)**	FrAgLi Ag<60s 0 0 – 5 0 0 > 150	FrLi<60s FrAr<60 0 0 0 0 > 150	FrAg FrAg 0 0 0 0 > 100	FrAr FrAr>60 5 30 3 0 100	FrAgAr AgAr 0 0 0 0 > 100	ArFr FrAgAr 2 5 0 0 100	ArFr FrAr 0 0 0 0 > 150	Ar-FrAr FrAr 0 0 0 0 > 150
4. Soil fertility **- CTC of clay (f)** **- bases saturation (f)** **- organic carbon (f)**	78.1 cmol/kg 95% 1.16 %	12.1 cmol/kg 80 % 0.49	33 cmol/kg 87 0.76	56 100 0.54	33.24 97.63 0.54	37 96.67 0.23	17 88 0.45	
Salinity and sodium content **- Ece dS/m (n)** **- PST (%) (n)**	2.84 11.86	0.13 2.27	3.41 15. 25	0.78 4.54	1.08 18.25	0.60 16.26	0.06 0.47	. .
Class	IIId(i)	IIIf	IIIdni	IIIb	IVdn	IIIn	IIIfs	IIIfs

Table 4b.

Limitations	**Soil Unit**						
	Cs	M3	SI1	SI	Wkp	Wp	Cw1
1. Topography **- slope % (t)**	0 - 2	0 - 5	15 - 30	15 - 30	10 - 15	10 - 15	0 - 1
2. Humidity **-flooding (i)** **- drainage (d)**	None Moderate	None Moderate	None Good	None Good	None Good	None Good	Strong Imperfect to bad
3. Soil physical features **- soil texture**							

. surface (s) **. subsoil (s)** **- coarse fragments (%)** **. surface (b)** **. subsoil (c)** **- stoniness (%)** **. surface (b)** **- rocky outcrops (%)** **. surface (a)** **- soil depth in cm (p)**	FrAr FrAr 0 5 0 0 150	Ar FrAr-FrAgAr 0 0 0 0 > 150	FrAr FrAr>60 5 30 3 0 30	Ag Ag 40 60 20 0 30	FrAr FrAr 10 40 0 0 60	ArFr FrAr 2 40 2 0 59	AgLi Ag 0 0 0 0 > 150
4. Soil fertility **- CTC of clay (f)** **- bases saturation (f)** **- organic carbon (f)**	55.47 cmol/kg 100.00% 0.66 %	15 cmol/kg 50 0.2	10.66 62 0.82	48.27 85.47 1.72	30.43 99.03 0.48	7 66.39 0.28	40 99 1.1
Salinity and sodium content **- Ece dS/m (n)** **- PST (%) (n)**	0.61 4.23	0.2 2	0.01 1.22	0.08 0.84	0.17 0.96	0.06 1.48	0.6 35
Class	IIIf(d)	IVfs(d)	VIIpbe	VIIpbe	Vpbe	Vpbe	IVdni

Table 4c.

Limitations	**Soil Unit**							
	Fa2	Fa2n	BI	Sm	Sv	Aj	A	G
1. Topography **- slope % (t)**	0 - 2	0 - 2	25	10	10 - 15		25 - 55	> 55
2. Humidity **-flooding (i)** **- drainage (d)**	Light Moderate	None Imperfect	None Good	None Good	None Good	None Good	None Good	None Good
3. Soil physical								

features								
- soil texture								
. surface (s)								
. subsoil (s)	FrAgLi	AgLi<60s	AgLi	ArFr	FrAr	Ar	Ar	Ar
- coarse fragments (%)	Ag<60s	FrAgAr<60	Ag	FrAr>60	FrAgAr	Ar	Ar	ArFr
. surface (b)								
. subsoil (c)								
- stoniness (%)								
. surface (b)	0	0	0	5	0	0	0	0
- rocky outcrops (%)	0	0	0	30	60	0	0	0
. surface (a)								
- soil depth in cm (p)								
	0	0	0	3	0	0	0	0
	0	0	5	0	0	0	0	0
	> 150	> 150	30	> 50	40	> 150	> 150	> 150
4. Soil fertility								
- CTC of clay (f)	38.09 cmol/kg	47.78 cmol/kg	40 cmol/kg	12	30.36	5.45		5.76 Cmol(+)/kg
- bases saturation (f)	96.58%	96.72 %	90	65	85.63	54.03		59.39 %
- organic carbon (f)	1.28 %	0.85	0.7 %	1.2 %	0.64 %	0.18 %		0.19 %
Salinity and sodium content								
- Ece dS/m (n)	0.23	2.61	0.2	1.50	0.09	0.07		0.04
- PST (%) (n)	3.08	45.15	0.20	0. 2	0.87	1.06		2.26
Class	II(i)	VIIdn	VIIpe	Vipbe	Vpb(e)	IVfs	IVfs	IVfs

4.2.1 Description of agricultural suitability of soils

Below is the description of soil suitability for dry land agricultural, according to its geomorphic location.

<u>Soils of Alluvial Areas (Groups Fa1, Fa2, Fa2n and Fs)</u>

Group Fa1

The soils of group Fa1 may be considered as soils of arable land. These have a general moderate capacity of agricultural suitability (Class III d (i)), particularly due to problems of soil drainage, which is slightly imperfect and, in some areas, their slight susceptibility to flooding during seasons of intensive rain, given its location at low altitudes and proximity to rivers. Thus, these soils are recommended for agricultural use, but attention should be paid for information on the floods and adequate practices of soil management to prevent their degradation. If these steps are followed properly, a good farming system may be developed, based on many annual and some perennial crops (banana, papaya). They have an excellent suitability for grazing.

Group Fa2

The soils of group Fa2 have good agricultural suitability (Class **IId (i)**). This class derives from its good physical and chemical properties, even though it shows some susceptibility to flooding. In effect, these are soils with high productive potential in the study area. They are even suited for the development of drainage and irrigation systems, particularly based on method of gravity irrigation.

Group Fa2n

These soils have serious limitations for agricultural use, which is associated with extremely high concentration of sodium, which can reach toxic levels for many annual and perennial crops. In some areas, there are drainage deficiencies. As such, these are regarded as unsuitable for agricultural use and considered for Class **VIdn**. However, these soils are well suited for grazing.

Group Fs

This group of soils is also for arable land, however, with a general and moderate agricultural suitability (Class **IIIf(s)**). The soils belong to this suitability class as a result of its moderate fertility related with the average content of carbon, basic nutrient medium and low content of clay minerals. In some areas, the soil has a coarse texture, which leads to low retention capacity of water and nutrients. The latter, in some cases, limits the irrigation suitability of these soils, particularly the **Fs** of coarse texture. In places where irrigation is probable, it is necessary to pay attention on the choice of the irrigation method, in which case, the spray irrigation method is more recommended than the gravity irrigation.
The farming of these soils requires a major effort in order to overcome these limitations; this is the case of incorporating large amounts of organic matter, application of moderate doses of mineral fertilizers and spray irrigation in order to achieve good yields and productivity of crops. These soils are excellently suited for grazing.

<u>Colluvial Soils (Groups Cs, Cw1, Cw2 and Cw3)</u>

Group Cs

The soils of the group Cs provide a good suitability for agricultural use (Class IIIf(d)). The main limitation is fertility, particularly on the issue of organic matter (organic C). These soils are recommended for the production of many annual agricultural crops. They are also excellent for grazing.

Group Cw1

The soils of the group Cw1 show a marginal suitability for agricultural use (class is **IVni**). This results from possible toxicity of sodium and sometimes susceptibility to flooding in seasons of intense rainfall. However, after heavy rains, the soils can retain good moisture contents capable of sustaining crops, for some raining intervals. These soils can be recommended for agricultural use, observing the risk of floods and carefully managing the irrigation and drainage in order to obtain good crop yields and soil resource conservation. The soils of this group have excellent suitability for grazing.

Group Cw2

They are arable soils with moderate suitability for agricultural use (Class **IIIb**). The main limitation of these soils is the stoniness of the subsoil. However, the level of stoniness does not prevent the farming of these soils, although the yields are not as high as expected. They have good suitability for grazing.

Group Cw3

The soils of this group also have moderate suitability for agricultural use (Class **IIIfs**). The main limiting factors are moderate fertility and medium-coarse texture. Thus, these are recommended for agricultural use. However, it is necessary to deal with fertility problems and unfavorable texture, including the management of crop stubbles for the increase of levels of organic matter, which in turn may improve capacity of crops to retain water and nutrients. This would be complemented by the addition of small doses of mineral fertilizer to meet the nutritional needs of crops and thereby obtaining good crop yields.

Group Cm

This is a group of soils belonging to arable land with moderate agricultural suitability (Class **IIIdni**). The main limitations of the agricultural capacity of soils include its slightly imperfect drainage, the possible toxicity of sodium and risk of flooding during heavy raining season. The agricultural use of such land should observe issues related to the cautious management of soils, including construction of small drains between small farming plots and main drains that allow rapid drainage of excess water. Here again, the management of crop stubbles is very important to improve soil structure.

Mananga Soils Platform (Groups M1, M2 and M3)

Group M1

The soils of group M1 show marginal suitability for agricultural use (Class **IVdn**). The main limitations are related to drainage defects and possible toxicity of sodium. Another limitation to these soils is the hardness of the mananga layer which, in addition to obstructing water infiltration it renders difficult the farming activity. These soils can be better explored for grazing.

Group M2

The soils of this group show a moderate suitability for agricultural use (Class **IIIn**). The main limitation of these soils is associated with possible toxicity of sodium. Sodium also allows the hardening of the subsoil, thus obstructing water infiltration. However, it can be recommended for use for dry land agricultural use for annual crops that are not very sensitive to considerable concentrations of sodium. These soils are excellent for grazing.

Group M3

The Mananga soils with a thick sandy surface layer (50-100 cm) have a marginal suitability for agricultural use (Class **IVfs(d)**). The limitations of these soils include low fertility, low capacity for water retention and sometimes poor drainage, especially when located in areas with depression. These soils are better for grazing.

Soils of Sandy Plain and Red Gritstone (Groups A, Aj and G)

The groups **A**, **Aj** and **G** share the features of being sandy, deep and low in fertility. Thus, these marginal soils have a marginal suitability for general agricultural use (Class **IVfs**). Its main limitations include low fertility and low water retention capacity. The soils of these groups can be better used for grazing and forestry.

Post-Mananga soils (Group P3)

This group of reddish deposits of coarse texture shows a marginal suitability for agricultural use (Class **IVfs**). Similar to groups **A**, **G** and **Aj**, it has limitations which are summarized in low fertility and low water retention capacity. As such, it is better used for grazing and forestry.

Soils of Sedimentary Rocks outcrops (Groups Wp andWpk)

The soils of these groups share four fundamental aspects, namely, that they are shallow, stony, located in a wavy topography and originated from the Tertiary sedimentary rocks. So, these are not suitable for agricultural use (Class **Vpbe**). The limitations of these soils are shallow, stony and the risk of erosion. The least effective depth and stoniness imply that the soil has less volume to be explored by the roots of plants. Therefore, a large number of crops can have difficulties to satisfactorily develop in these soils.

The sloping topography indicates that farming based on annual crops could lead to accelerated erosion of the soil, resulting in the rapid degradation of these, hence reducing in their ability to sustain the plants. However, these soils are suitable forest use, with the conservation of native species for the collection of firewood, poles and non-forest by-products (honey production). In areas with least accentuated slopes, these can be used for grazing. They may eventually also be used for the purposes of forest conservation and recreation.

Soils of Round Pebbles Platforms (Groups SI, SI1, Sv and Sm)

The soils of the groups **SI** and **SI1** are very shallow (0-30 cm) and based on round gravel. These soils are unsuitable for agricultural use (Class **VIIpbe**). Apart from very shallow depths, these soils are very stony and with steep slope, thus with a very high risk of erosion. The best uses of these soils are agroforestry or forest permanent conservation. The soils of groups **Sv** and **Sm** are also not suitable for dry land agricultural use (Class **Vpb(e)**). They present limitations of depth, stoniness, and in some areas, risk of erosion. These are suitable for grazing and forestry.

Soils of Vulcanic Rocks (Group BI)

These are soils originating from volcanic rocks located in areas with very steep and rocky outcrops. They are not suitable for agricultural use (Class **VIIpe**). The main limitations include very shallow depth and high risk of erosion. They can be used for agroforestry.

4.2.2 Conclusion

The assessment of the overall agricultural suitability of soils at the LNP Support Zone shows that only soils of the Alluvial Zone are suitable for agricultural use, with the exception of soils in Group Fa2n, which are extremely sodic. Following the Alluvial Zone are colluvial ones, which also have moderate suitability for agricultural use. The soils of the inner Flattened Raised Area are marginally suitable for agricultural use, or can be used, but with many difficulties, due to its low fertility and water retention capacity.

The soils of Mananga can be directed to use grazing, while the outcrops of Volcanic and Sedimentary Rocks are recommended for exclusive use for permanent forest conservation. The soils of Round Pebbles Platforms are suitable for grazing and forestry.

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6. Attachments

ANNEX A1. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL004P

Location: Pafuri-Cicualacuala Coordinates: Lat. 22º26´16´´S, Long. 31º21´48´´ E
Sheet: 83 Ground form: River Terrace Topography: Almost Plain
Soil Unit: (Local) **Fs** ; FAO-WRB 2006: **Haplic Fluvisols (arenic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-11 : dark yellowish-brown (10 YR 3/6) when dry and dark brown (10 YR 3/3) when moist; silty-loam; spotless; weak and fine structure of subangular anisoform type; gentle, very friable, slightly sticky and slightly plastic; rare pores, very fine, without rocky fragments; no mineral nodules; without effervescence; dominant roots, very thin; clear and plain limit.

B1 11-31 : dark (10 YR 4/3) when dry and dark brown (10 YR 3/3) when moist; loamy texture; spotless; weak and average structure of subangular anisoform type; gentle, friable, slightly sticky, plastic; rare pores, very fine, without rocky fragments; no mineral nodules; without effervescence; rare roots, very thin; clear and plain limit.

2B2 31-72: very pale brown (10 YR 7/3) when dry and brown (10 YR 5/3) when moist, sandy; spotless; grain simple structure; without porosity; no rocky fragments; no mineral nodules; without effervescence; rare fine roots; clear and plain limit.

2B3 72-105: Brown (10 YR 5/3) when dry and brown (10 YR 4/3) when moist, silty-loam; spotless; weak and fine structure of granular type; mild, very friable, not sticky and slightly plastic; few pores, very fine; without rocky fragments; no mineral nodules; without effervescence; rare and thin roots; clear and plain transition.

B4 105-145: Brown (10 YR 4/3) when moist; silty loam; spotless; weak and medium structure of granular type; not sticky, but plastic; few and thin pores; no rocky fragments; without mineral nodules; no effervescence; rare and thin roots; clear and plain transition.

B5 145-155: Brown (10 YR 5/3) when moist; spotless; sandy; simple grains, not sticky and not plastic; without pores; without rocky fragments; no mineral nodules; without effervescence; rootless.

Physical and chemical features

Sample GL004P													
	Horizon	A	Class	B1	Class	B2	Class	B3	Class	B4	Class	B5	Class
	Depth	0-11		11-31		31-72		72-105		105-145		145-155	
pH H_2O	(1:2.5)	7.35	Light Basic	7.69	Light Basic	7.25	Light Basic	7.39	Light Basic	7.77	Light Basic	7	Neutral
CEmS/cm	(1:2.5	0.103	Not saline	0.099	Not saline	0.057	Not saline	0.222	Not saline	0.19	Not saline	0.054	Not saline
C	%	1.21	Average	1.03	Average	0.13	Very low	0.32	Very low	0.64	Low	0.13	Very low
MO	%	2.09	Average	1.77	Average	0.23	Very low	0.55	Very low	1.1	Low	0.23	Very low
Ca	me/100g	15	Very high	16.6	Mto high	2.4	Low	7	High	13	Very high	3.6	Low
Mg	me/100g	5	Very high	6.2	Very high	0.4	Average	1.8	Very high	2	Very high	0.8	Very high
Na	me/100g	0.49	Average	0.72	Average	0.13	Low	0.21	Average	0.33	Average	0.15	Low
K	me/100g	0.74	Very high	0.4	Average	0.04	Very low	0.2	Low	0.28	Average	0.08	Very low
Al3++H+	me/100g	1.5	Not toxic	1	Not toxic	0.75	Not toxic	1	Not toxic	0.75	Not toxic	0.75	Not toxic
CTC	me/100g	22.3	Average	25.2	High	3.7	Very low	11.2	Low	18.4	Average	5.4	Low
P	mg/100g	1.692	High	1.036	Low	0.161	Very low	0.262	Very low	0.346	Very low	0.161	Very low
Clay	%	23.52		22.97		2.22		5.61		11.81		2.26	
Loam	%	49.84		40.11		0.63		9.74		26.75		0.81	
Sandy	%	26.64		36.92		97.14		84.65		61.45		96.93	
Class	Texture			Silty		Sandy		Silty sand		Silty sand		Sandy	

ANNEX A2. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL005P

Location: Pafuri-Cicualacuala Coordinates: Lat. 22º26´41´´S, Long. 31º23´50´´ E
Sheet: 83 Ground form: River Terrace Topography: Almost Plain
Soil unit: (Local) **Fa2**; FAO-WRB 2006: **Mollic Fluvisols (siltic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-18: Brown (10 YR 4/3) when dry, greyish-brown (10 YR 3/2) when moist, silty-clay-loam; spotless; moderate and large structure of subangular anisoform type; slightly hard, friable, sticky and slightly plastic; common, very fine and few average pores; without rocky fragments; no mineral nodules; without effervescence; many termite cavities; dominant, common, medium and very thin roots; gradual and plain transition.

B1 18-45: Greyish brown (10 YR 3/2) when dry and very dark brown (10 YR 2/2) when moist; silty-clay-loam; spotless; moderate and large structure of subangular anisoform type; slightly hard, friable, sticky and slightly plastic; dominant average and thin pores; without rocky fragments; without mineral nodules; without effervescence; common cavities unspecified; dominates very fine roots and common medium; gradual and plain transition.

B2 45-74: Dark brown (10 YR 3/3) when moist; clayish; spotless; very strong structure large of subangular anisoform type; sticky and slightly plastic; dominates Averages and fine pores; without rocky fragments; no nodules minerals; without effervescence; common, medium and large rare roots; gradual and plain transition.

B3 74-103: Dark brown (10 YR 3/3) when moist; clay-loam; few, small, distinct, diffuse and brown spots; very strong and large structure of subangular anisoform type; sticky and plastic; irregular and solid clay compacting; dominant, common, thin and average pores; without rocky fragments; rare, mild, averages, irregular, unknown in nature, black mineral nodules; without effervescence, thin, medium and rare roots; gradual and plain transition.

B4 103-150: Dark brown (10 YR 3/3) when moist, silty-clay-loam; few, small distinct, diffuse, brown spots; very strong and large structure of subangular anisoform type; sticky and plastic; irregular and solid clay compacting; dominant, common, thin and average pores; without rocky fragments; rare, mild, averages, irregular, unknown in nature, black mineral nodules; without effervescence; rare, thin and medium roots.

Physical and chemical features

Sample GL005P											
	Horizon	A	Class	B1	Class	B2	Class	B3	Class	B4	Class
	Depth	0-18		18-45		45-74		74-103		103-150	
pH H_2O	(1:2.5)	7.11	Light Basic	7.59	Light Basic	7.54	Light Basic	7.76	Light Basic	8.05	Mod. Basic
CEmS/cm	(1:2.5	0.211	Not saline	0.378	Not saline	0.251	Not saline	0.174	Not saline	0.173	Not saline
C	%	2.3	High	1.7	Average	1.46	Average	0.88	Low	0.79	Low
MO	%	3.96	High	2.93	Average	2.51	Average	1.51	Low	1.35	Low
Ca	me/100g	20	Very high	31	Very high	30.6	Very high	24.8	Very high	26.4	Very high
Mg	me/100g	6.6	Very high	5.8	Very high	5.6	Very high	6.4	Very high	7.4	Very high
Na	me/100g	1.36	Very high	1.28	Very high	1.12	Very high	0.98	High	1.02	Very high
K	me/100g	1.68	Very high	0.92	Very high	0.68	Very high	0.44	Very high	0.44	Very high
Al3++H+	me/100g	2.75	Light Toxic	1.25	Not toxic	1.25	Not toxic	1	Not toxic	0	Not toxic
CTC	me/100g	32.2	High	40.7	Very high	39.7	High	32.6	High	36.3	High
P	mg/100g	1.91	High	2.18	Very high	1.793	High	1.052	Low	0.834	Low
Clay	%	38.04		38.8		48.22		40.68		39.09	
Loam	%	52.44		46.41		37.23		40.5		40.65	
Sand	%	9.52		14.79		14.55		18.82		20.27	
Class	Texture	Clay loam		Clay loam		Clay		Clay loam		Clay loam	

Photos of soil profile and landscape of profile site

ANNEX A3. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL004AP

Location: Pafuri-Cicualacuala Coordinates: Lat. 22º26´45´´S, Long. 31º21´23´´ E
Sheet: 83 Ground form: River Terrace Topography: Almost Plain

Soil unit: (Local) **Fa2n**; FAO-WRB 2006: **Mollic Fluvisols (sodic)**

Morphological characteristics

Horizon: Depth. (cm)

A 0-36: Dark brown (10 YR 3/3) when dry and dark greyish brown (10 YR 3/2) when moist; clay-loam; spotless; strong and large structure of prismatic type; hard, firm, sticky and plastic; common, very thin pores; no rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; dominant, thin roots; clear and plain transition.

B1 36-51 : Dark brown (10 YR 4/3) when dry and dark brown (10 YR 3/3) when moist; clay-loam; spotless; strong and large structure of subangular anisoform type; hard, firm, sticky and plastic; few, thin pores; no rocky fragments; no mineral nodules; without effervescence; few, thin roots; clear and plain transition.

B2 51-71: dark yellowish-brown (10 YR 6/3) when dry and same colour (10 YR 3/4) when moist; silty loam; spotless; weak, large of subangular anisoform type; hard, friable, not sticky and not plastic; rare very thin pores; without rocky fragments; without mineral nodules; without effervescence; few, thin roots; clear and plain transition.

B3 71-92: Dark brown (10 YR 3/3) when dry and very dark greyish brown (10 YR 3/2) when moist; silty clay; spotless; strong, large structure of subangular anisoform type; hard, firm, sticky and plastic; rare, very thin pores; without rocky fragments; no mineral nodules; without effervescence; rare, fine roots; clear and plain transition.

B4 92-150: very dark greyish-brown (10 YR 3/2) when dry and moist; silty-clay-loam; spotless; strong, large structure of subangular anisoform type; hard, firm, sticky and plastic; common very thin pores; without rocky fragments; without mineral nodules; no effervescence; rare, medium and fine roots.

Physical and chemical features

Sample

GL004AP											
	Horizon	A	Class	B1	Class	B2	Class	B3	Class	B4	Class
	Depth	0-36		36-51		51-71		71-92		92-150	
pH H_2O	(1:2.5)	7.38	Light Basic	8.55	Strong Basic	9.18	Extr. Basic	8.78	Strong Basic	9.02	Ext. Basic
CEmS/cm	(1:2.5	0.376	Not saline	0.659	Not saline	0.784	Not saline	4.75	Light Saline	4.36	Light Saline
C	%	1.85	High	0.73	Low	0.26	Very low	0.79	Low	0.49	Low
MO	%	3.19	High	1.26	Low	0.45	Very low	1.35	Low	0.84	Low
Ca	me/100 g	25.2	Very high	15.4	Very high	5	Average	10.8	Very high	14.6	Very high
Mg	me/100 g	9.8	Very high	9	Very high	4.2	Very high	10	Very high	5.8	Very high
Na	me/100 g	3.39	Very high	8.76	Very high	9.16	Very high	47.77	Very high	38.32	Very high
K	me/100 g	1.32	Very high	0.36	Averag e	0.24	High	0.76	Very high	0.64	Very high
Al3++H+	me/100 g	2.25	Light Toxic	0	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100 g	45	Very high	31.5	High	19.6	Average	69.7	Very high	59.9	Very high
P	mg/100g	2.735	Very high	1.137	Averag e	0.497	Average	0.48	Very low	0.43	Very low
Clay	%	44.34		36.41		11.52		36.48		28.55	
Loam	%	42.8		21.77		6.67		34.09		18.28	
Sand	%	12.86		41.82		81.81		29.43		53.18	
Class	Texture	Clay loam		Silty clay		Silty sand		Silty clay		Silty sand	

ANNEX A4. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GA024P

Location: Nhanganhanga-Mabalane Coord.: Lat. 23º48´09´´S, Long. 32º30´04´´ E
Sheet: 83 Ground form: River Terrace Topography: Almost Plain
Soil unit: (Local) **Fa1**; FAO-WRB 2006: **Mollic Fluvisols (clayic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-15: Brown (10 YR 4/3) when dry and dark greyish brown (10 YR 3/2) when moist; clay-loam; spotless; weak, fine structure of subangular anisoform type; mild, friable, sticky and slightly plastic; few, thin pores; no rocky fragments; no nodules minerals; slight effervescence; dominant, thin roots; clear and plain transition.

B1 15-52: dark greyish-brown (10 YR 4/2) when dry and dark greyish brown (10 YR 3/2) when moist; clayish; spotless; strong, large structure of prismatic type; extremely hard, extremely firm, sticky and plastic; rare, thin pores; rare rocky fragments in the form of average and fine gravel; uneven nature fresh limestone; few, average, sub round, hard, mineral nodules of black monogamous; slight effervescence; common, thin roots; diffuse and wavy transition.

B2 51-71: Dark grey (10 YR 4/1) when dry and very dark grey (10 YR 3/1) when moist; clayish; spotless; strong, medium structure of columnar type; extremely hard, extremely firm, very sticky and very plastic; rare thin pores; rare rocky fragments in the form of thin, irregular, fresh nature gravel of quartz type and rare, thin, irregular, fresh from nature of quartz type; rare, thin, irregular, mild mineral nodules of white calcareous nature and rare, thin, irregular, mild of white calcareous nature; slight effervescence; rare thin roots; diffuse and wavy transition.

B3 71-92: Dark grey (10 YR 4/1) when dry and very dark grey (10 YR 3/1) when moist; clayish; spotless; strong, large structure of subangular anisoform type; very hard, very firm, sticky and plastic; few, thin pores; rare rocky fragments in the form of thin, uneven, fresh gravel of calcareous nature and rare, thin, irregular, fresh of quartz nature; rare, average, sub round, hard mineral nodules of manganeous nature with black colour and common, average, irregular, mild of white calcareous nature; moderate effervescence; rootless; clear and plain transition.

B4 92-150 : dark yellowish-brown (10 YR 3/4) when dry and brown (10 YR 3/3) when moist; clayish; spotless; moderate, medium structure of subangular anisoform type; slightly hard, friable, sticky and plastic; common, thin pores; rare rocky fragments in the form of thin gravel

and average, irregular, fresh of calcareous nature; rare, thin, irregular, mild in nature mineral nodules of white calcareous nature and rare, thin, irregular, mild of white quartz nature; slight effervescence; rootless.

Physical and chemical features

Sample GA024P											
	Horizon	A		Bg1	Class	Bg2	Class	Bg3	Class	Bgk	Class
	Depth	0-15		20-45		55-65		75-100		110-140	
pH H_2O	(1:2.5)	8.8	Ext. Basic	8.5	Basic	8.7	Strong Basic	8.18	Mod. Basic	8.26	Mod Basic
CEmS/cm	(1:2.5	0.346	Not saline	0.165	Not saline	1.4	Not saline	5.55	Mod. Saline	5.01	Mod. Saline
C	%	0.6	Low	1.16	Average	0.58	Low	0.39	Low	0.11	Very low
MO	%	1.03	Low	2	Average	1	Low	0.67	Low	0.2	Very low
Ca	me/100g	36.8	Very high	33.4	Very high	33.4	Very high	52.4	Very high	52.4	Very high
Mg	me/100g	20.4	Very high	11.6	Very high	20.4	Very high	23.8	Very high	21.6	Very high
Na	me/100g	7.97	Very high	1.6	High	16.72	Ext. high	28.66	Ext high	26.87	Ext high
K	me/100g	1	Average	1.56	High	1.64	High	1.84	High	1.6	High
Al3++H+	me/100g	0	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100g	67.2	Very high	48.2	Very high	73.2	Very high	106.9	Very high	102.8	Very high
P	mg/100g	0.035	Very low	1.461	Average	0.236	Very low	-0.032	Very low	0.119	Very low
Clay	%	62.17		40.29		63.28		67.25		48.06	
Loam	%	28.62		51.8		26.99		24.73		39.05	
Sand	%	9.21		7.91		9.73		8.03		12.89	
Class	Texture	Clayish		Clayish loam		Clayish		Clayish		Clayish	

ANNEX A5. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL002P

Location: Pafuri-Chicualcuala Coord.: Lat. 22º27´12´´S, Long. 31º21´12´´ E

Sheet: 83 Ground form: Hill Topography: Wavy
Soil unit: (Local) **SI**; FAO-WRB 2006: **Mollic Leptosols (skeletic)**

Morphological characteristics

Horizon: Depth. (cm)

A 0-31 : dark greyish-brown (10 YR 3/2) when dry and very dark brown (10 YR 2/2) when moist; clayish spotless; moderate, medium structure of granular type; mild, friable, but little sticky plastic; few, thin pores; many rocky fragments; very large, rounded of basaltic and rhyolitic nature; no mineral nodules; without effervescence; few unspecified cavities; few thin and medium roots; abrupt and irregular transition.

B1 21-52: dark greyish-brown (10 YR 4/2) when dry and brown (10 YR 3/2) when moist; clayic; spotless; moderate, thin structure of granular type; slightly hard, friable, sticky and plastic; rare, thin pores; many rocky fragments, very large, rounded of basaltic and rhyolitic nature; without mineral nodules, no effervescence; few unspecified cavities; rare, thin, medium roots.

Physical and chemical features

Sample GL002P					
	Horizon	A	Class	B	
	Depth	0-31		31-52	
pH H_2O	(1:2.5)	6.36	Light Acid	6.07	Light Acid
CEmS/cm	(1:2.5	0.094	Not saline	0.064	Not saline
C	%	2.32	Very high	0.8	Low
MO	%	4	Very high	1.39	Low
Ca	me/100g	32.8	Very high	28	Very high
Mg	me/100g	11.4	Very high	16.2	Very high
Na	me/100g	0.45	High	0.43	High
K	me/100g	0.4	Average	0.28	Average
Al3++H+	me/100g	6	Light Toxic	6.75	Light Toxic
CTC	me/100g	52	Very high	53.7	Very high
P	mg/100g	0.682	Low	0.262	Low
Clay	%	55.41		63.85	
Loam	%	19.55		14.94	
Sand	%	25.04		21.21	
Class	Texture	Clayish		Clayish	

ANNEX A6. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL001P

Location: Pafuri-Chicualcuala Coord.: Lat. 22º30´43´´S, Long. 31º22´27´´ E
Sheet: 83 Ground form: Hill Topography: Wavy
Soil unit: (Local) **SI1**; FAO-WRB 2006: **Haplic Leptosols (skeletic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-15: dark yellowish-brown (10 YR 4/4) when dry and dark brown (10 YR 3/3) when moist; sandy-silty; spotless; grain, simple structure, not sticky and not plastic; common, thin pores; many rocky fragments; very large, rounded of quartz nature; without mineral nodules, no effervescence; few unspecified cavities; many thin roots; gradual and wavy transition.

B1 21-52: Brown-yellowish (10 YR 5/4) when dry and dark yellowish brown (10 YR 4/4) when moist; sandy-silty; spotless; weak, thin structure of granular type; very mild, very friable, not sticky and not plastic; rare, thin pores; many rocky fragments, very large, rounded of quartz nature; without mineral nodules; no effervescence; common, thin roots.

Physical and chemical features

Sample GL001P			
Specs	Horizon	A	Class
	Depth	0-15	
pH H_2O	(1:2.5)	5.93	Mod. acid
CEmS/cm	(1:2.5	0.098	Not saline
C	%	0.82	Low
MO	%	1.42	Low
Ca	me/100g	5.4	High
Mg	me/100g	1.6	High
Na	me/100g	0.15	Average
K	me/100g	0.56	High
Al3++H+	me/100g	2.25	Light Toxic
CTC	me/100g	12.3	Low
P	mg/100g	0.228	Low
Clay	%	9.7	
Loam	%	8.06	
Sand	%	82.24	

Class	Texture	Sand silty	

ANNEX A7. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL002P

Location: Coordinates: Lat. 22º27´12´´S, Long. 31º21´13´´ E
Sheet: 83 Ground form: Hill down slope Topography: Wavy
Soil unit: (Local) **SI** ; FAO-WRB 2006: **Mollic Leptosols (clayic)**

Morphological characteristics

Horizon A (0 - 31 cm) Dark brown (7.5 YR 3/2) when dry and brown (7.5 YR 3/1) when moist. Silty-clay; granular, thin, weak structure, mild, friable, slightly sticky and slightly plastic consistency. Many thin pores, common averages, few unspecified cavities; abundant, thin, common, medium and large roots. Without effervescence at HCl (10%), abundant, average, plentiful, fresh, rounded, irregular rocky fragments of quartz and rhyolitic nature.

Horizon C (31 - 52) Brown (7.5YR 4/3) when dry and brown (7.5 YR 3/2) when moist; abundant, large, fresh, round and irregular rocky fragments of quartz and rhyolitic nature. Clayish, rare, thin, pores; large, common roots. Without effervescence at HCl (10%).

Physical and chemical features

GL001P			
Specs	Horizon	A	Class
	Depth	0-15	
pH H_2O	(1:2.5)	5.93	Mod. acid
CEmS/cm	(1:2.5	0.098	Not saline
C	%	0.82	Low
MO	%	1.42	Low
Ca	me/100g	5.4	High
Mg	me/100g	1.6	High
Na	me/100g	0.15	Average
K	me/100g	0.56	High
Al3++H+	me/100g	2.25	Light Toxic
CTC	me/100g	12.3	Low
P	mg/100g	0.228	Low
Clay	%	9.7	
Loam	%	8.06	
Sand	%	82.24	
Class	Texture	Silty sand	

ANNEX A8. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GA42S1

Location: Chikondzo-Mabalane Coord.: Lat. 23º17´30´´S, Long. 32º14´41´´ E
Sheet: Ground form: Hill Topography: Wavy
Soil unit: (Local) **Sm** ; FAO-WRB 2006: **Haplic Cambisols (skeletic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-10: Dark brown (7.5 YR 3/3) when dry and same colour (7.5 YR 3/2) when moist; silty-clay-loam; spotless; weak, average structure of granular type; slightly hard, friable, slightly sticky and slightly plastic; common, thin, rare, large and average pores; without rocky fragments; no mineral nodules; without effervescence; few cavities unspecified; few thin and medium roots; gradual and plain transition.

Bw 10-30: Dark brown (7.5 YR 3/4) when dry and very dark brown (7.5 YR 2.5 / 3) when moist; clay-sandy; spotless; weak, medium structure of subangular anisoform type; slightly rough, firm, slightly sticky and slightly plastic; few, thin pores; without rocky fragments; no mineral nodules; without effervescence; rare, thin roots; clear and plain transition.

B/C 30-50: Brown (7.5 YR 4/3) when dry and dark brown (7.5 YR 3/4) when moist; sandy clay; spotless; moderate, average structure of angular anisoform type; slightly hard, firm, slightly sticky and slightly plastic; rare, very thin pores; dominant rocky fragments in the form of average, large, rounded, fresh gravel of quartz nature; without mineral nodules; no effervescence; rare, thin roots.

ANNEX A9. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GS51S2

Location: Zulo-Massingir Coord.: Lat. 24º00´27´´S, Long. 32º28´15´´ E
Sheet: Ground form: Pediment Topography: Mildly Wavy
Soil unit: (Local) **Sv** ; FAO-WRB 2006: **Leptic Luvisols (skeletic)**

Morphological characteristics

Horizon: Depth. (cm)

A 0-10: dark reddish-grey (5 YR 4/2) when dry and dark reddish brown (5 YR 2.5/2) when moist; silty loam; spotless; weak, thin structure of granular type; mild, very friable, not sticky and not plastic; common, thin and average pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; few, thin and medium roots; gradual and plain transition.

B1 10-30: dark reddish-brown (5 YR 3/4) when dry and the same colour (5 YR 3/2) when moist; silty loam; spotless; weak, medium structure of subangular anisoform type; mild, friable, not sticky and not plastic; few thin pores; without rocky fragments; no mineral nodules; slight effervescence, thin, medium and rare roots; gradual and plain transition.

Bt 30-50: reddish-brown (5 YR 4/4) when dry and dark reddish brown (5 YR 3/3) when moist; silty-clay-loam; spotless; moderate, medium structure of subangular anisoform type; slightly, hard, firm, slightly sticky and slightly plastic; rare, very thin pores; few rocky fragments in the form of average, rounded, fresh gravel of quartz nature; without mineral nodules; moderate effervescence; rare, thin roots; clear and plain transition.

B/C 50-80: reddish brown (5 YR 4/4) when dry and dark reddish brown (5 YR 3/3) when moist, silty-clay-loam; spotless; moderate, medium structure of anisoform subangular type; slightly hard, firm; slightly sticky and slightly plastic; rare, very thin pores; dominant rocky fragments in the form of average and very large, rounded, fresh gravel of quartz nature; without mineral nodules; moderate effervescence; rare, thin roots.

ANNEX A10. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL003S

Location: Pafuri-Chicualacuala Coord.: Lat. 22º26´41´´S, Long. 31º19´04´´ E
Sheet: Ground form: Hill Topography: Strongly Wavy
Soil unit: (Local) BI; FAO-WRB 2006: **Mollic Leptosols (skeletic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-20 : Dark brown (10YR 3/3) when dry and very dark brown (7.5 YR 2.5 / 2) when moist; clay-loamy; spotless; moderate, medium structure of subangular anisoform type; mild, friable, slightly sticky and plastic; common, thin and average pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; few, thin and medium roots; gradual and plain transition.

B/C 20+ : very large, irregular, fresh and meteorized gravel mix of basaltic nature with very dark reddish-brown clay soil matrix.

ANNEX A11. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GS041P

Location: Macaringue-Massingir Coord.: Lat. 24º07´337´´S, Long. 32º34´53´´ E
Sheet: Ground form: Pediment Topography: Mildly Wavy
Soil unit: (Local) **Wp**; FAO-WRB 2006: **Leptic cambisols (dystric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-20 : dark reddish-brown (5 YR 3/3) when dry and dark reddish brown (5 YR 3/2) when moist; silty sandy; spotless; weak, medium, structure of granular type; mild, very friable, not sticky and not plastic; dominant, average pores; common rocky fragments, of thin, irregular, fresh gravel of quartz nature; no mineral nodules; without effervescence; dominant termite cavities; few, thin roots and common very thin; clear and wavy transition.

B1 20-40 : Dark brown (2.5 YR 3/4) when dry and the same colour (2.5 YR 3/3) when moist; sandy silty; spotless; moderate, large structure of subangular anisosform type; hard, friable; not sticky and not plastic; dominant thin pores; common rocky fragments, of thin, irregular, fresh gravel of quartz nature; no mineral nodules; without effervescence; dominant termite cavities; few, common very thin roots; clear and wavy transition.

Bt 40-59 : Intense Brown (2.5 YR 4/6) when dry and dark brown (2.5 YR 3/4) when moist; silty sandy; spotless; weak, average structure of granular type; mild, friable, not sticky and not plastic; dominant common, average and thin pores; abundant rocky fragments of thin, irregular, fresh gravel of quartz nature; no mineral nodules; without effervescence; few termite cavities; very thin and common roots.

Physical and chemical features

Sample GS041P

	Horizon	A	Class	B1	Class	B2	Class
	Depth	0-20		20-40		40-59	
pH H_2O	(1:2.5)	6.38	Light acid	6.29	Light acid	6.25	Light acid
CEmS/cm	(1:2.5	0.061	Not saline	0.061	Not saline	0.081	Not saline
C	%	0.5	Low	0.31	Very low	0.17	Very low
MO	%	0.87	Low	0.53	Very low	0.3	Very low
Ca	me/100g	3.6	Low	3.4	Low	3.2	Low
Mg	me/100g	1	Very high	1.2	Very high	1.4	Very high
Na	me/100g	0.19	Low	0.13	Low	0.13	Low
K	me/100g	0.72	High	0.8	High	1.04	Very high
Al3++H+	me/100g	1.75	Light Toxic	2.5	Mod. Toxic	2.25	Mod. Toxic
CTC	me/100g	8.3	Very low	9	Very low	9	Very low
P	mg/100g	0.505	Low	0.051	Very low	0.051	Very low
Clay	%	10.29		16.44		17.62	
Loam	%	7.72		7.4		6.71	
Sand	%	81.99		76.17		75.66	
Class	Texture	Silty sando		Silty sand		Silty sand	

ANEX A12. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL23P1

Location: Hassane-Chicualacuala Coord.: Lat. 23º02´57´´S, Long. 32º07´49´´ E
Sheet: Ground form: Pediment Topography: Wavy
Soil unit: (Local) **Wpk**; FAO-WRB 2006: **Haplic Leptosols (calcaric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-21 : Brown-grey (10 YR 5/2) when dry and dark greyish brown (10 YR 4/2) when moist; silty sandy; spotless; weak, thin structure of granular type; mild, very friable, slightly sticky and not plastic; common, thin and few average pores; abundant rocky fragments of average, sub rounded, fresh gravel of calcareous nature and few of quartz nature; no mineral nodules, strong effervescence; dominant thin roots; clear and wavy transition.

B1 21-60 : Brown (10 YR 5/3) when dry and the same colour (10 YR 4/3) when moist; silty sand; spotless; moderate, medium structure of subangular

anisosform type; mild, friable, slightly sticky and slightly plastic; common thin pores; dominant rocky fragments, of average, sub rounded, fresh gravel of calcareous nature and a few, large, sub rounded, fresh, of quartz nature; no mineral nodules; strong effervescence; common thin roots and a few medium.

Physical and chemical characteristics

Sample GL23P1					
	Horizon	A	Class	C	Class
	Depth	0-21		21-60	
pH H_2O	(1:2.5)	7.26	Light Basic	8.2	Basic
CEmS/cm	(1:2.5	0.204	Not saline	0.158	Not saline
C	%	0.67	Low	0.37	Low
MO	%	1.16	Low	0.65	Low
Ca	me/100g	21.8	Very high	26	Very high
Mg	me/100g	7	Very high	4.8	Very high
Na	me/100g	0.25	Average	0.33	Average
K	me/100g	0.88	High	0.56	High
Al3++H+	me/100g	0.5	Not toxic	0	Not toxic
CTC	me/100g	30.4	High	31.9	High
P	mg/100g	0.421	Low	0.018	Very low
Clay	%	10.6		19.54	
Loam	%	10.96		11.84	
Sand	%	78.44		68.62	
Class	Texture	Silty sand		Silty sand	

ANNEX A13. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL23AP1

Location: Panhame-Chicualacuala Coord.: Lat. 23º02´10´´S, Long. 32º06´39´´ E
Sheet: Ground form: Denudation plain Topography: Mildly wavy
Soil unit: (Local) **M2**; FAO-WRB 2006: **Calcic Luvisols (sodic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-20 : Dark Brown (7.5 YR 3/2) when dry and very dark brown (7.5 YR 2.5 / 2) when moist; silty sand; spotless; strong, large structure of subangular anisoform type; mild, friable, slightly sticky and not plastic; dominant, thin and average pores; rare rocky fragments of average, irregular, fresh gravel of quartz nature; no mineral nodules; slight effervescence; few unspecified cavities; dominant thin, common and medium roots; clear and wavy transition.

Bt 20-42 : Dark brown (7.5 YR 3/3) when dry and the same colour (7.5 YR 3/2) when moist; sandy-clay-silty; spotless; strong, large structure of prismatic type; extremely hard, very firm, sticky and plastic; few pellicles, less distinct on the aggregate side, on the horizontal side of structural elements; hardened compacting by clay; dominant, average, common and thin pores; common rocky fragments of average, irregular, fresh gravel of quartz nature; no mineral nodules; slight effervescence; few unspecified cavities; common, medium and thin roots; clear and wavy transition.

Btk 42-100 : Brown (7.5 YR 4/3) when dry and dark brown (7.5 YR 3/3) when moist; sandy-clay-silty; spotless; strong, medium structure of prismatic type; extremely hard, very firm, sticky and plastic; few pellicles, less distinct on the aggregate side, on the horizontal side of structural elements; medium compacting by clay; average, common and thin pores; no rocky fragments; dominant mineral nodules of average, irregular, mild of white calcareous nature; strong effervescence; few, medium and rare roots.

C 100+ limestone or marl mixed with clay.

Physical and chemical features

Sample GL23AP1							
	Horizon	A	Class	B1	Class	B2	Class
	Depth	0-20		20-42		42-100	
pH H_2O	(1:2.5)	7.66	Mod. Basic	8.91	Stron. Basic	9.27	Extr. Basic
CEmS/cm	(1:2.5	0.111	Not saline	0.432	Not saline	0.836	Not saline
C	%	0.37	Very low	0.3	Very low	0.16	Very low
MO	%	0.65	Very low	0.51	Very low	0.27	Very low
Ca	me/100g	6.4	High	16.4	Very high	20.8	Very high
Mg	me/100g	6.2	Very high	11.2	Very high	14.4	Very high
Na	me/100g	0.68	Average	5.18	Very high	9.56	Very high
K	me/100g	1.32	Very high	0.88	High	0.84	High
Al3++H+	me/100g	1.5	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100g	17.1	Average	33.7	High	45.9	Very high
P	mg/100g	0.857	Low	0.135	Very low	0.203	Very low

Clay	%	9.04		22.47		33.33	
Loam	%	10.85		14.42		16.93	
Sand	%	80.11		63.11		49.74	
Class	Texture	Silty sand		Silty sand		Silty sand	

ANNEX A14. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL039P

Location: Mtsilele-Chicualacuala Coord.: Lat. 22º43´43´´S, Long. 31º51´2´´ E
Sheet: Ground form: Pediment Topography: Mildly wavy
Soil unit: (Local) **M1**; FAO-WRB 2006: **Calcic Luvisols (sodic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-15 : Very dark brown (10 YR 2/2) when dry and black (10 YR 2/1) when moist; silty sand; spotless; thin, weak to moderate structure of subangular anisoform type; slightly hard, friable, sticky and plastic; common, thin and average pores; without rocky fragments; no mineral nodules; without effervescence; common unspecified cavities; dominant thin roots; clear and plain transition.

Bt 15-38 : Very dark brown (10 YR 2/2) when dry and black (10 YR 2/1) when moist; sandy-clay-silty; spotless; strong, medium structure of columnar type; hard, firm, sticky and plastic; discontinued compacting; hard of silex; dominant and common, average, thin pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; common, medium roots. Diffuse and plain transition.

Btk 38-70 : Very dark grey (10 YR 3/1) when dry and very dark brown (10 YR 2/2) when moist: clay; spotless; structure strong, average, columnar type; hard, firm, sticky and plastic; compactness discontinuous, solid silica; dominant, common, thin and average pores; without rocky fragments; no mineral nodules, strong effervescence; few, wide and open cavities; dominant common, medium and thin roots; abrupt and plain transition.

Bk 70-100 : Brown (10 YR 4/3) when dry and very dark greyish brown (10 YR 3/2) when moist; sandy clay; spotless; very strong, large structure subangular anisoform type; very hard, very firm, sticky and plastic; continuous compacting, solid, clay; common, thin pores; without rocky fragments; abundant, average, irregular mineral nodules of white

calcareous nature; strong effervescence; thin, few, medium and rare roots; diffuse and plain transition.

BC 100-150 : Brown (10 YR 4/3) when dry and dark brown (10 YR 3/3) when moist; sandy-clay-silty; spotless; very strong, large structure subangular anisoform type; very hard, very firm, sticky and plastic; continuous compacting, solid, clay; common, very thin pores; without rocky fragments; dominant, average, irregular mineral nodules of white calcareous nature; strong effervescence; medium, rare roots.

Physical and chemical features

Sample GL039P											
	Horizon	A	Class	B1	Class	B2	Class	B3	Class	B4	Class
	Depth	0-15		15-38		38-70		70-100		100-150	
pH H_2O	(1:2.5)	6.73	Light acid	6.95	Light acid	8.67	Strong Basic	8.63	Strong Basic	7.96	Basic
CEmS/cm	(1:2.5	0.214	Not saline	0.144	Not saline	2.04	Not saline	1.58	Not saline	0.552	Not saline
C	%	1.5	High	0.69	Low	0.21	Very low	0.24	Very low	0.54	Low
MO	%	2.58	High	1.19	Low	0.35	Very low	0.42	Very low	0.93	Low
Ca	me/100g	12.6	Very high	14	Very high	19	Very high	20.6	Very high	14.8	Very high
Mg	me/100g	4.8	Very high	8.2	Very high	10.4	Very high	9	Very high	8.8	Very high
Na	me/100g	0.72	High	1.32	Very high	10.16	Very high	13.74	Very high	3.59	Very high
K	me/100g	1.64	High	1.28	High	3.36	Very high	2.8	Very high	1.48	Very high
Al3++H+	me/100g	2.75	Not toxic	2	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100g	22.5	Average	26.8	High	42.9	Very high	46.1	Very high	28.7	High
P	mg/100g	2.938	High	0.387	Low	0.102	Low	0.068	Very low	0.219	Low
Clay	%	17.65		29.98		45.07		36.8		30.82	
Loam	%	22.06		8.56		11.96		14.96		8.81	
Sand	%	60.29		61.46		42.97		48.24		60.38	
Class	Texture	Silty sand		Clay sand		Clay		Clay sand		Clay sand	

ANNEX A15. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL002AP

Location: Pafuri-Chicualacuala Coord.: Lat. 22º26´58´´S, Long. 31º21´10´´ E
Sheet: 83 Ground form: Narrow valley Topography: Wavy
Soil unit: (Local) **Cs**; FAO-WRB 2006: **Colluvic Cambisols (siltic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-42 : Dark brown (10 YR 3/3) when dry and dark greyish brown (10 YR 3/2) when moist; silty sand; spotless; weak, average structure of granular type; slightly hard, friable, slightly sticky and plastic; common, thin, rare, average and large pores; rare, thin, average, round, fresh rocky fragments of basalt and quartz nature; no mineral nodules; moderate effervescence; few unspecified cavities; few, thin and medium roots; abrupt and plain transition.

Bw 42-81 : Brown (10 YR 4/3) when dry and dark brown (10 YR 3/3) when moist; silty sand; spotless; weak, medium structure of subangular anisosform type; hard, firm, slightly sticky and slightly plastic; few, thin pores; common rocky fragments in the form of average, large, rounded and fresh gravel of basalt and quartz nature; no mineral nodules; moderate effervescence; rare, thin roots; clear and plain transition.

B/C 81-150 : Brown-grey (10 YR 5/2) when dry and dark greyish brown (10 YR 4/2) when moist; silty sand; spotless; weak, medium structure of angular anisoform type; mild, friable, slightly sticky and slightly plastic; rare, very thin pores; dominant rocky fragments in the form of too large, rounded, fresh gravel of basalt and quartz nature; no mineral nodules, strong effervescence; rootless.

Physical and chemical features

Sample GL002AP							
	Horizon	A	Class	B	Class	C	Class
	Depth	0-42		42-81		81-150	
pH H_2O	(1:2.5)	8.31	Mod. Basic	7.47	Light Basic	7.77	Light Basic
CEmS/cm	(1:2.5	0.225	Not saline	0.11	Not saline	1.48	Not saline
C	%	0.79	Low	0.52	Low	0.39	Very low
MO	%	1.35	Low	0.9	Low	0.68	Very low

Ca	me/100g	41.6	Very high	37.4	Very high	39.8	Very high
Mg	me/100g	12.2	Very high	16	Very high	15.6	Very high
Na	me/100g	0.9	High	2.79	Very high	3.59	Very high
K	me/100g	0.68	High	0.52	High	0.4	Average
Al3++H+	me/100g	0	Not toxic	0.5	Not toxic	0.75	Not toxic
CTC	me/100g	54.4	Very high	56.2	Very high	59.1	Very high
P	mg/100g	0.11	Low	0.144	Low	0.11	Low
Clay	%	10.21		14.28		12.05	
Loam	%	36.16		31.27		26.02	
Sand	%	53.63		54.45		61.92	
Class	Texture	Silty sand	Reasonable	Silty sand	Reasonable	Silty sand	Reasonable

ANNEX A16. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GA029P

Location: Maguezi-Mabalane Coord.: Lat. 23º57´51´´S, Long. 32º33´41´´ E
Sheet: 83 Ground form: Downslope Topography: Almost plain
Soil unit: (Local) **Cw1**; FAO-WRB 2006: **Sodic Vertisols (calcaric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-11 : Very dark greyish-brown (10 YR 3/2) when moist; silty clay; spotless, very friable, slightly sticky and slightly plastic; dominant, thin pores; no rocky fragments; no mineral nodules; without effervescence; rare, large, medium and thin roots; diffuse and wavy transition.

B1 11-30 : Very dark brown (10 YR 2/2) when moist; clay; spotless; friable, very sticky and plastic; few thin pores; without rocky fragments; no mineral nodules; without effervescence; rare medium and large thin roots; diffuse and wavy transition.

B2 30-54 : Very dark grey (10 YR 3/1) when moist; clay; spotless; friable, sticky and plastic; common, thin pores; without rocky fragments; no mineral nodules; without effervescence; rare large roots; diffuse and wavy transition.

B3 54-76 : Very dark greyish-brown (10 YR 3/2) when moist; sandy clay; spotless; firm, very sticky and very plastic; few thin pores; without rocky fragments; no mineral nodules; slight effervescence; rare large roots; diffuse and wavy transition.

B4 76-106 : Dark brown (10 YR 3/3) when moist; sandy-clay- silty; spotless; friable, sticky and plastic; few thin pores; without rocky fragments; no mineral nodules; slight effervescence; rootless, diffuse and wavy transition.

B5 105-150 : Very dark greyish-brown (10 YR 3/2) moist; sandy-clay-silty; spotless; friable, sticky and plastic; few thin pores; without rocky fragments; no mineral nodules; slight effervescence; rootless.

Physical and chemical features

Sample GA029P													
	Horizon	A	Class	B1	Class	B2	Class	B3	Class	B4	Class	B5	Class
	Depth	0-11		11-35		35-50		60-75		80-100		110-130	
pH H_2O	(1:2.5)	7.3	Light Basic	7.34	Light Basic	7.85	Mod. Basic	8.74	Strong Basic	8.69	Strong Basic	8.74	Strong Basic
CEmS/cm	(1:2.5	0.386	Not saline	0.273	Not saline	0.278	Not saline	0.428	Not saline	0.839	Not saline	1.27	Not saline
C	%	1.74	Average	1.38	Average	1.13	Average	0.75	Low	0.38	Low	0.29	Very low
MO	%	3.01	Average	2.38	Average	1.95	M	1.29	Low	0.66	Low	0.5	Very low
Ca	me/100g	27	Very high	23.6	Very high	22.6	Very high	12	Very high	6.8	High	7.4	High
Mg	me/100g	16.2	Very high	17	Very high	15.2	Very high	8.4	Very high	7.6	High	9.8	Very high
Na	me/100g	2.59	High	7.77	Very high	11.15	Very high	11.95	Very high	15.13	Very high	17.92	Very high
K	me/100g	2.8	Very high	1.96	Very high	1.92	Very high	1.08	Very high	1	Very high	0.96	Very high
Al3++H+	me/100g	0.5	Not toxic	0.55	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100g	49.7	Very high	51.4	Very high	51.5	Very high	33.4	High	30.5	High	36.1	High
P	mg/100g	4.466	Very high	4.389	Very high	4.767	Very high	1.007	Average	2.084	High	0.553	Low
Clay	%	56.51		56.58		55.68		36.06		33.31		23.77	
Loam	%	40.86		25.55		23.2		10.82		16.65		18.67	
Sand	%	2.63		17.86		21.12		53.12		50.04		57.56	
Class	Texture	Loam clay		Clay		Clay		Clay sand		Clay sand		Clay sand	

ANNEX A17. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL006P

Location: Pafuri-Chicualacuala Coord.: Lat. 22º28´23´´S, Long. 31º15´36´´ E

Sheet: 83 Ground form: Valley Topography: Almost Plain
Soil unit: (Local) **Cw2**; FAO-WRB 2006: **Collucic Cambisols (greyic)**

Morphological characteristics

Horizon: Depth (cm)

A 0-16 : Dark greyish-brown (10 YR 4/2) when dry and dark brown (10 YR 3/4) when moist; clay; spotless; weak, medium structure of subangular anisoform type; mild, very friable sticky and slightly plastic; common, very thin pores; without rocky fragments; no mineral nodules; without effervescence; common unspecified cavities; dominant, common thin and average roots; gradual and wavy transition.

B1 16-33 : Very dark greyish-brown (10 YR 3/2) when dry and very dark grey (10 YR 2/2) when moist; clay; spotless; weak, medium structure of subangular anisoform type; mild; friable, very sticky and slightly plastic; average few pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; dominant, medium and thin roots; gradual and plain transition.

B2 33-50 : Dark greyish-brown (10 YR 4/2) when dry and very dark greyish brown (10 YR 3/2) when moist; sandy-clay-silty; spotless; weak, large structure of anisoform subangular type; slightly hard, friable, sticky and slightly plastic; dominant, average and common thin pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; common, medium, few, large and thin roots; clear and plain transition.

B3 50-75 : Dark brown (10 YR 3/4) when dry and same colour (10 YR 3/3) when moist; silty sand; spotless; weak, medium structure of subangular anisoform type; mild, friable, slightly sticky and slightly plastic; common, thin and large pores; dominant, large, subrounded and fresh rocky fragments of quartz nature; without mineral nodules; no effervescence; few unspecified cavities; rare, very thin, few and medium roots; abrupt and plain transition.

B4 75-90 : Dark brown (10 YR 4/3) when dry and same colour (10 YR 3/3) when moist; sandy-clay-silty; spotless; very strong, large structure of anisoform subangular type; slightly hard, firm, sticky and slightly plastic; common, average and large pores; few, average, subrounded and fresh rocky fragments of quartz nature; without mineral nodules; no effervescence; rare, medium and thin roots; abrupt and plain transition.

2B5 90-104 : Dark brown (10 YR 4/3) when dry and same colour (10 YR 3/3) when moist; sandy; spotless; simple grains, not sticky and not plastic; common, thin pores; dominant, average, sub rounded and fresh rocky fragments of quartz nature, without mineral nodules, no effervescence, thin, medium and rare roots; clear and plain transition.

B6 104-123 : Dark yellowish-brown (10 YR 4/4) when dry and brown (10 YR 4/3) when moist; sandy; spotless; simple grains; not sticky and not plastic; common, thin pores; common, average, sub rounded and fresh rocky fragments of quartz nature; without minerals without nodules; without effervescence; rare, very thin roots; abrupt and plain transition.

B7 123-150 : Dark greyish-brown (10 YR 4/2) when dry and very dark greyish brown (10 YR 3/2) when moist; silty; dominant, medium, distinct, diffuse and brown spots; structure, medium structure of columnar type; slightly hard, friable, sticky and slightly plastic; common, thin pores; without rocky fragments; no mineral nodules; without effervescence; rare, very thin roots.

Physical and chemical features

Sample GL006P									
	Horizon	A	Class	B1	Class	B2	Class	B3	Class
	Depth	0-16		16-33		33-50		50-75	
pH H_2O	(1:2.5)	7.55	Light Basic	7.7	Light Basic	7.76	Light Basic	7.53	Light Basic
CEmS/cm	(1:2.5	0.345	Not saline	0.322	Not saline	0.322	Not saline	0.182	Not saline
C	%	1.96	High	1.64	Average	1.07	Average	0.41	Low
MO	%	3.38	High	2.84	Average	1.84	Average	0.71	Low
Ca	me/100g	35.4	Very high	39	Very high	35.8	Very high	27	Very high
Mg	me/100g	2.8	Very high	9.6	Very high	2.2	Very high	1	Very high
Na	me/100g	0.45	Average	0.53	High	0.56	High	0.41	Average
K	me/100g	3.2	Very high	1.4	Very high	0.76	Very high	0.48	Very high
Al3++H+	me/100g	0.75	Not toxic	0.75	Not toxic	1.25	Not toxic	1	Not toxic
CTC	me/100g	41.6	Very high	52.3	Very high	40.9	Very high	28.9	High
P	mg/100g	2.331	Very high	0.228	Very low	1.204	Average	0.228	Very low
Clay	%	40.72		44.18		34.36		16.64	
Loam	%	34.17		25.27		15.29		5.66	
Sand	%	25.12		30.54		50.36		77.71	
Class	Texture	Clay		Clay		Clay sand		Clay sand	

Sample GL006P									
	Horizon	B4	Class	B5	Class	B6	Class	B7	Class
	Depth	75-90		90-104		104-123		123-150	
pH H_2O	(1:2.5)	7.79	Light Basic	8.28	Mod. Basic	8.4	Mod. Basic	8.31	Mod. Basic
CEmS/cm	(1:2.5	0.21	Not saline	0.126	Not saline	0.104	Not saline	0.154	Not saline
C	%	0.64	Low	0.21	Very low	0.13	Very low	0.86	Low
MO	%	1.1	Low	0.35	Very low	0.23	Very low	1.48	Low
Ca	me/100g	28.8	Very high	20.8	Very high	14.8	Very high	34.6	Very high
Mg	me/100g	1.6	Very high	0.8	Very high	1.2	Very high	3.4	Very high
Na	me/100g	0.45	Average	0.29	Average	0.21	Average	0.53	High
K	me/100g	0.76	Very high	0.36	High	0.28	Average	0.68	Very high
Al3++H+	me/100g	0.75	Not toxic	0	Not toxic	0	Not toxic	0	Not toxic
CTC	me/100g	32.7	High	22.9	Average	17.5	Average	39.9	High
P	mg/100g	0.194	Very low	0.161	Very low	0.127	Very low	0.194	Very low
Clay	%	23.63		9		1.48		27.52	
Loam	%	7.43		1.47		0.33		28.5	
Sand	%	68.94		89.52		98.19		43.98	
Class	Texture	Clay sand		Sandy		Sandy		Silty	

ANNEX A18. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL016S

Location: Pafuri-Chicualacuala Coord.: Lat. 22º30´06´´S, Long. 31º33´22´´ E
Sheet: 83 Ground form: Valley Topography: Almost Plain
Soil unit: (Local) **Cw3**; FAO-WRB 2006: **Colluvic Cambisols (dystric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-25 : Brown (7.5 YR 5/3) when dry and dark brown (7.5 YR 3/4) when moist, silty sand; spotless; weak, thin structure of subangular anisoform type; mild, very friable, not sticky and not plastic; common, very thin pores; without rocky fragments; no mineral nodules; without effervescence; common unspecified cavities; dominant, common thin and average roots; gradual and plain transition.

B1 25-60 : Brown (7.5 YR 4/3) when dry and dark brown (7.5 YR 3/3) when moist; sandy-clay-silty; spotless; weak, medium structure of subangular anisoform type; mild, very friable, slightly sticky and slightly plastic; few, average pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; dominant, medium and thin roots; gradual and plain transition.

B2 60-120 : Brown (7.5 YR 4/4) when dry and dark brown (7.5 YR 3/3) when moist; sandy-clay-silty; spotless; structure, large weak of subangular anisoform type; slightly hard, friable, slightly sticky and slightly plastic; few, thin, average and rare pores; without rocky fragments; no mineral nodules; without effervescence; common, thin, few and medium roots.

ANNEX A19. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GA22A2

Location: Tsinine-Mabalane Coord.: Lat. 23º46´22´´S, Long. 32º29´11´´ E
Sheet: Ground form: Pediment Topography: Mildly Wavy
Soil unit: (Local) **Cm**; FAO-WRB 2006: **Mollic Cambisoils (calcaric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-35 : Very dark brown (10 YR 2/2) when dry and black (10 YR 2/1) when moist; silty clay; spotless; moderate, medium structure of subangular anisoform type; slightly hard, firm, slightly sticky and plastic; common, thin and average pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; few, thin and medium roots; gradual and plain transition.

Bw 35-55 : Very dark grey (10 YR 3/1) when dry and very dark brown (10 YR 2/2) when moist: sandy-clay-silty; spotless; solid, very hard, very firm, slightly sticky and slightly plastic; few thin pores; without rocky fragments; no mineral nodules; without effervescence; rare thin roots; gradual and plain transition.

C 55-90 : Dark yellowish-brown (10 YR 4/4) when dry and dark brown (10 YR 3/3) when moist; sandy-clay-silty; rare spots; moderate, medium structure of subangular anisoform type; slightly hard, firm, slightly sticky and slightly plastic; rare, very thin pores; multiple rocky fragments in the form of thin, irregular, fresh gravel of quartz and calcareous nature, without mineral nodules; moderate effervescence; without thin roots.

ANNEX A20. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL030S

Location: Pafuri-Chicualcuala Coord.: Lat. 22º41´06´´S, Long. 31º44´01´´ E
Sheet: 83 Ground form: Sandy plain Topography: Mildly Wavy
Soil unit: (Local) **A**; FAO-WRB 2006: **Haplic Arenosols (dystric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-30 : Brown (10 YR 4/3) when dry and dark yellowish brown (10 YR 3/4) when moist; sandy; spotless; simple grains, not sticky and not plastic; common, thin, average, large and rare pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; few, thin, common, medium and large roots; gradual and wavy transition.

B1 30-60 : Dark yellowish-brown (10 YR 4/4) when dry and same colour (10 YR 3/4) when moist; sandy; spotless; simple grain structure; loose, non-sticky and non-plastic; few, thin pores; without rocky fragments; no mineral nodules; without effervescence; rare, thin, common, average and large roots; gradual and wavy transition.

B2 60-90 : Dark yellowish brown (10 YR 4/4) when dry, same colour (10 YR 3/6) when moist; sandy; spotless; single grain structure; loose, non-sticky and non-plastic; rare, very thin pores; without rocky fragments; no mineral nodules; without effervescence; average, common, rare and large roots; gradual and wavy roots.

B3 90-120 : Dark yellowish brown when dry, (10 YR 4/6) the same colour (10 YR 4/4) when moist; sandy; spotless; single grain structure; loose, non-sticky and non-plastic; rare, very thin pores; without rocky fragments; no mineral nodules; without effervescence; medium, rare roots.

ANNEX A21. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL02P1

Location: Mapai-Chicualcuala Coord.: Lat. 22º52´12´´S, Long. 31º51´07´´ E
Sheet: 83 Ground form: Sandy plain Topography: Mildly Wavy
Soil unit: (Local) **G**; FAO-WRB 2006: **Ferralic Arenosols (dystric)**

Morphological characteristics

Horizon: Depth. (cm)

A 0-26 Brown-reddish dark (2.5 YR 3/4) when dry and red-brown (2.5 YR 3/2) when moist; silty sand; spotless; single grains; very weak, very thin,

structure of granular type; very mild, very friable, not sticky and not plastic; dominant, average and thin pores; without rocky fragments; no mineral nodules; without effervescence; common unspecified cavities; dominant, very thin, rare and medium roots; diffuse and plain transition.

B1 26-66 : Dark red (2.5 YR 3/6) when dry, reddish-brown (2.5 YR 3/3) when moist; silty sand; spotless; very weak, very thin structure of granular type; very mild, very friable, not sticky and not plastic; dominant, very thin pores; without rocky fragments; no mineral nodules; without effervescence; few termite cavities; common, thin, rare and large roots; diffuse and wavy transition.

Bw1 66-104 : Red (2.5 YR 4/6) when dry and dark reddish brown (2.5 YR 3/4) when moist; silty sand; spotless; very weak, very thin structure of granular type; very mild, very friable, not sticky and not plastic; dominant, very thin pores; without rocky fragments; no mineral nodules; without effervescence; few termite cavities; few, thin, rare, medium and large roots, diffuse and wavy transition.

Bw2 104-150 : Dark red (2.5 YR 3/6) when dry and dark reddish-brown (2.5 YR 3/4) when moist; silty sand; spotless; very weak, very thin structure of granular type; very mild, very friable, not sticky and not plastic; dominant, very thin pores; without rocky fragments; no mineral nodules; without effervescence; few termite cavities; few, thin, medium and rare roots.

Physical and chemical features

Sample GLoo1P1									
	Horizon	A	Class	B1	Class	B2	Class	B3	Class
	Depth	0-26		26-66		66-104		104-150	
pH H_2O	(1:2.5)	5.97	Mod. acid	6.36	Light acid	5.89	Mod. acid	6.43	Light acid
CEmS/cm	(1:2.5	0.032	Not saline	0.042	Not saline	0.037	Not saline	0.046	Not saline
C	%	0.37	Very low	0.2	Very low	0.16	Very low	0.1	Very low
MO	%	0.65	Very low	0.34	Very low	0.27	Very low	0.17	Very low
Ca	me/100g	1.8	Low	1.8	Low	1.4	Low	1.2	Low
Mg	me/100g	0.8	High	1.2	Very high	2	Very high	1.8	Very high

Na	me/100g	0.13	Low	0.13	Low	0.13	Low	0.13	Low
K	me/100g	0.16	Low	0.32	Average	0.46	High	0.72	High
Al3++H+	me/100g	2.5	Mod. Toxic	1.5	Light Toxic	1.5	Light Toxic	1.25	Light Toxic
CTC	me/100g	6.4	Low	5.9	Low	6.5	Low	5.9	Low
P	mg/100g	0.874	Low	0.085	Very low	0.102	Very low	0.051	Very low
Clay	%	8.01		11.27		11.58		12.81	
Loam	%	4.01		3.81		3.92		3.16	
Sand	%	87.98		84.91		84.5		84.03	
Class	Texture	Silty sand		Silty sand		Silty sand		Silty sand	

ANNEX A22. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GL02P1

Location: Mapai-Chicualcuala Coord.: Lat. 22º55´16´´S, Long. 31º53´30´´ E
Sheet: 83 Ground form: Sandy plain Topography: Mildly Wavy
Soil unit: (Local) **Aj**; FAO-WRB 2006: **Ferralic Arenosols (dystric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-20 dark reddish-brown (2.5 YR 3/3) when and the same colour (2.5 YR 2.5 / 3) when moist; sandy; spotless; simple grains; loose, non-sticky and non-plastic; dominant, average and thin pores; without rocky fragments; no mineral nodules; without effervescence; rare unspecified cavities; dominant, very, thin, common, medium roots; diffuse and plain transition.

B1 26-60: dark reddish-brown (2.5 YR 3/4) when dry and same colour (2.5 YR 2.5 / 4) when moist; sandy; spotless; simple grains, loose, non-sticky and non-plastic; many thin pores; no rocky fragments, no mineral nodules; without effervescence; few termite cavities; common, thin, rare and large roots; diffuse and wavy transition.

B2 60-120 : dark reddish-brown (2.5 YR 3/4) when dry and same colour (2.5 YR 2.5 / 4) when moist; sandy; spotless; simple grains; loose; non-sticky and non-plastic; many, common, average, thin and rare pores; without rocky fragments; no mineral nodules; without effervescence; rare termite cavities; few, thin, average and rare roots.

ANNEX A23. Characteristics of the Representative Profiles of Soils in the study area

Profile Code: GA027B2

Location: NTlavene-Mabalane Coord.: Lat. 22º55´16´´S, Long. 31º53´30´´ E
Sheet: 83 Ground form: Sandy plain Topography: Mildly Wavy
Soil unit: (Local) **P3**; FAO-WRB 2006: **Ferralic Cambisols (dystric)**

Morphological characteristics

Horizon: Depth (cm)

A 0-20 Grey-red (5 YR 5/2) when dry and very dark grey (5 YR 3/1) when moist; silty-sandy; spotless; simple grain structure; loose; non-sticky and non-plastic; dominant, thin and average pores; without rocky fragments; no mineral nodules; without effervescence; common unspecified cavities; dominant, very thin, common and medium roots; diffuse and plain transition.

B1 26-50 : Dark reddish-grey (5 YR 4/2) when dry and dark reddish brown (5 YR 3/2) when moist; sandy-silty; spotless; very weak, thin structure, of granular type; very mild, very friable, not sticky and not plastic; many very thin, common and average pores; without rocky fragments; no mineral nodules; without effervescence; few unspecified cavities; common, thin, few, medium and large roots; diffuse and wavy transition.

B2 50-70 : Brown-red (5 YR 5/3) when dry and same colour (5 YR 3/3) when moist; sandy-silty; spotless; very weak, thin structure of granular type; very mild, very friable, not sticky and not plastic; common, very thin, average and rare pores; without rocky fragments; no mineral nodules; without effervescence; rare termite cavities; few, thin, rare and average roots; clear and plain transition.

Bw 50-70 : Reddish-brown (5 YR 4/3) when moist; sandy silty; spotless; weak, medium structure of subangular anisoform type; mild, friable slightly sticky and not plastic; few, very thin, rare and average pores; without rocky fragments; no mineral nodules; without effervescence; medium and rare roots.