REPORT OF MAPPING GULLIES IN BEREA DISTRICT

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Contents

1.0 INTRODUCTION

A gully is an incision formed on the land due to erosion, with a depth of 1.0 metre and above, and varying width. Gullies in Lesotho are estimate to cover an area of 100 ha. The government of Lesotho with the Ministry of Forestry and Land Reclamation (Department of Conservation (DoC)) has adopted the use of Geographic Information Systems (GIS) to identify and map gullies around the country in order to identify their coverage, location, vulnerable soils and their impact on different land uses which include settlements, cropland (arable land), rangelands and forests. Mapping was started at Berea district as a baseline with the plan to extent to the other 9 districts.

Berea district has an area of 197,831.55 ha of which about 36,453.89ha are settlements, 41,380 ha rangelands (only cattlepost areas). Croplands, mapped from 1979 topographic maps, are estimated to occupy about 95,950 ha of the district, but extracting settlements (about 14,493.67 ha) which have encroached over the years about 81,456.33 ha of them are expected to remain. Of the four ecological zones (Lowlands, Foothills, Highlands and Senqu River Valley) of Lesotho, Berea and Mafeteng are the only districts which do not have the Senqu River Valley. Since financial year 2003-2004 to 2011-2012 about 117 catchments have been worked in Berea, but only 41 have been mapped and their hectarage calculated as 10 865.63 ha which is 0.05% of the total area of Berea. Thus any information related to catchments will be based on only those that have been mapped. Annex 3 shows the location of the catchments in Berea starting from 2004-05 financial years.

The objective of this report is to show the location of gullies in Berea, the area ,in hectares, which they cover, the types of soils where gullies are located, the extent of gullies in different land uses and the location of gullies in catchments which have been worked on through the ministerial Catchment Management Programme.

1.1 Soil Associations in Berea district

This section explains briefly the characteristics of the soil associations that are found in the Berea district as explained in the Soils of Lesotho. The knowledge of their morphology can have a positive influence on the use and management of these soils. Table 1 shows the Soil Associations names, colour and the area they cover in hectares.

Table 1: Berea Soil Associations Names, Colours and Areas

Association Name	**Colour**			**Area in Berea (ha)**
ROCK(SANDSTONE)_BEREA_NTSI_MATELA	R160	G102	B50	**36,393.4**
BEREA_MATELA_NTSI	R186	G165	B0	**13,682.75**
KHABOS_BELA_BEREA	R15	G124	B129	**5,066.6**
LERIBE_BEREA_SEPHULA	R219	G0	B0	**2,821.2**
MATSA_FUSI_POPA	R180	G254	B0	**705.3**
POPA_ROCKLAND_(BASALT)_MATSANA	R155	G156	B219	**57,204.0**
RALEBESE_MATSABA_MACHACHE	R254	G246	B164	**40,104.9**
SEPHULA_MASERU_BEREA	R233	G224	B96	**41,306.8**
SOFONIA_CALEDON_KOLONYAMA	R194	G251	B254	**564.6**
Total				**197,849.55**

1.1.1 Rockland (Sandstone) Berea_Matela_Ntsi Soil Association

This association occupies approximately 36,393.4 ha of the soil associations in Berea district. This association is usually found below sandstone escarpments or accompanying detritus slopes and colluvial land. Other less major soils of this association occupy the landscape above the escarpment. They are situated in the following topographic sequence: thin Ntsi soils drain into the somewhat poorly drained Berea soils on gently sloping areas which in turn drains into the well drained Matela, soils on adjacent hillcrests.

Rockland (sandstone) occupy about 34% of the association while Ntsi soils 25%, Berea soils 15%, Matela 10%, colluvial land 10%, escarpments (sandstone) 4% and Maliele soils 2% of the associationOnly about 27% of this association is suitable for agriculture being limited to Berea, Matela and Maliele soils. Fruit trees can be grown with care and maintenance on the colluvial slopes, but with the existing care and maintenance sustainability might be poor and yields not profitable. Woodlots of pine eucalyptus can survive on colluvial slopes. Unfortunately the remaining (63%) part of the association is too thin for tillage agriculture.

1.1.2 Berea_Matela_Ntsi Soil Association:

Soils of this association are shallow to deep, well to somewhat poorly drained, sandstone derived and have a sandy loam and loam texture. They are usually found on cave sandstone plateaus and red bed deposits. This association occupies 13,682.75 ha of the Berea district.

Berea soils occupy about 28% of the association, Matela 15%, Ntsi 15%, Rockland (sandstone) 15%, Qalaheng 10%, Sephula 8%, Maseru 5%, Theko 2% and Thoteng 2%. This associations drains into small intermittent streams as well as dry dongas (gullies) and feeds into secondary streams that flow into the Caledon River.

The arable land of this association (Berea and Matela) can be cultivated with cereals, legumes and potatoes. Ntsi soils are shallow and should be left uncultivated. The remaining minor soils are poorly drained and are characterised by gullies as shown in Map 2.

1.1.3 Khabos_Bela_Berea Soil Association:

These soils are moderately deep to deep, fine sandy loam to clay and are usually found on alluvial terraces and flood plains of major rivers, their tributaries and on marginal areas. This association covers 5,066.6 ha of the Berea district.

Khabos soils occupy about 50% of the association, Bela 12%, Berea 12%, Kolonyama 8%, Kubu 8%, Sofonia 8% and Caledon 2%. These soils differ greatly in terms of texture and fertility. Almost all the arable soil of this association can be cultivated with maize, beans, peas, wheat, potatoes, sorghum and vegetables. However the sandier soils including Caledon and Sofonia, provide poor seed beds and cannot support good plant growth without supplemental irrigation. Kolonyama and Bela are often too wet to allow crops to reach maturity.

1.1.4 Leribe_Berea_Sephula Soil Association:

These soils are moderately deep to deep and have a well to poor drainage. Their texture varies from sandy loam, loam and clay loam. This association covers 2,821.2 ha of the Berea district. The most dominant soils in this association are Leribe and Berea soils at 32% each, followed by Sephula 16%, Rockland (sandstone) 7%, Ntsi 5%, Maseru 5%, and Maseru dark variant 3%. The Leribe and Berea soils which are the most dominant are extensively cultivated in the upper part of the catchment and are planted maize but sorghum, beans and wheat can also be planted. Management practices that improve the water holding capacity of these soils such as minimum tillage, weed control and residue management or stubble mulching are highly recommended. Minimum tillage is recommended since increased soil compaction is a concern. On the steeper slopes, the resistance of these soils to erosion can be enhanced by terrace maintenance and reconstruction if damaged as well as diversion furrows. Grasses and legumes are especially helpful in reducing runoff and erosion in steeper slopes. Unfortunately, the Sephula soils are associated with occurrence of dongas. They are characterised by slow permeability and infiltration rates which contribute to low tolerance and resistance to erosion. The vulnerability of these soils to erosion depends on the length and steepness of the slope. Low available water holding capacity of these soils causes drying of the rooting zone and droughty in most years. The fields in the Sephula series need maintenance and reseeding of terraces.

1.1.5 Matsana - Fusi - Popa Soil Association

These soils are dark, shallow to deep and nearly level to strongly sloping; commonly well to moderately well drained mostly basalt derived loam, clay loam or clay on mountain uplands and valleys. Matsana soils occupy about

45%, Fusi soils 20%, Popa 20%, Rockland basalt 8%, Thabana 5% and Phechela 2%. These soils have natural fertility and are cultivated with maize, potatoes, beans, wheat and peas with the latter being most successful. Popa and Rockland basalt are not suitable for tillage agriculture.

1.1.6 Popa - Rockland basalt – Matsana Soil Association

These soils are mostly dark, shallow to moderately deep, undulating to steep, mostly well to moderately well drained, almost entirely basalt derived loam or clay loam with small inclusions of sandy loam or clay on mountain uplands. Popa soils occupy above 55% of the association, Rockland basalt about 27% and Matsana soils 15%, Fusi, Thabana and Phechela soils occupying 1% each. Most of the arable soils of these associations are Matsana, Fusi and Thabana and cultivated with maize, potatoes, beans, wheat and peas with the latter being most successful.

1.1.7 Ralebese_Matsaba_Machache Soil Association

Soils in this association are usually shallow to deep and are basalt-derived. They are commonly found in the foothill uplands. The principal soils of this association are the Ralebese, Matsaba and Machache series whilst minor soils comprise Rockland (basalt and sandstone), Matela and Phechela. The arable soils of this association can be cultivated with maize, beans, peas, wheat, potatoes and sorghum. It is recommended that Ralebese and Rockland should be left uncultivated. Phechela and Thabana soils present problems in internal drainage during seasons of high rainfall which makes their management and workability very difficult due to the presence of high clay content.

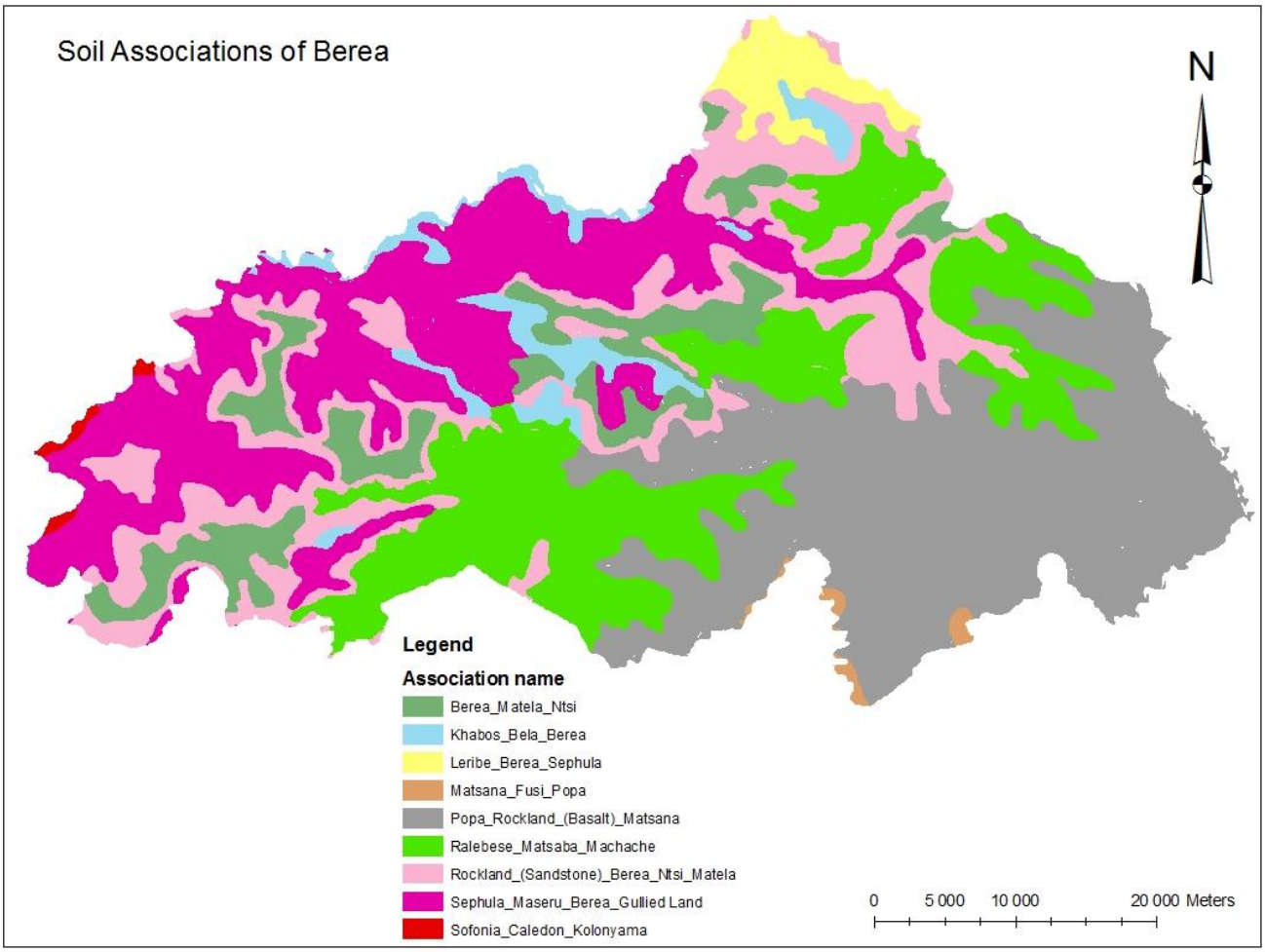
1.1.8 Sofonia_Caledon_Kolonyama Soil Association

Soils of this association are moderately deep to deep with a fine sandy loam to clay loam texture. They are found on alluvial terraces and flood plains of major rivers and their tributaries. Principal soils of this association are the Sofonia, Caledon and Kolonyama series with the minor soils being Rockland (sandstone), gullied land and the Bosiu and Maseru series. Almost all of these soils with the exception of Rockland and gullied land can be cultivated to maize, beans, peas, wheat, potatoes, sorghum grain and vegetables. However, Caledon soils provide poor seed beds and cannot support good growth without supplemental irrigation. Kolonyama soils are also often too wet to cultivate or to mature a crop.

1.1.9 Sephula_Maseru_Berea_Gullied Land Soil Association

This association covers 41,306.8ha in the Berea district. These soils are shallow to deep and are mostly poorly drained to very poorly drained. They are derived from sandstone and basalt derived loam with a clay loam or clay texture and is found below sandstone escarpments. These soils are found just north of Teyateyaneng village. The principal soils in this association are the Sephula, Maseru and Berea series and gullied land while the minor soils comprise rockland (sandstone), Tsiki, Rama, Leribe, Ntsi, Matela, Phechela and Maseru dark variant.

Almost all of the major duplex soils of this association can be cultivated with maize, sorghum, beans or vegetables. However, yields are generally poor. They are characterised by accelerated erosion (donga formation). Therefore duplex soils should be treated with care. There should be no mechanical disturbance to these soils. Breaking up of the soil is discouraged. These areas should be used for fodder production with minimum to zero tillage practices. Reseeding of the degraded areas and marginal lands, especially the abandoned fields, preferably with indigenous grasses is highly recommended. After the establishment of the grasses, harvesting should be in the form of cutting for since trampling by animals may lead to compaction and disturbance of the soil. Education as well awareness campaigns should be done to inform the field owners on the dangers of poor management practices. Biological measures are best suited to control the alarming rate of soil erosion in this catchment. Grasses and trees with fibrous roots are recommended.



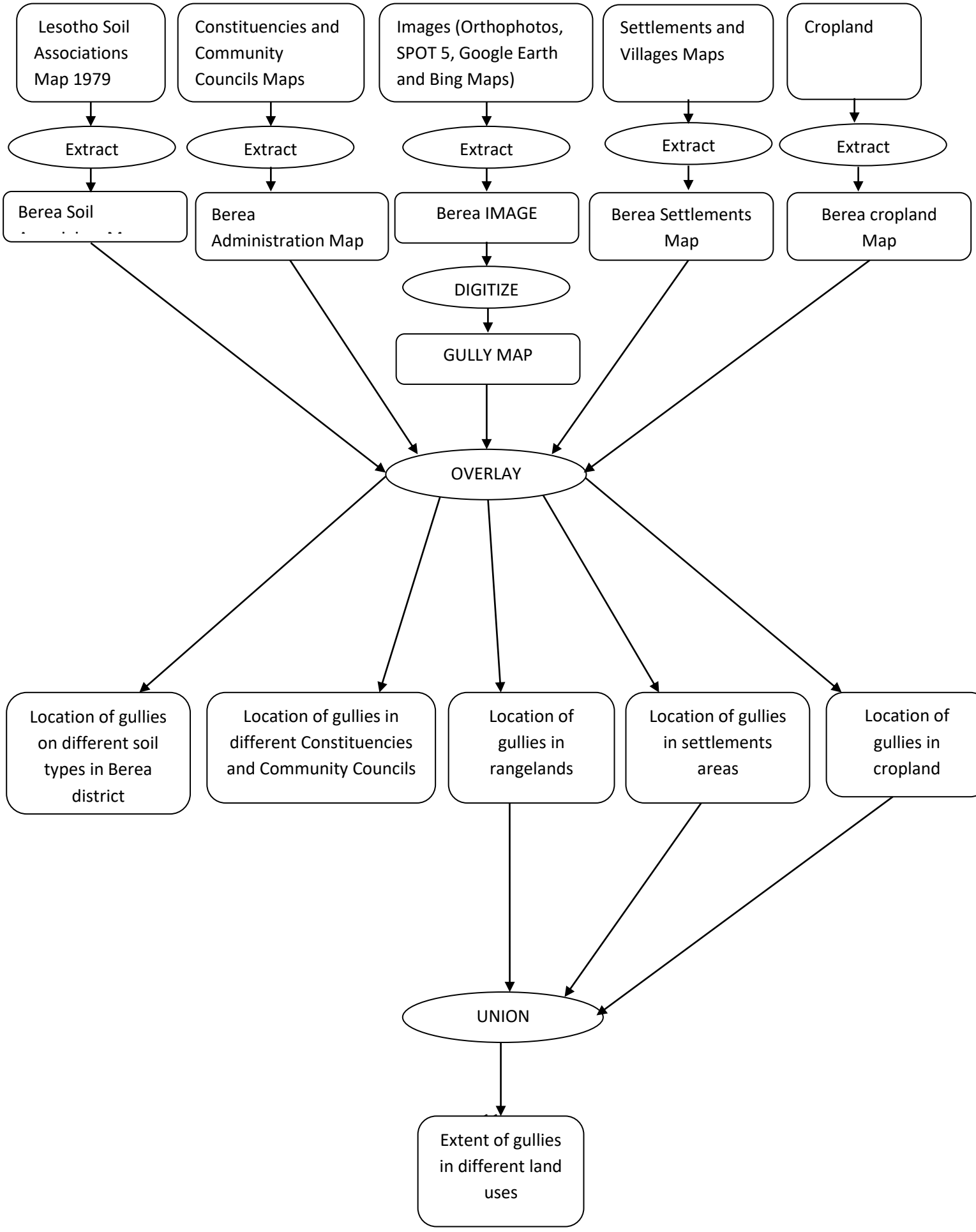
Map 1 Soil Associations in Berea

2.0 METHODOLOGY

Gullies were identified from Orthophotos and mapped using ArcGIS 10 with ArcEditor licence (trial version) coupled with ArcGIS 9.3.1 ArcInfo licence. The Orthophotos used cover all the lowlands part of the country and a larger part of Quthing district. In order to map gullies in the Foothills and Mountains another raster image, SPOT 5, was used and coupled with Google earth and Bing maps images. Digital Elevation Model (DEM) of 30m is used to highlight the elevation of the location of the gullies. Constituency and Community Councils Maps (from Land Use Planning), Settlements and Villages Maps (from MTDP project) were also used to show the extent of gullies in rangelands and settlement. Forestry Map is yet to be produced therefore this report does not cover the extent of gullies in forests yet there were gullies which were identified and mapped in forests.

The model summary of the data used and maps produced is below.

Structural presentation of the model of data used and maps produced

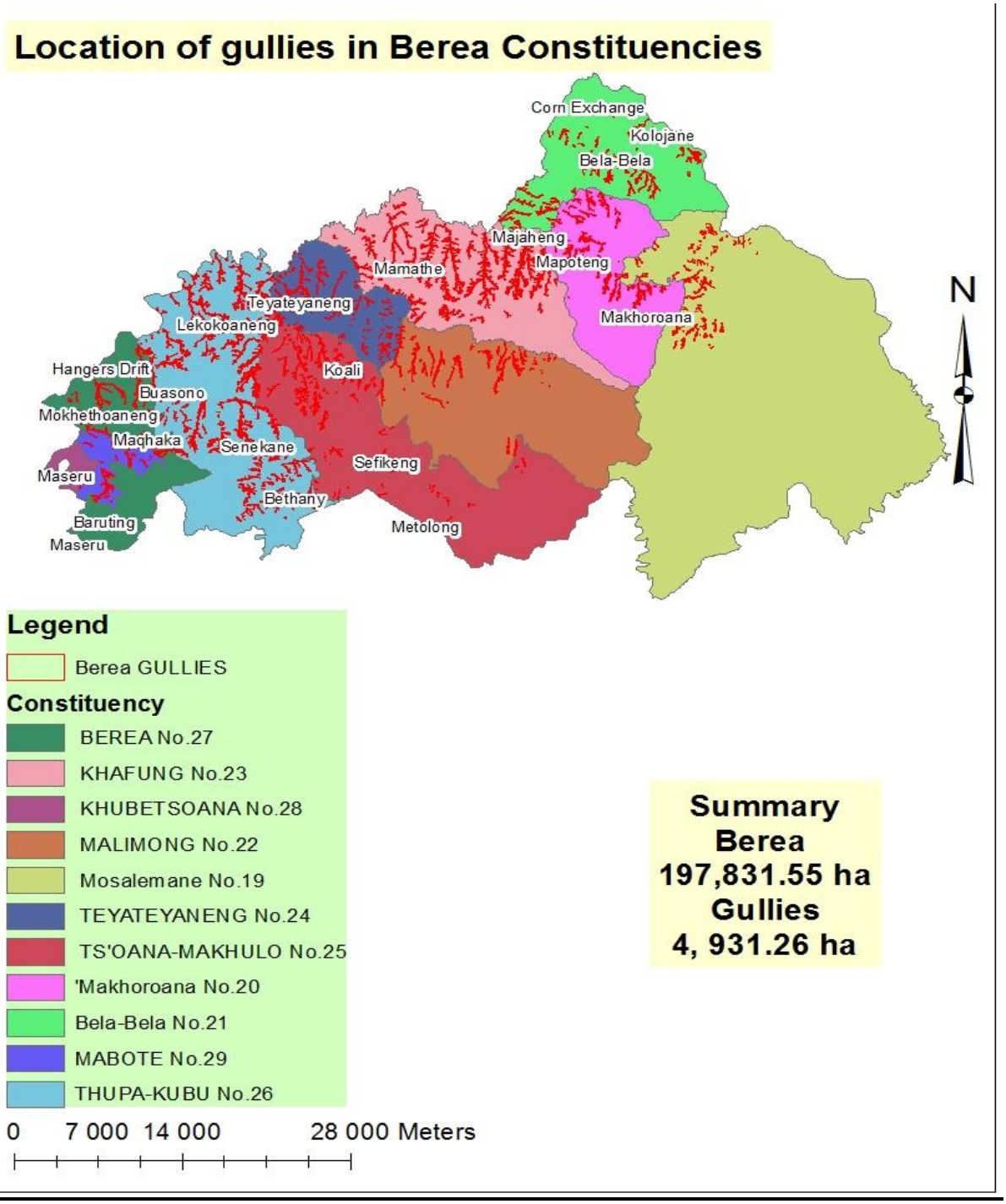


3.0 DISCUSSIONS

About 1760 gullies were identified in Berea district covering a total of 4,931.26 ha which is about 2.5% of the total area of the district. Most of the gullies are found at the lowlands areas along Mohokare River. Thupa Kubu Constituency has more gullies than any other Constituency while Khubetsoana constituency has the least. This may be contributed to the difference in major land uses in the constituencies where Thupa Kubu has crop farming as the major land use while Khubetsoana has settlements as the major land uses. Alternatively the topography of the two areas may also be the major contributor to different land uses thus indirectly affecting formation of the gullies. Table 1 below shows the areas of gullies in different Constituencies of Berea.

Table 2: Coverage of gullies in different Constituencies of Berea

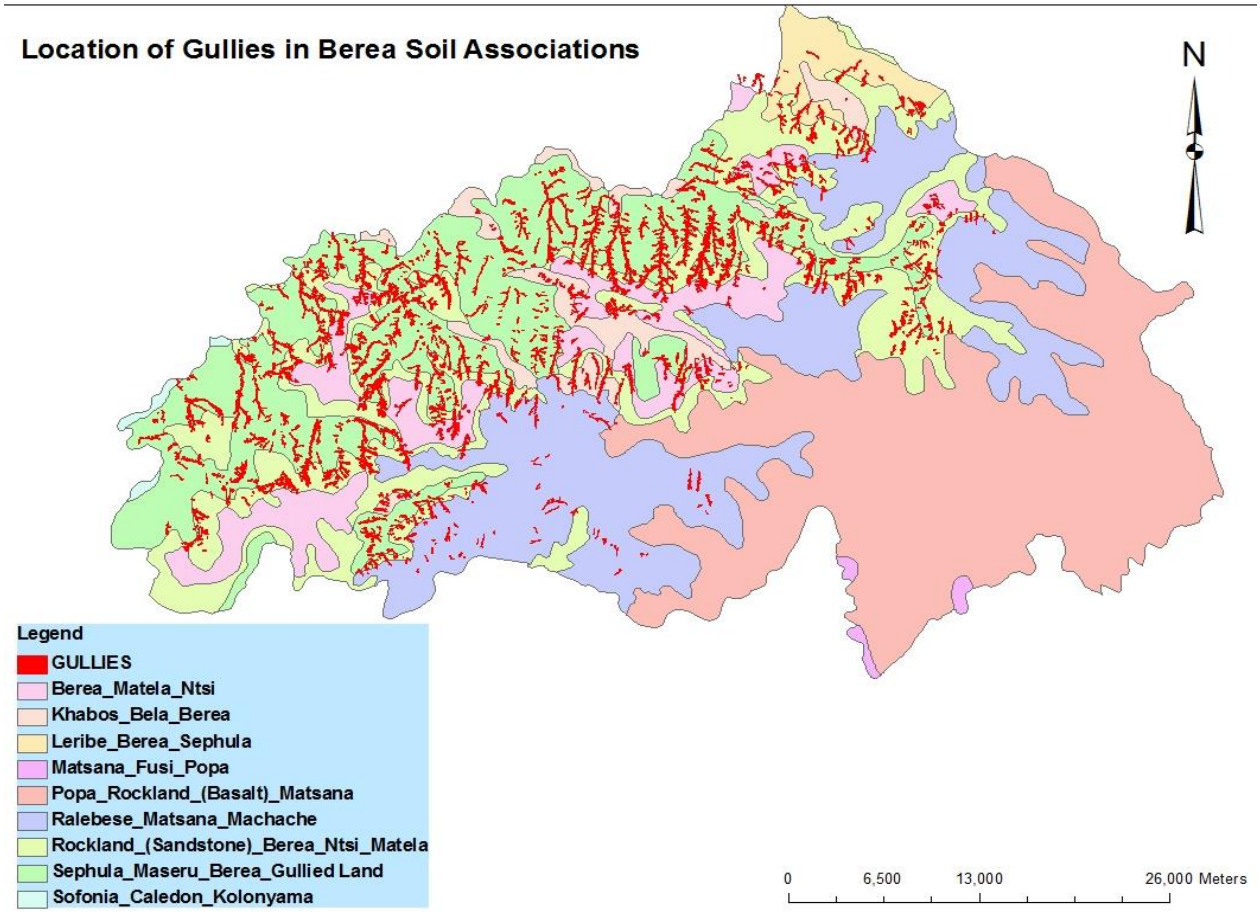
Constituency Name (ha)	**Area (ha)**	**No of gullies**	**Area of Gullies (ha)**
Bela-Bela	13915	68	394.83
Berea	10495	178	599.18
Khafung	18516	166	94.75
Mabote	2346	106	193.57
Thupa-Kubu	24433	653	1748.76
Tetateyaneng	7727	198	389.86
Mosalemane	58407	148	198.58
Malimong	21807	64	371.01
‘Makhoroana	12573	83	310.55
Ts’oana Makhulo	25078	290	627.05
Khubetsoana	1023	2	3.69



Map 2: Location of gullies in Constituencies of Berea districts

3.1 Types of soils where gullies are found

Table 1 above showed the soil associations in Berea district according to Lesotho soils classification. Map 3 below shows the location of gullies in different soil associations.

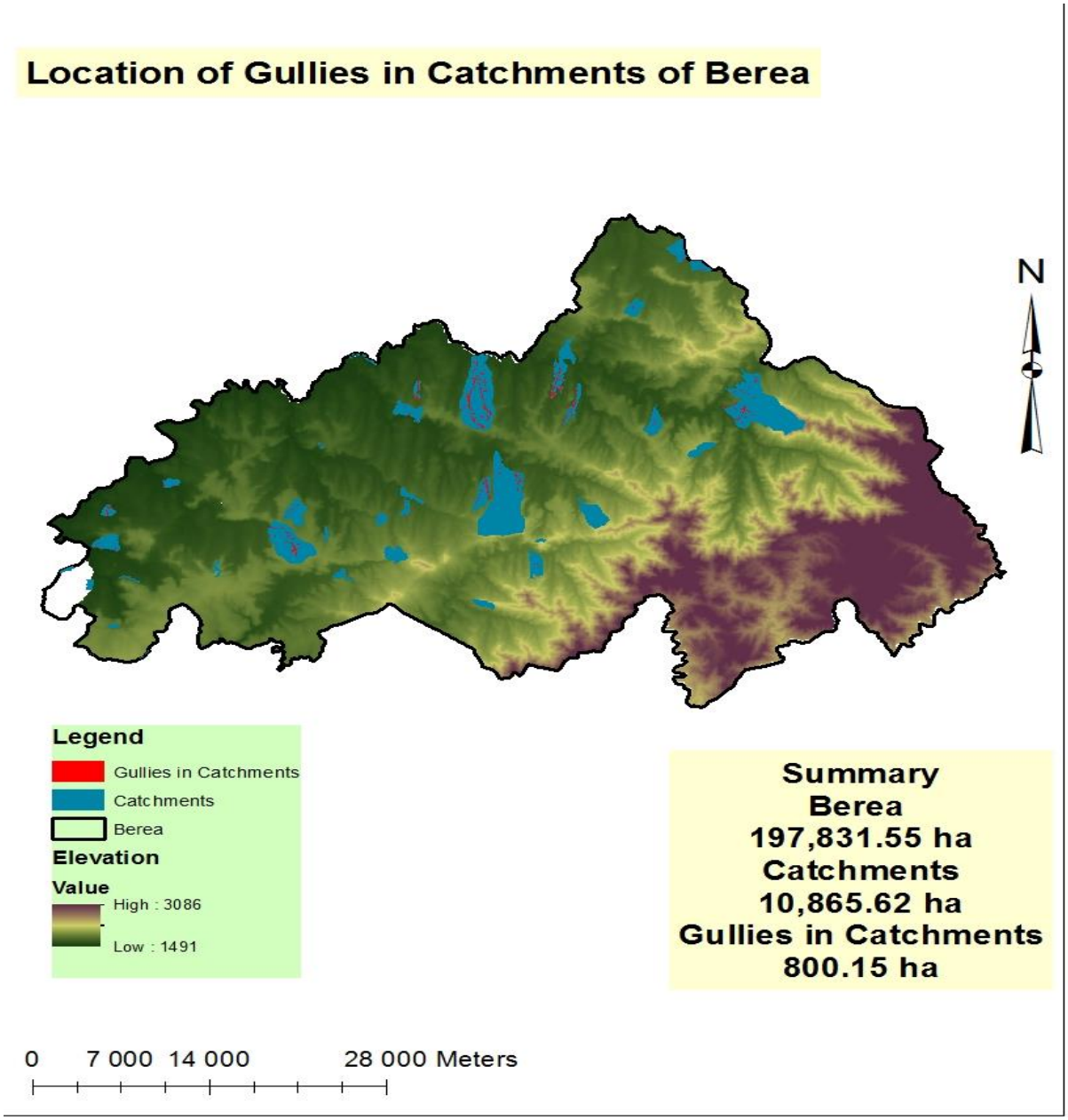


Map 3: Location of gullies in different Soil Associations of Berea

The Sephula_Maseru_Berea_Gullied Land Soil Association has more gullies than any other soil association. The presence of duplex soils in the Sephula_Maseru_Berea_Gullied Land Soil Association as mentioned in 1.1.9 above may have contributed to the accelerated rate of erosion in these areas which then resulted in the formation of gullies. This association is also used for cultivation and lack of proper soil conservation activities may have led to the accelerated formation of gullies in those areas. On the other hand, Ralebese_Matsana_Machache soil association has the least amount of gullies whereas Popa_Rockland_(Basalt)_Matsana soil association has no gullies at all. This is probably because the latter is located mostly in the highlands where the area is mostly used as rangeland whereas the Ralebese_Matsana_Machache soil association is used for cultivation. The use of proper soil conservation practices should be strongly highlighted in all areas that are vulnerable to soil erosion.

3.2 Gullies in Catchments

A total of 161 gullies were found to be located in catchments with an area of 800.15 ha. While this figure is only based on catchments that have been mapped, assumption is that more gullies may fall within catchment, thus field verification or more mapping by the district staff would aid to locate more catchments. Map 4 below shows the location of gullies in catchments.



Map 4: Location of Gullies in Catchments

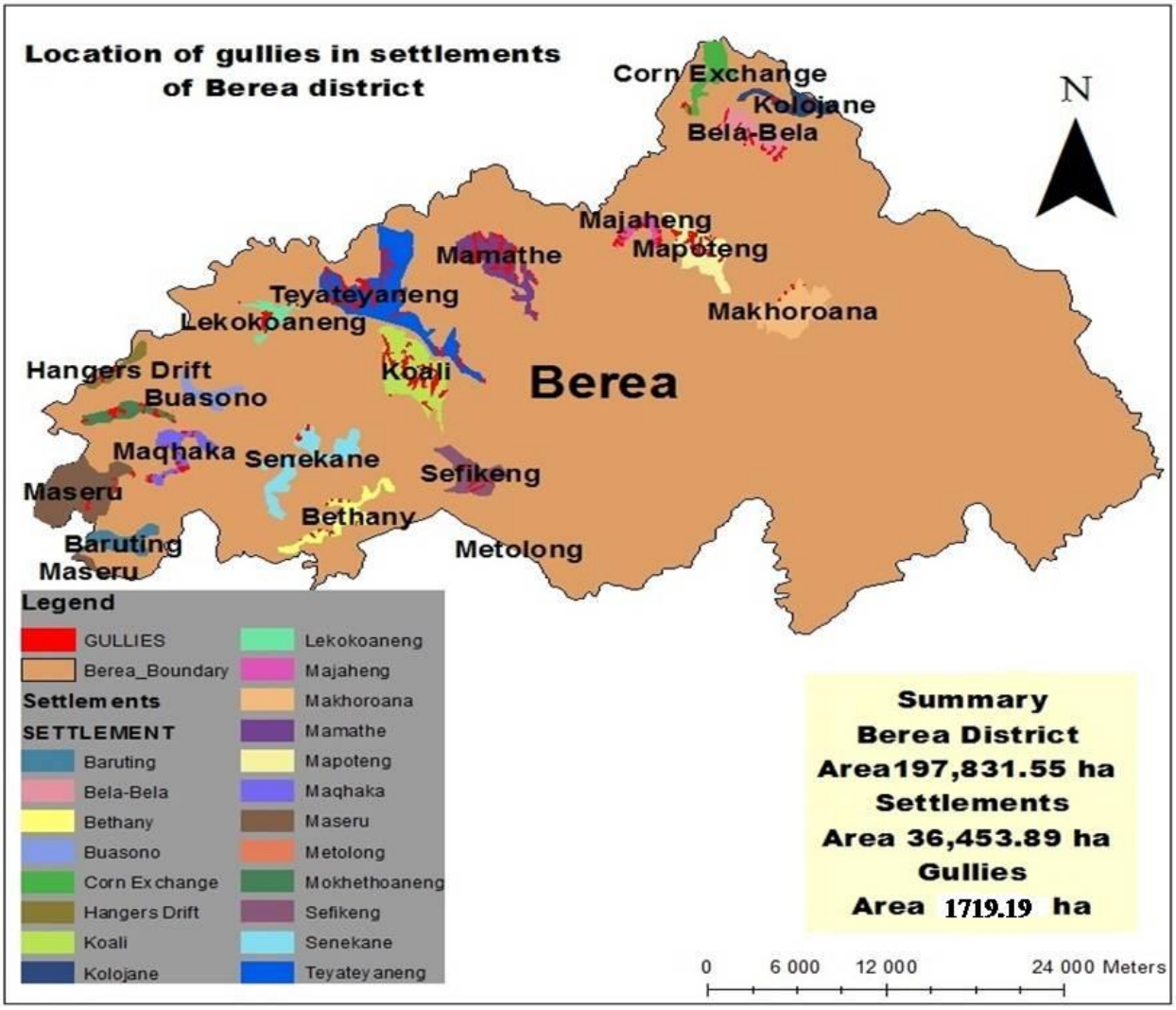
3.3 Impact of gullies on different land uses

3.3.1 Settlements

Settlement areas in Berea cover about 36,453.89 ha. Of this area 1719.19 ha is gullies. Map 4 below shows the extend of gullies in settlements

Table 3: Coverage of Gullies in settlements of Berea District

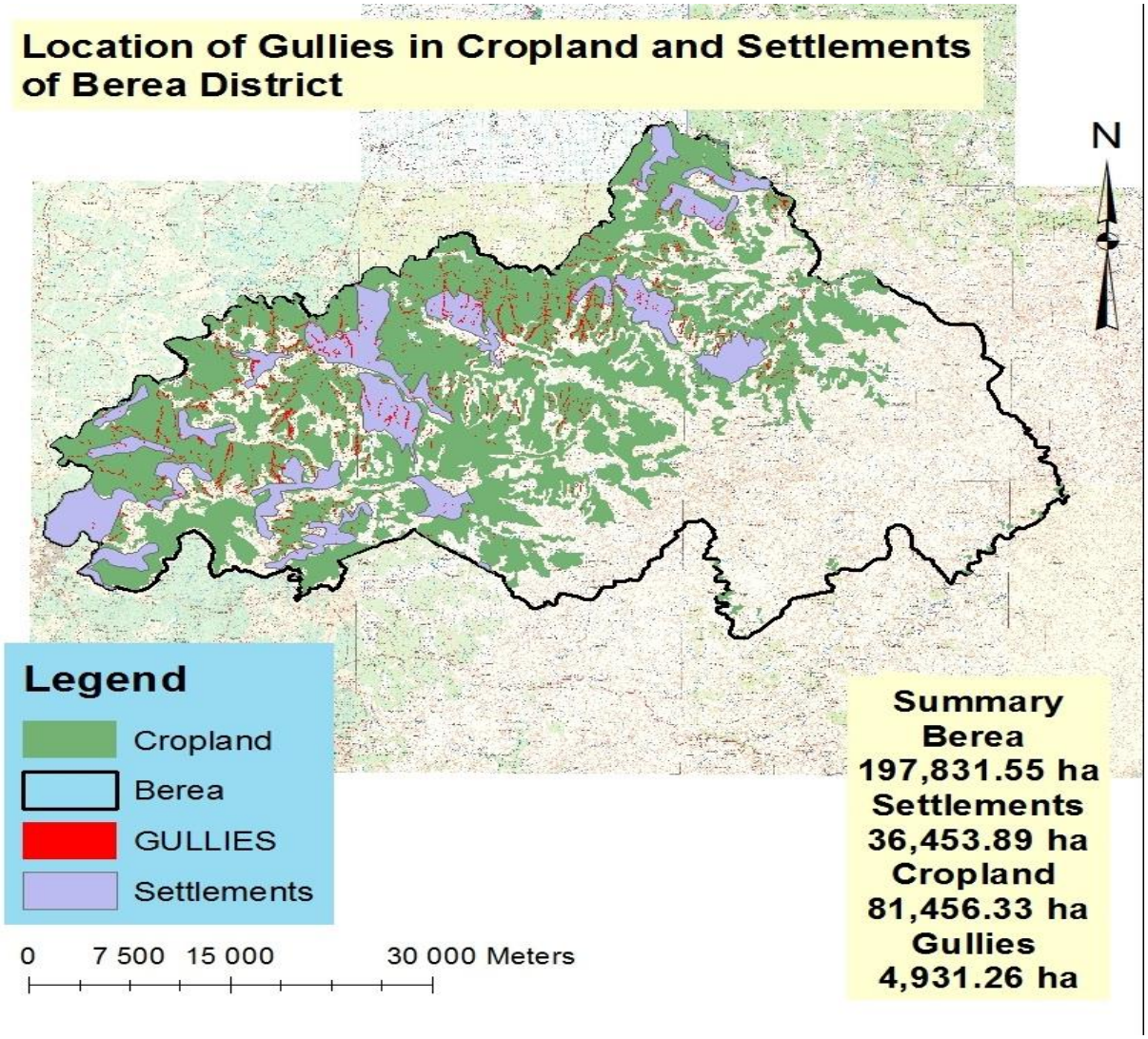
Constituency Name (ha)	Settlement Area (ha)	No of gullies in settlements	Area of Gullies in Settlements (ha)
Bela-Bela	2414.44	16	120.92
Berea	2076.6	66	326.33
Khafung	1948.54	28	374.46
Mabote	757.84	19	36.78
Thupa-Kubu	3417.23	61	447.4
Tetateyaneng	3019.54	54	169.31
Mosalemane	0.128	-	-
Malimong	91.5	2	21.11
‘Makhoroana	2676.30	23	101.11
Ts’oana Makhulo	5363.67	28	118.08
Khubetsoana	16721.78	2	3.69
Total			**1719.9**



Map 5: Location of gullies in settlement areas of Berea

3.3.2 Cropland

Cropland was deduced to occupy about 95, 950 ha but after extracting settlements (14,493.67 ha) which have encroached over the years about 81,456.33 ha are expected to remain. Gullies identified and mapped in cropland occupy an area of 2,787 ha. This figure tallies with the location of the soils which are mostly used for cropping, which is the lowlands part of Berea district. Map 5 below shows location of gullies in cropland and settlements of Berea.



Map 6 Location of gullies in Cropland and Settlements of Berea

3.3.3 Rangelands

Rangelands have been found to occupy 41,380 ha in Berea district; however this coverage only includes cattlepost areas. Therefore, it is important that there be an exercise by the district Range Resources Management staff to map the village grazing areas so that the location and impact of gullies in these rangelands can be deduced. From the mapped gullies there seem to be none located in the cattlepost areas. This information requires field verification as the imagery used (2005 SPOT 5 imagery and 2006 Lowlands coverage Orthophotos) to map gullies may have had gullies in areas where there was cloud cover or the image was too old before there were gullies in those areas. Therefore when such information has been obtained it will be included in this report.

3.3.4 Forest Areas

Currently the Ministry has no digital forest map, thus the location and impact of gullies in forests has not been calculated in this report. However, when the information on forests has been mapped it will be included in the report.

4.0 CONCLUSION

This excise was done to map gullies in Berea district, determine their coverage in different land uses and also the types of soils they are found.

Gully coverage in Berea district was found to be 4,931.26 which are 2.5% of the total area of the district. They are located mostly in the Lowlands along the Mohokare River. Sephula_Maseru_Berea_Gullied Land Soil Association has more gullies than any other soil association while Popa_Rockland_(Basalt)_Matsana has the least. Settlement areas in Berea cover about 36,453.89 ha and of this area 1719.19 ha is gullies. Croplands were found to occupy about 81,456.33 ha after extracting 14,493.67 ha of settlements which have encroached over the years and of these gully encroachment was found to be 2,787 ha.

5.0 CHALLENGES

- Lack of accessibility to recent data, such as latest satellite images or Orthophotos, may have affected the number and size of the identified gullies as the images and Orthophotos used were taken in 2005 and 2006 respectively. But since they are the latest available images they are the most accurate. Thus efforts to obtain latest images will be made to continuously update the information on the gullies to obtain as accurate information as possible.

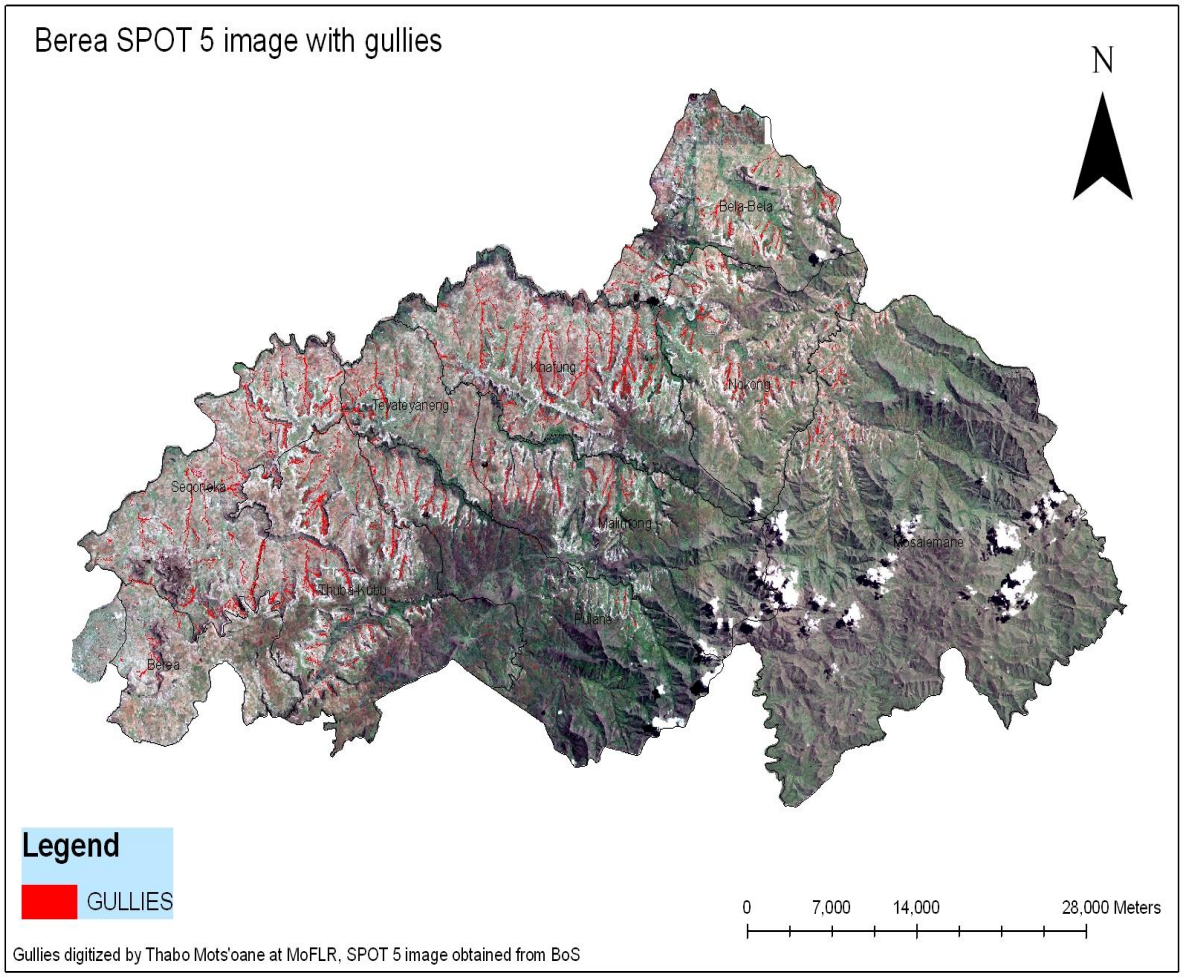
- Although the workstation computers used are of high quality, there is a need to upgrade them, especially their memories, because as more work is done and saved on them they become slower and thus slow the progress at times they may crash just like one of them did during the exercise.

- In order to speed up the digitization of all the gullies in the country there is a need to have more people in the GIS Unit.

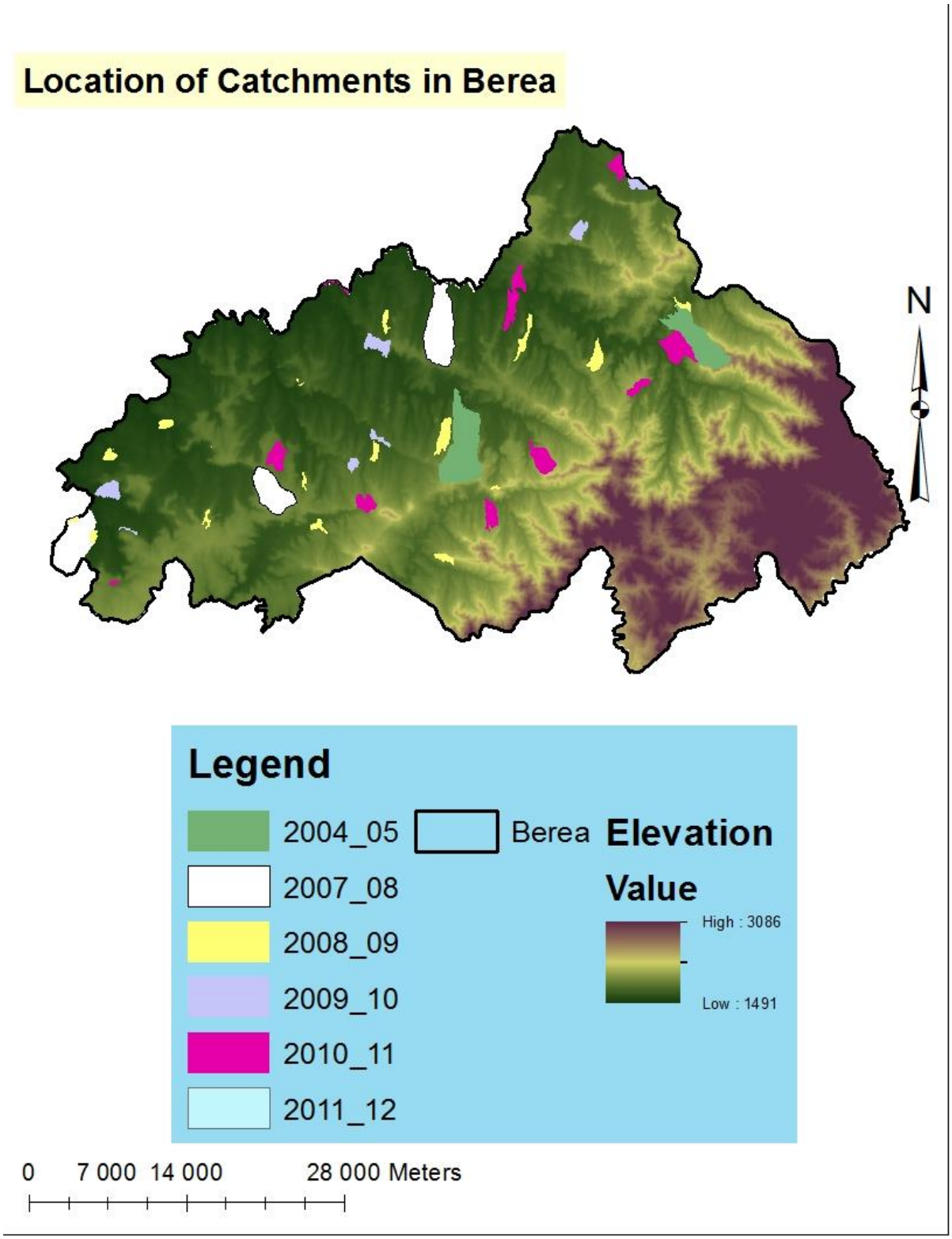
- There will be a need to have field visitations by the Department of Conservation staff to identify the type of erosion and ways of controlling it on the identified gullies and also to verify the information about the gullies.

Annexure

Annex 1



Annex 2


Location of Catchments in Berea
N
Legend
2004_05
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Berea
Elevation
Value
High : 3086
Low : 1491
0
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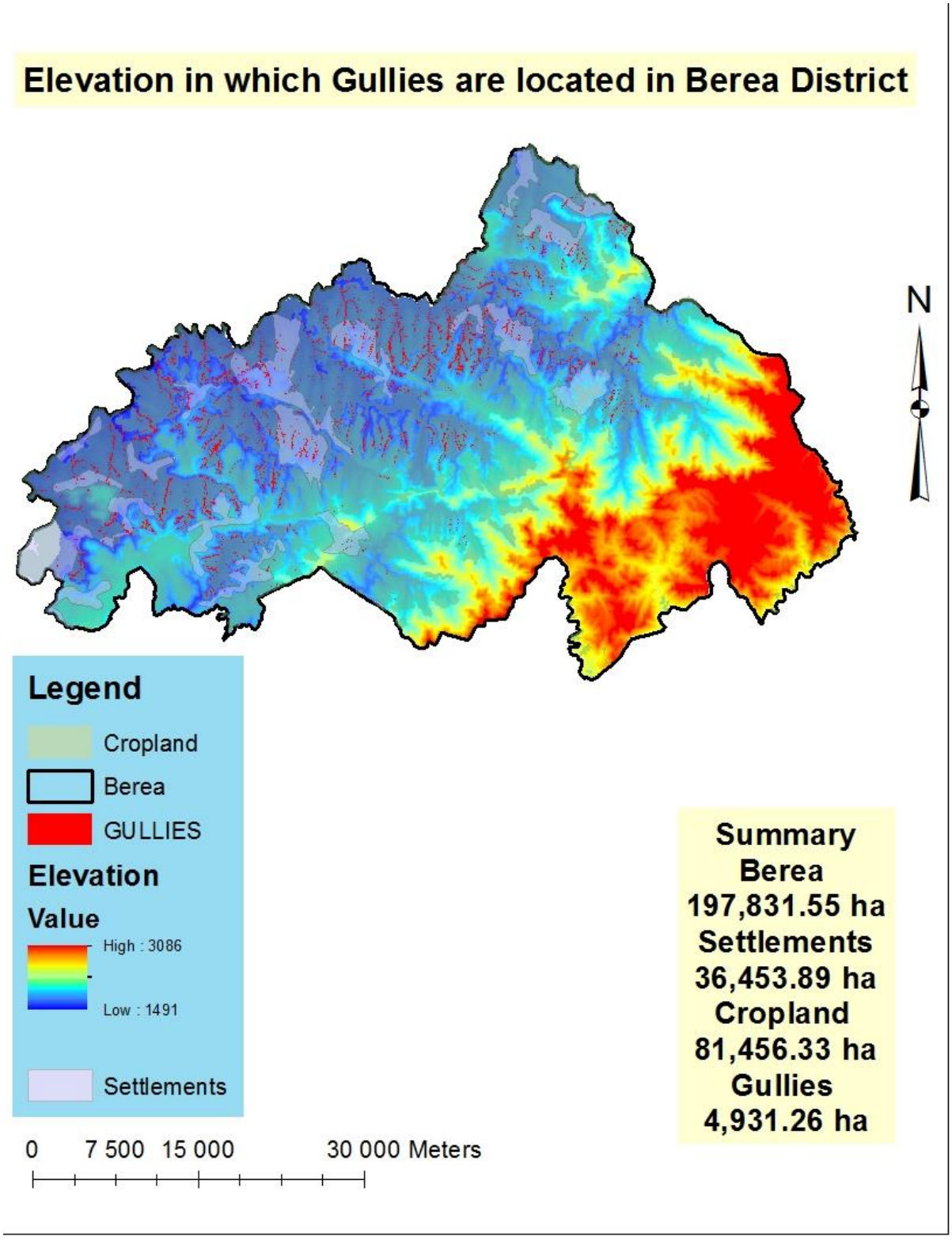
28 000 Meters

Annex 3


Elevation in which Gullies are located in Berea District
N
Legend
Cropland
Berea
GULLIES
Elevation
Value
High : 3086
Low : 1491
Settlements
Summary
Berea
197,831.55 ha
Settlements
36,453.89 ha
Cropland
81,456.33 ha
Gullies
4,931.26 ha
0
7 500
15 000
30 000 Meters