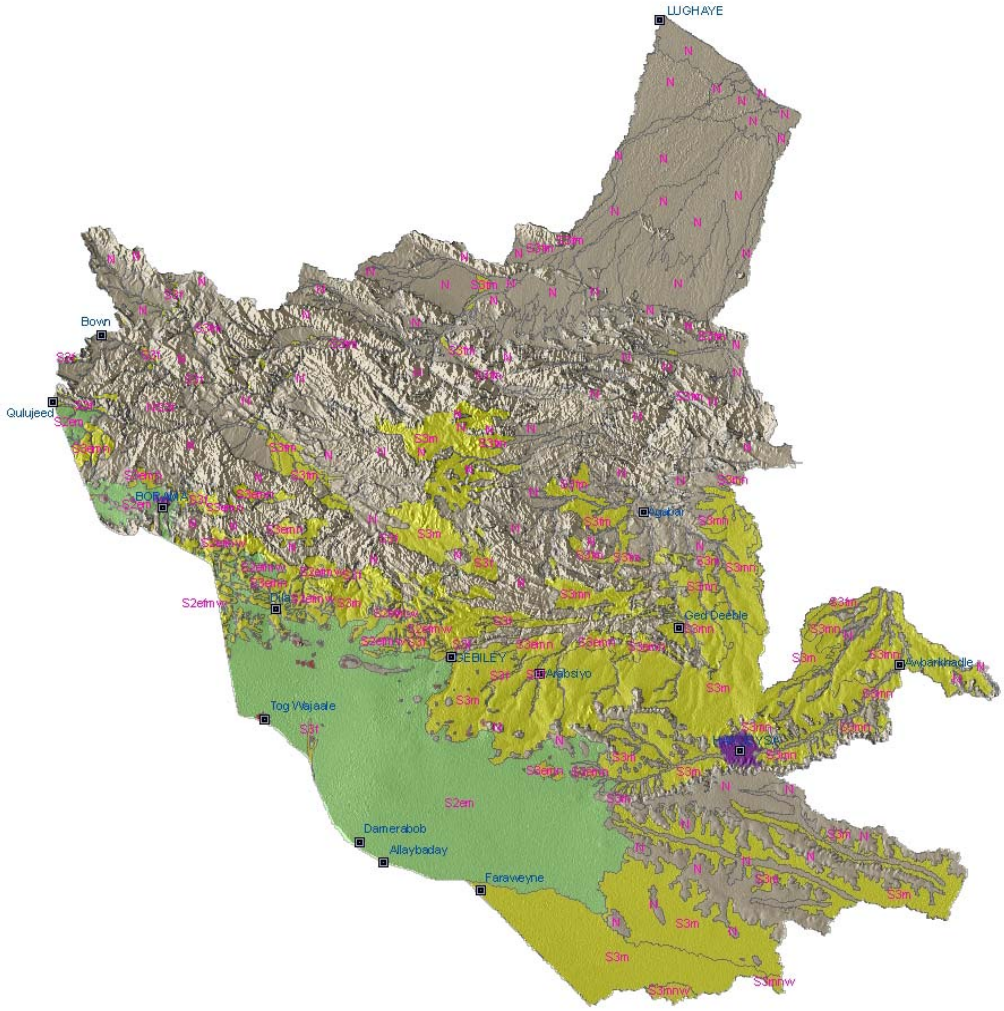
Land Suitability Assessment of a Selected Study Area in Somaliland



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List of acronyms

ALES	Automated Land Evaluation System
FAO	Food and Agriculture Organization
GIS	Geographical Information System
GP	Growing Period
LCCS	Land Cover Classification System
LC	Land Characteristic
LGP	Length of Growing Period
LQ	Land Quality
LUR	Land Use Requirement
LUT	Land Use Type
masl	meters above sea level
NGO	Non Governmental Organization
PET	Potential Evapotranspiration
RBU	Resource Base Unit
SOMALES	Somalia Automated Land Evaluation System
SWALIM	Somalia Water and Land Information Management

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1 INTRODUCTION

Knowledge of the land and water resources is a key component for planning the development of any region. This knowledge is used in land suitability assessments, which determine the potentiality of the land (land resources supply) for different land use types (land user demand).

Land evaluation is the process of predicting land performance over time according to specific types of use (Dent and Young, 1981; FAO, 1983; Rossiter, 1996). It is a very important step in land use planning which according to FAO (1985) is the systematic assessment of land and water potential and alternatives for land use and economic and social conditions in order to select and adopt the best land use options.

The present study is based on land resource data collected by the SWALIM team in the period 2005 – 2006 as detailed in various SWALIM Land Reports and uses established and tested FAO methodology to assess land suitability for various types of land agricultural land use.

Major types of land use considered are rainfed agriculture (crops), irrigated agriculture, extensive grazing (pastoralism) and plantation forests. Results are presented in the form of Tables, Maps and narratives.

The results presented do not constitute a land use plan, but only form one of the many inputs for such a plan. If an area has been classified as highly suitable for a certain use, it does not necessarily mean that this use is recommended. Land use recommendations should be based on many socio-economic and cultural factors, in addition to a physical suitability assessment. However, if a certain area has been classified as physically unsuitable for a certain use, it is unlikely that this use will ever be considered in a comprehensive land use plan.

In addition to giving a land suitability assessment of the study area, this report also gives details of the Somalia Automated Land Evaluation System (SOMALES). This system is also applied for a SWALIM study area in southern Somalia and can be used for similar exercises in the future. Not only can other areas be studied in a similar way, also other types of land use can be analyzed through SOMALES.

2 STUDY AREA

2.1 Location and delineation

The study area of Dur-Dur and Gebiley in Somaliland is located between 10° 41′ 36″ - 9°10′ 30″ N and 43° 00′ 52″ - 44° 27′ 54″ E (see Figure 1), covering a total area of 12 939 km^2. It lies between the Ethiopian border and the Red Sea and covers the Districts of Dila, Gebiley, Faraweyne and Allaybaday, and parts of the districts of Hargeisa, Borama, Baki and Lughaya[1].

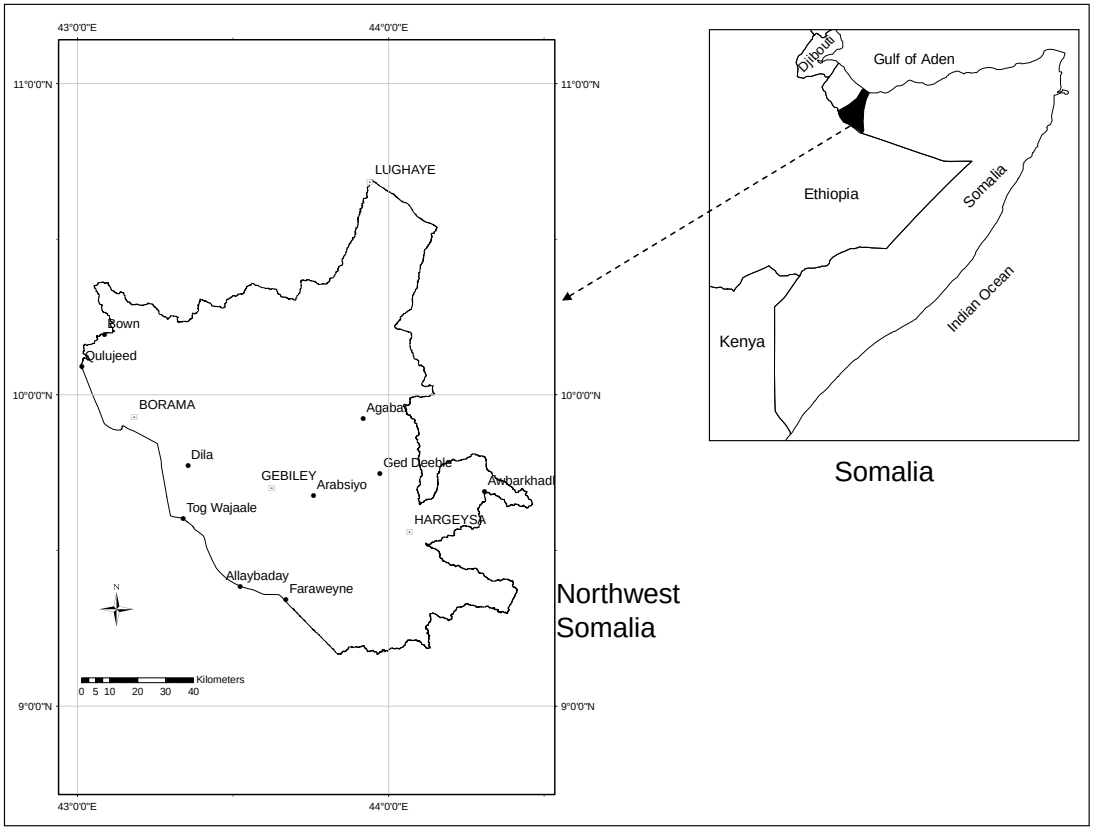


Figure 1: Study area

2.2 Climate

The study area lies at the eastern extremity of the sub-Saharan semi-arid zone commonly referred to as the Sahel. The climate is hot dry desert in the coastal plain (Lughaya and northern part of Baki District) and arid further inland. Semi-arid conditions prevail at higher altitudes in the Al Mountains and on the plateau around Borama and Gebiley. Mean annual rainfall ranges from less than 200 mm in the northern coastal area of Lughaye, to 500 - 600mm in the west near Borama, while the rest of the study area has a mean annual rainfall of 300 - 500mm (see Figures 2 and 3).

The study area lies entirely between the two subtropical anticyclone belts. The main weather pattern is controlled by the passage of the seasonal monsoon winds. Rainfall in the area is thus bimodal (see Figure 2). Primary *Gu* rains occur from March to June, followed by a hot period with low rainfall called *Xagaa* in June and July. Short *Deyr* rains occur from August to October, followed by the cooler long dry *Jilaal* period from November to February.

Temperatures in the area are influenced by altitude and the strength and temperatures of the seasonal winds. Temperatures decrease with increasing altitude. In the higher altitudes of the Al Mountains and Plateau areas temperatures vary considerably with the seasons, with a mean

[1] The Districts of Dila, Faraweyne and Allaybaday were recently formed

annual temperature of 20-24°C, while the coastal region has mean annual temperatures of 28-32°C.

Relative humidity of the highlands is mostly around 40%, except during rainy periods when it may go up to 80%. High temperatures in the coastal areas combine with a high relative humidity of more than 70% to create an exceedingly hot, humid environment.

The study area is subject to high potential evapotranspiration (PET), with an annual average of between 1300 and 3000mm. Rainfall is far less than the PET in most months and a significant water deficit exists throughout the region for most of the year (Figure 2). Consequently, rainfall is not always sufficient for successful crop production.

2.3 Geology/Lithology

The study area is covered by rocks dating from Pre-Cambrian to Recent, comprising sedimentary, igneous and metamorphic rocks. The geology of the area is complex and characterized by many different systems of faults and fractures, mainly oriented parallel to the coast (i.e. WNW-ESE).

The Al Mountain and adjoining plateaus in the south are made up of Pre-Cambrian metamorphic Basement Complex rocks, Cambrian granitic intrusions and Tertiary limestone and sandstone. The northern Piedmonts and Coastal Plain are covered by Pleistocene to Recent alluvial and aeolian sands, silts and gravels. Sand dunes and beach deposits occur in a narrow strip along the coast. Pleistocene basalt outcrops and other volcanic rock outcrops occur dispersed along the northern escarpment and coastal plain.

2.4 Landform and Soils

From a geomorphologic point of view, the study area may be divided into three landscapes: (1) Piedmonts and the Coastal Plain, (2) Mountainous and Hilland, and (3) Plateau. The middle mountain range and the southern plateau are locally known as *Oogo*. There are three main ephemeral river systems that drain from the plateau and traverse the mountain range in the direction of the Red Sea, and from the southern side of the same mountain to the southern highlands respectively. They are called *Togga Durdur*, *Togga Biji* and *Togga Waheen*.

(1) *Piedmonts and the Coastal Plain*. The northern section of the study area is taken up by gently sloping coastal plain (locally called *Guban*) and Piedmonts with elevation ranging from sea level to 600m, from the Red Sea southwards up to the mountains. It is characterised by debris and colluviums carried by several toggas crossing the plain to the sea. The beds of the toggas are very wide, and subject to flash floods during the rainy season.

(2) *Mountainous and Hilland*. In the middle of the study area are the Al Mountains (Golis Mountains), oriented almost E-W parallel to the coast, with a very rugged topography rising to more than 1500m asl. Both sides of the mountains, towards the sea and southern hinterland, are drained by numerous streams of varying sizes.

(3) *Plateau*. South of the Al Mountains are large, gently undulating and almost flat highlands and plateaus, varying in altitude between 1500 - 1900m asl and cut by several streams (called Togga, Tug or Wadi), draining in north-easterly direction towards the coast.

On the high plateau, soils are predominantly deep and heavy textured Calcic Vertisols and Haplic Calcisols. The Mountainous and Hilland area mainly has rocky, stony and shallow soils (Leptosols and Regosols). The Piedmonts and Coastal Plain mainly has poorly developed alluvial and colluvial soils (Fluvisols and Regosols), some of which are stony. Sandy soils (Haplic Arenosols) occur in the aeolian deposits in a narrow zone parallel to the coast.

More details on landform and soils of the area can be found in FAO-SWALIM Technical Report No. L-05 (Vargas and Alim, 2007). An assessment of chemical and physical soil degradation processes is given in FAO-SWALIM Technical Report no. L-10 (Vargas *et al*, 2007).

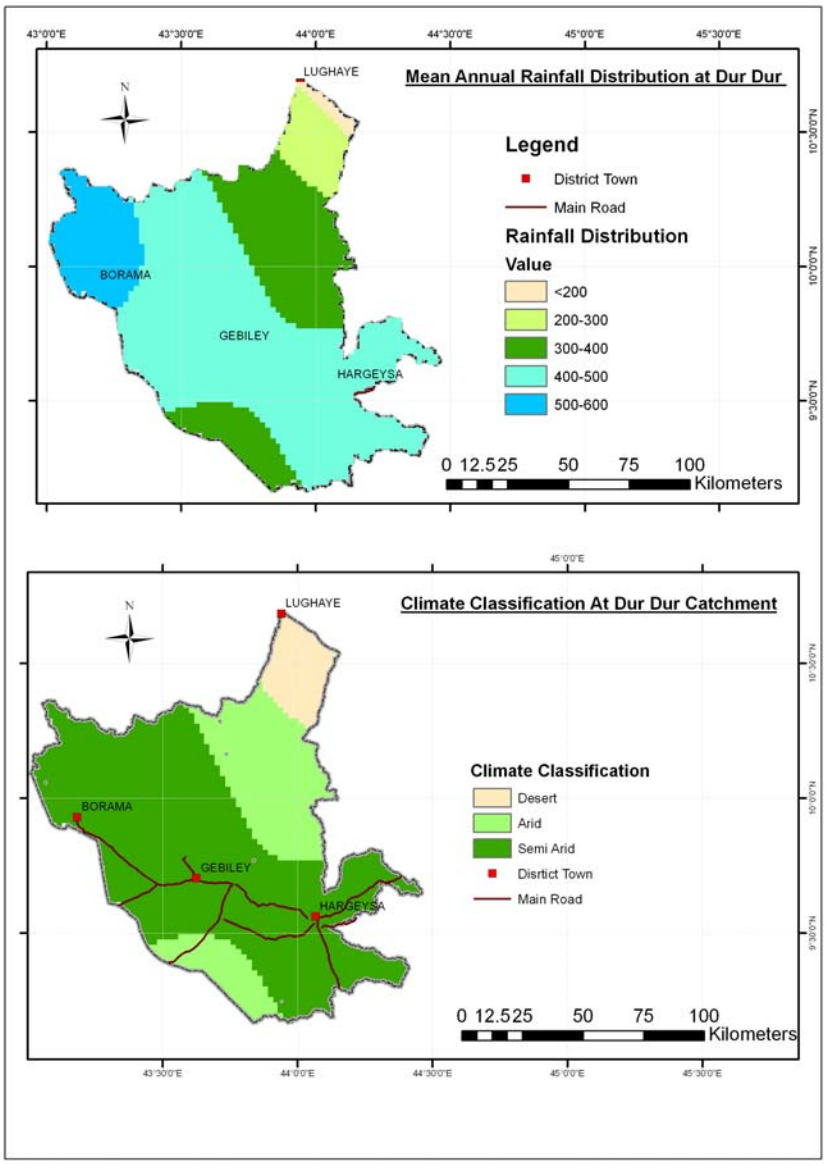
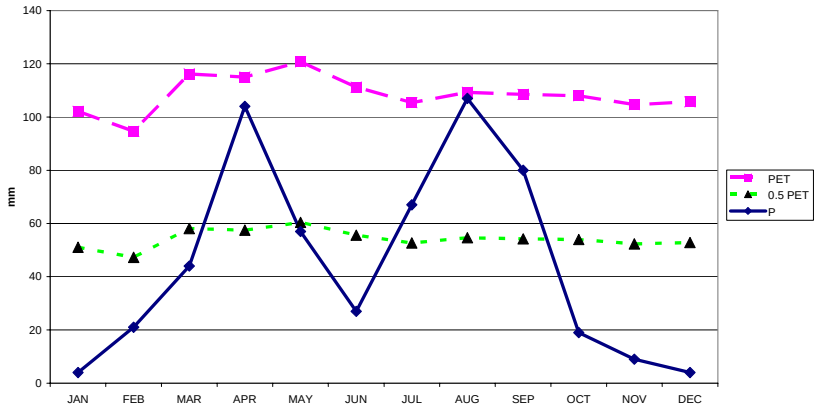
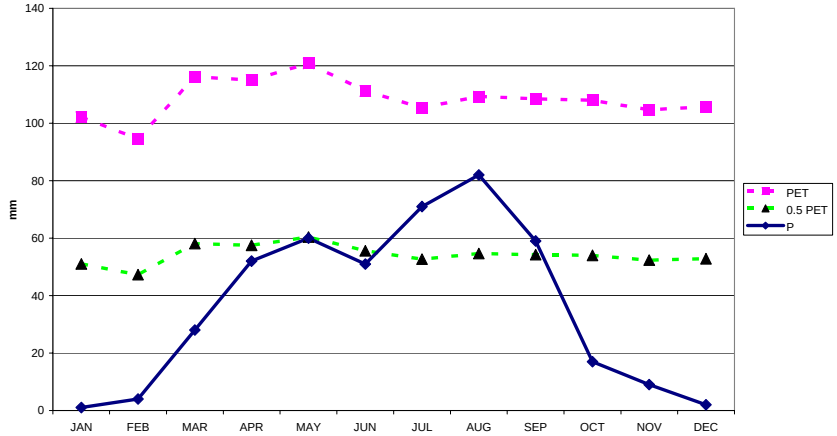


Figure 2: Rainfall distribution and climate classification of the study area

Borama (1454m) P = 543mm LGP Zone 12



Gebiley (1563m) P = 436mm LGP Zone 11



Hargheysa (1326m) P = 418mm LGP Zone 3

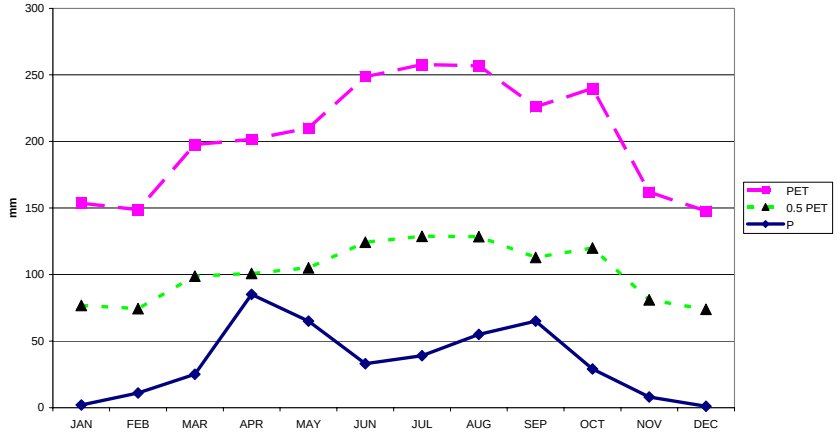


Figure 3: Rainfall (P), Potential Evapotranspiration (PET) and 0.5PET

2.5 Land cover

The study area is mostly covered with natural vegetation, partly degraded by human activities such as the grazing of livestock, firewood collection and the production of charcoal. Land cover classes include Open Shrubs, Open Trees and Open to Closed Herbaceous. Other mapping units include Urban and Associated Areas (Settlement/Towns and Airport), Bare Areas (Bare Soils and Sandy areas) and Natural Waterbodies.

The main woody species in the study area include *Acacia nilotica, Acacia nubica, A. tortilis, A. bussei, A. senegal, Croton gilletti, Hypoestes hildebrandtii, Acalypha fruticosa, Grewia tenax,*and *Balanites aegyptiaca.* Common herbaceous species are *Cenchrus ciliaris, Cynodon dactylon, Sporobolus marginatus, Tragus racemosus* and *Aristida adscensionis*.

More details on land cover and vegetation of the area can be found in FAO-SWALIM Technical Report No. L-03 (Monaci *et al*, 2007). An assessment of biological soil degradation processes is given in FAO-SWALIM Technical Report no. L-10 (Vargas *et al*, 2007).

2.6 Land Use

Map 1 shows the present land use in the study area. This map and land use in general is described in detail in FAO-SWALIM Technical report No. L-04 (Oduori *et al*, 2007). Main land use classes are Transhumance Pastoralism, Rainfed Agriculture and Irrigated Orchards. Semi Sedentary Pastoralism also occurs, as well as Hay Production in enclosures. Pastoralism is often combined with Wood Collection, either as firewood or for charcoal production

2.6.1 Rainfed Agriculture

Rainfed agriculture is practised around Gebiley, Borama and Hargeisa. Given the low rainfall in the area (average 400mm/year), water harvesting is practiced through the construction of soil bunds. The most common crops grown are maize, sorghum, qat (*miraa*), millet and cowpea, and intercropping is common. Table 1 shows crop calendars for various rainfed crops in the study area.

Rainfed Agriculture is characterized by low inputs, with soil bunds being the main land improvement. Farmers with sufficient resources hire tractors for land preparation or use oxen. Others prepare the land manually. Seeds are mostly of a local variety, including the late maturing *Elmi Jama* sorghum. The use of fertilizer and manure is negligible. Crops are produced for food, market and fodder for animals. Post-crop residues are cut and stored as animal feed. Crops that have failed to mature are also used as animal feed.

Crop yields are very low due to low input levels, moisture stress, poor farming techniques, pests and diseases and poor seeds. The most notorious weed is called *kalinoole* in the Somali language, while pests include the maize stalk borer. Many farmers lack tillage capacity. Soil conservation activities are limited, and exposed and loosened soil is washed downstream, resulting locally in gulley formation.

Rainfed agriculture can be improved through the provision of farm power, soil and water conservation measures, pest and weed control, introduction of early-maturing sorghum varieties and farmer education. Migration to better areas is also an option in some case. The selection of crops grown by the farmers requires review. Presently, the most common sorghum variety has a very long growing period, whereas early-maturing varieties could be more appropriate. Early maturing maize and cowpea varieties should also be considered. In all cases, planting should be done as early as possible at the right time of year.

2.6.2 Irrigated Orchards

Irrigated orchards are found in river valleys and are characterised by the use of supplementary water from dams and shallow wells, the extensive use of farm manure and, in some cases, fertilizer. Crops grown are mostly fruits such as citrus, guava, papaya and custard apple, intercropped with watermelon and vegetables. Land improvements include fencing and water harvesting through soil bunding, surface dams, shallow wells, *berkeds*, and diversion furrows. The orchards are mostly less than 2ha in size.

Planting materials used are mainly locally raised and not improved. Tractors and oxen are used to provide farm power, mainly during the preparatory stages of ploughing and construction of irrigation infrastructure. However, due to high costs of machinery purchase and hire, most farmers cannot afford them. Some farmers have water pumps, used to pump water from the shallow wells and dams into fields.

Crops are mostly grown for commercial purposes, however, long distance to markets coupled with poor roads makes it difficult for farmers to sell their produce. Farm labour is drawn mainly from family members, but some farmers make use of hired labour.

Crop condition within irrigated fields is generally better than in rainfed fields. However, in some cases poor yields are attributed to incidences of pests (monkeys, pigs) and diseases, or shortage of water.

Although a few farmers have received training from NGOs, very often irrigation techniques are poorly applied and wasteful.

Irrigated farming can be improved through the construction of improved soil and water conservation structures such as check dams, gabions and bunds, improved pest control, improved soil fertility through appropriate use of animal manure and fertilizer, and farmer education.

Table 1: Crop Calendar Rainfed Agriculture

Crop	JILAAL (dry season)			GU (long rains)			XAGAA (KHARIF) (low rainfall)	DEYR (short rains)			JILAAL (dry season)	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st Maize												
2nd Maize												
Sorghum												
1st Sesame												
2nd Sesame												
Water Melon												
1st Cowpea												
2nd Cowpea												
Qat (Miraa)												
Vegetables												
Vegetables												

Notes:

1. *Kharif* is a short period of modest rainfall in the period July/August, preceding the *Deyr*.
2. Primary rainfed crops are grown in the long rains of *Gu* and a second crop may be planted immediately after to take advantage of the limited rains of *Kharif*. The late maturing sorghum variety continues to grow into Kharif, maturing after approximately six months. Water stress is experienced by the sorghum crop immediately after the Gu rains have ended, but the crop recovers with the onset of the Kharif rains.
3. Qat (*miraa*) is a perennial crop and therefore remains standing in the fields throughout the year. Irrigated crops may be grown all year round as long as water is available.

2.6.3 Transhumance Pastoralism

Transhumance Pastoralism is the most common type of grazing system in the area in which animals are moved in a regular pattern associated with water and forage availability. Goats are associated with steep slopes, while cattle, camels and sheep are found in the valleys and plains where grazing is more practical. Produce include milk, meat, hides and ghee, for both domestic and commercial use.

Sources of water for livestock include shallow wells, springs, boreholes and dams, some of which are in a very poor condition. Most shallow wells and dams dry up during the dry season and animals have to be walked for long distances to access other water sources. Water sources are poorly constructed and their ability to retain water is low.

There are many constraints associated with livestock production, mostly inter-related. They include disease, water shortage, lack of good quality pasture, collapsing wells, ever-expanding number of enclosures, invasion of unpalatable plant species (e.g. cacti) and other forms of land degradation, and low market prices for livestock products.

Pastoralism can be improved through the provision of veterinary services; exploitation of ground water, upgrading of wells, eradication of invasive plants, controlled grazing and the re-vegetating degraded areas.

2.6.4 Hay Production and Grazing

Hay production in enclosures is common along the alluvial plains, where moisture is retained for longer periods after rains. Hay is harvested and sold in the bigger towns, or consumed locally. Enclosures are illegal, and are a source of conflict within the community. Harvested hay is poorly stored, as it is exposed to the sun and is easily attacked by termites. The exposed hay also loses moisture, becoming too dry to suffice as animal feed.

2.6.5 Wood Collection for Charcoal Burning

Charcoal burning is a common practice, occurring wherever there are trees, especially *Acacia bussei*, *A. etbaica* and *A.nilotica*. The practice is illegal and conducted against the wishes of pastoralist communities and government. Charcoal burning has promoted a decline in range quality and an increase in land degradation, especially through water erosion. Trees cut for charcoal burning are thorny and their branches are left on the ground after cutting, making it difficult for animals to move freely and reducing available grazing grounds. Kilns are always covered by grass, which has the added effect of reducing grass cover in rangelands. Wood collection for charcoal burning always occurs as a mixed land use class, in which the land use class is always used as grazing grounds for animals.

2.6.6 Sedentary-Pastoralism

Sedentary pastoralism is practiced in the Lughaya area along the coast. Dairy animals and weak or young animals are kept at night near the homesteads and taken out daily by herders to the communal rangeland. The practice exerts pressure on pasture around settlements. All other characteristics pertaining to Sedentary Pastoralism are similar to those of Transhumance Pastoralism.

2.7 Population

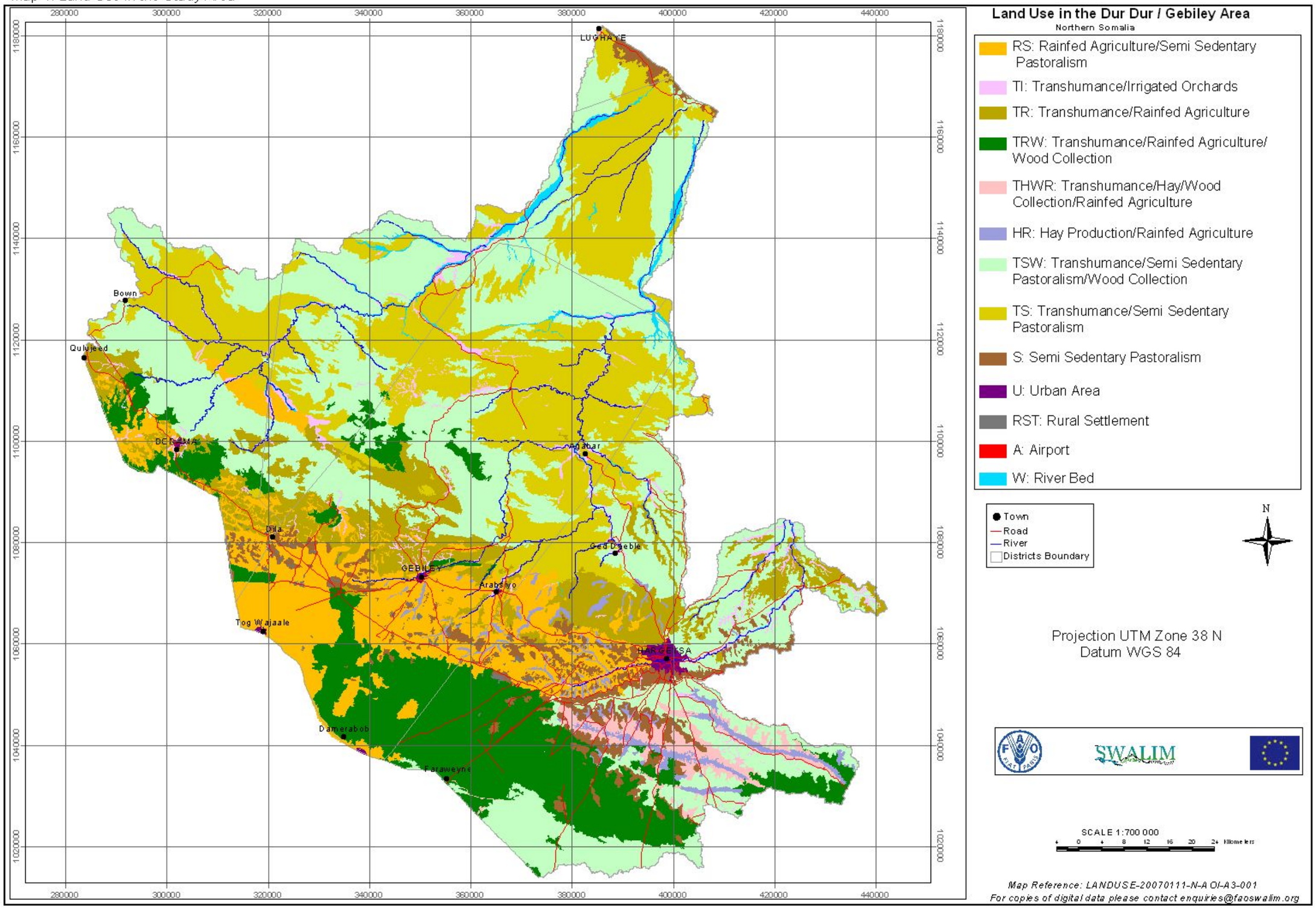
The study area consists of the Districts of Dila, Gebiley, Faraweyne and Allaybaday, and parts of the districts of Hargeisa, Borama, Baki and Lughaya.

According to Somalia UNDP 2005 (Table 2), the estimated urban and non-urban population for Hargeisa by mid-2005 was 560 028, making it the second most populated town in Somalia. Borama had a population of 215 616 and Gebiley 79 564 inhabitants. These three centres are the main towns in the study area.

Table 2: Regions, districts, and their populations (Somalia UNDP 2005, draft version)

Zone	Region	District (* Regional capital)	Estimated population 2005 (mid-year)		
			Total	Urban	*Non-urban*
North-west			**1,828,739**	**819,989**	**1,008,750**
	Awdal		**305,455**	**110,942**	**194,513**
		Borama *	215,616	82,921	132,695
		Baki	25,500	8,577	16,923
		Lughaye	36,104	14,010	22,094
		Zeylac	28,235	5,434	22,801
	Woqooyi Galbeed		**700,345**	**490,432**	**209,913**
		Hargeisa *	560,028	422,515	137,513
		Berbera	60,753	42,070	18,683
		Gebiley	79,564	25,847	53,717

Map 1: Land Use in the Study Area



3 MATERIALS

Materials used in the land evaluation exercise include:

- information on the land resources of the study area as compiled by SWALIM
- information on the requirements and physical limitation for various types of land use (e.g. crop requirements and requirements for various grazing animals and forestry species (various sources)
- existing methodology and tools (see Chapter 4)

3.1 Land Resources data

Land Resource data used in the present study includes information on soils, climate (temperature, Length of Growing Period, rainfall variability), landform (relief, slope, altitude), land cover and existing water points.

All these data are available from SWALIM. In many cases the existing thematic information has to be simplified and re-grouped, as detailed in the following sections.

3.1.1 Simplified Soil Grouping for Land Evaluation

Detailed soil information of the area can be found in FAO-SWALIM Technical Report No. L-05 (Vargas and Alim, 2007). For the purpose of land evaluation the numerous soil groups identified have been grouped into six classes (see Table 3).

In addition to Soil Groups, individual soil characteristics are also used in land evaluation. Relevant soil characteristics and their classification are given in Table 4.

3.1.2 Length of Growing Period (LGP) and rainfall variability

For the whole of Somalia, fifteen LGP Zones have been identified and mapped by SWALIM, of which five zones (i.e. zones 1, 2, 3, 11 and 12) are relevant for the study area. Detailed information can be found in FAO-SWALIM Technical Report No. L-13 (Venema, 2007). Large parts of Somalia are characterized by a bi-model rainfall pattern and have two distinct LGPs in a single year and two different LGP calculations for each of the zones are presented below. The first calculation (Table 5) takes into account the longest LGP only, which is most significant for rainfed production of annual crops. The second calculation (Table 6) adds up all the LGPs occurring in a year and is more relevant for rainfed production of perennial crops, natural vegetation for grazing, and for the growth of forestry species.

There is a close correlation between the LGP Zones as defined by SWALIM and the Bioclimatic zones as defined by SOGREAH (1982), at least for the study area. Since SOGREAH gives a carrying capacity for each Bioclimatic Zone, a tentative carrying capacity can be given to LGP Zones (see Table 7). This information can be used land evaluation for extensive grazing (pastoralism).

3.1.3 Temperature classes

Six temperature classes have been defined (Table 8). There is a close relationship between Altitude and Mean Annual Temperature (Velthuizen and Verelst, 1995). For the whole of Somalia, the mean temperature for the growing season is not much different from the mean annual temperature. Exceptions are the desert zone and the highlands, where the mean summer temperatures are considerably higher than the mean annual temperatures.

Table 3: Simplified Soil Classes for Land Evaluation

Class	**Soil Group** (WRB: IUSS, 2006)			**Main limitations for plant growth**
	Group	**Prefix**	**Suffix**	
1	Calcisols	Haplic	Aridic, Clayic	Water and wind erosion; low nutrient availability; surface crusting
		Hypercalcic	Aridic, Clayic	
		Vertic	Aridic, Clayic	
		Endosalic	Aridic, Clayic	
			Episkeletic, Clayic	
2	Cambisols	Fluvic	Calcaric	Water erosion; flooding; low nutrient
	Fluvisols	Haplic	Calcaric, Aridic	wind erosion; flooding; low nutrient availability
		Calcic	Aridic, Salic	Excess salts; wind erosion; flooding; low nutrient availability
3	Leptosols	Haplic	Skeletic	stoniness; limited rooting depth; low moisture; low nutrient availability
		Hyperskeletic Lithic		
		Lithic	Calcaric	
	Regosols	Haplic	Skeletic	stoniness; limited rooting depth; low moisture; low nutrient availability
			Episkeletic, Arenic	stoniness; low moisture (sandy and/or stony); low nutrient availability; Wind erosion
			Calcaric	low nutrient availability
			Calcaric, Aridic	limited rooting depth; low moisture (sandy and/or stony)
			Aridic	low moisture (sandy and/or stony); low nutrient availability
			Calcaric, Arenic	low moisture (sandy and/or stony); low nutrient availability; wind erosion
4	Solonchak	Haplic		high excess salts; low nutrient availability
5	Vertisols	Haplic	Calcaric, Chromic	low nutrient availability
		Calcaric Grumic	(Chromic)	
		Calcic	Chromic	
		Calcic	Bathyhyposalic, Bathyhyposodic	
		Calcic Mazic	Bathyhyposalic, Bathyhyposodic	low nutrient availability; poor workability (hard topsoil)
		Calcic Mazic	Chromic	
		Calcaric Grumic	Hyposodic, Chromic	moderate excess salts; low nutrient availability; poor workability (hard topsoil)
		Calcic Grumic	Calcaric, Hyposodic	
		Calcic Grumic	Hyposodic, Hyposalic, Chromic	
		Calcic	Calcaric, Hyposalic	
		Calcic	Calcaric, Hyposodic	
		Calcic	(Calcaric), Hyposodic, Chromic	
6	Arenosols	Haplic	Calcaric, Aridic	water and wind erosion; low moisture (sandy); low nutrient availability

Table 4: Soil characteristics used for Land Evaluation

Soil Characteristics

Soil Depth		Coarse fragments (topsoil & subsoil)		Drainage	
class	values (cm)	class	values volume %	class	description
VS very shallow	< 25	F few	< 5	0	very poor
SS shallow	25-50	M many	5-40	1	poor
MD moderately deep	50-100	A abundant	40-80	2	imperfect
DD deep	100-150	D dominant	> 80	3	moderately well
VD very deep	>150			4	well
				5	somewhat excessive
				6	excessive

Soil Characteristics

Sodicity (subsoil)		Salinity (subsoil)		pH(H2O) (topsoil)		CEC (topsoil)	
class	value (ESP) %	class	value (EC) (dS/m)	class	values	class	values me/100g
NS	< 6	NS	< 2	NE neutral	6.6-7.5	L low	< 16
MS	6-15	SS	2-3	AL alkaline	7.5-8.5	M medium	16-24
SO	15-25	MS	3-5	VA v. alkaline	> 8.5	H high	> 24
VS	25-40	SA	5-8				
ES	>40	VS	8-12				
		ES	> 12				

Soil Characteristics

Ca++ (topsoil)		Mg++ (topsoil)		Ca/Mg (topsoil)	
class	values me/100g	class	values me/100g	class	value (ratio)
L low	< 10	L low	< 1	VL very low	< 1.2
M medium	10-25	M medium	1-5	L low	1.2-2.3
H high	25-50	H high	5-10	M medium	2.3-10
V very high	> 50	V very high	> 10	H high	10-25
				VH very high	> 25

Soil Characteristics

Organic Carbon (topsoil)		Calcium Carbonate (topsoil)		Surface salts	
class	values (%)	class	values (%)	class	value %
VL very low	< 0.4	N non-calcareous	< 0.1	0 none	< 0.1
LO low	0.4-0.8	S slightly calcareous	0.1-10	1 low	0.1-15
ME medium	0.8-1.2	M moderately calcareous	10-20	2 moderate	15-40
HI high	> 1.2	H highly calcareous	20-30	3 high	40-80
		V very highly calcareous	> 30	4 dominant	> 80

Soil Characteristics

Texture

S sandy	S Sand	Si silty	Si Silt
	LS Loamy Sand		SiL Silty Loam
L loamy	L Loam		SiCL Silty Clay Loam
	SL Sandy Loam		SiC Silty Clay
	SCL Sandy Clay Loam	C clayey	SC Sandy Clay
			C Clay

Table 5: Length of longest LGP and rainfall variability during Growing Period for all LGP Zones of Somalia*

LGP of longest GP (days) **	Zone	Description of LGP	Variability rainfall in Growing Period (April-July)
0	1	No LGP; mean annual rainfall < 100 mm ***	Very High (200-400%)
< 30	2	Insignificant LGP; mean annual rainfall 100-250 mm ***	Very High (100-300%)
	3	Insignificant LGP; mean annual rainfall 250-500 mm ***	High (70-100%)
30-59	4	single, Gu 30-59	
	5	single, Deyr 30-59	
	6	double, Gu and Deyr equal length of 30-59 each	
60-89	7	single, Gu 60-89 days	
	8	double, Gu main (60-89 days) (Deyr short and ignored)	
	9	double, Deyr main (60-89 days) (Gu short and ignored)	
	13	double, Gu and Deyr of equal length of 60-89 each	
90-119	10	single, Gu 90-119 days	
	11	single, Gu + Deyr (merging, total 90-119 days)	
	12	double, with short dry interval, total LGP 90-119 days	High (50-100%)
	14	double, Gu main (90-119 days) (Deyr short and ignored)	
120-149	15	double, Gu main (120-149 days) (Deyr short and ignored)	

* this Table to be used for evaluation of rainfed annual crops

** LGP defined as the longest growing period, in case of a bi-modal pattern with a long dry interval of 3 months or more

*** An LGP is defined as the period (in days) that Precipitation exceeds half the Potential Evapotranspiration (P>0.5PET). Even though there may be significant rainfall, LGP in Zones 1,2 and 3 is very short or non-existent due to very high PET (P<0.5PET throughout the year)

Table 6: Total LGP and annual rainfall variability of the 15 LGP Zones of Somalia*

LGP total (days) **	Zone	Description of LGP	Variability annual rainfall
0	1	No LGP; mean annual rainfall < 100 mm ***	High (80-200%)
< 30	2	Insignificant LGP; mean annual rainfall 100-250 mm ***	High (60-100%)
	3	Insignificant LGP; mean annual rainfall 250-500 mm ***	Low-Medium (25-50%)
30-59	4	single, Gu 30-59	Medium (40-50%)
	5	single, Deyr 30-59	
	6	double, Gu and Deyr equal length of 30-59 each	
60-89	7	single, Gu 60-89 days	
90-119	8	double, Gu main (60-89 days) (Deyr 30-59 days)	
	9	double, Deyr main (60-89 days) (Gu 30-59 days)	Medium (30-50%)
	10	single, Gu 90-119 days	
	11	single, Gu + Deyr (merging, total 90-119 days)	Low (20%)
	12	double, with short dry interval, total LGP 90-119 days	
120-149	13	double, Gu and Deyr of equal length of 60-89 each	Low (20-40%)
	14	double, Gu main (90-119 days) (Deyr 30-59 days)	
150-179	15	double, Gu main (120-149 days) (Deyr 30-59 days)	

* this Table to be used for evaluation of rainfed perennial crops, natural vegetation and forestry species

** LGP defined as the sum of both growing periods in case of bi-modal pattern

*** An LGP is defined as the period (in days) that Precipitation exceeds half the Potential Evapotranspiration (P>0.5PET). Even though there may be significant rainfall, LGP in Zones 1,2 and 3 is very short or non-existent due to very high PET (P<0.5PET for all months)

Table 7: Estimated carrying capacity of Bioclimatic Zones and corresponding LGP Zones

Bioclimatic Zone (SOGREAH)	**Carrying Capacity (ha/LSU) (SOGREAH)**	**LGP Zone (SWALIM)**
Coastal	20-25	1
Sub-coastal	50-100	2
Acacia bussei	5-20	3
Acacia etbaica	5-10	11, 12

Table 8: Mean annual temperature classes for Somalia and correlation with altitude zones

Class		Mean annual temperature Ta (°C)	Altitude (masl)
WA	Warm	18-20	1550-1875
VW	Very Warm	20-22	1250-1550
		22-24	900-1250
HO	Hot	24-26	600-900
		26-28	300-600
VH	Very Hot	28-30	0-300

3.1.4 Simplified Landform information for Land Evaluation

With respect to information on landform, most relevant for the present land evaluation exercise are the relief types as defined in SWALIM report no L-02 (Paron and Vargas, 2007). Of particular importance are the drainage characteristics of the various relief types, i.e. whether the land is shedding or receiving water and also the status of active erosion processes. The relief types identified in the study area have been grouped into 5 classes (Table 9).

Table 9: Simplified relief classes for land evaluation

1	**2**	**3**	**4**
Water shedding	**Water receiving**	**Neutral**	**Active erosion**
S08 Escarpment S16 Dissected ridge S24 Inselberg S25 Cuesta S26 Mesa S27 Hogback S29 Hill S31 Ridge S30 Hill complex	**2a** Closed E05 Playa F13 Depression S15 Depression (structural) F16 Delta **2b** Drained F04 Braided river plain F05 Meandering river plain F12 Alluvial plain F17 Flat valley floor F18 River plain F25 River incision	C03 Sandy Coast F14 Pediment F15 Dissected pediment G08 Talus slope S32 Planation surface S34 Slope	F08 Badland (complex gully) F09 Gully/rill erosion surface F10 Sheet erosion surface S33 Denudational slope S35 Denudational surface

SWALIM information on slope (inclination) is continuous and no distinct classes have been used, but any classes can be created as needed. Classes used in the present evaluation exercise are shown in Table 10.

Table 10: Slope classes for land evaluation

Class	Value (%)	Description
1	0-4	Level to very gently sloping
2	4-10	Gently sloping to sloping
3	10-16	Moderately sloping
4	16-25	Strongly sloping
5	> 25	Steep to very steep

3.1.5 Simplified Landcover information for Land Evaluation

Information on landcover is particularly relevant with respect to evaluation for extensive grazing and forestry. SWALIM report no L-03 (Monaci *et al*, 2007) gives the main 19 aggregations of landcover types for the study area. For the purpose of land evaluation these have been further aggregated into 14 classes (Table 11).

Table 11: Aggregated landcover classes of study area for land evaluation

Class	Land Cover
1	Irrigated Agriculture (crop fields > 80% of the area)
	Mixed units of Irrigated Agriculture (crop fields 80-50% of area)
2	Clustered Irrigated Agriculture (crop fields 50-20% of area)
	Isolated Irrigated Agriculture (crop fields 20-10% of area)
3	Mixed Water Supply Agriculture (crop fields > 50% of area)
	Mixed units if Mixed Water Supply Agriculture (crop fields 80-50% of area)
4	Rainfed Agriculture (crop fields > 80% of area)
	Mixed units of Rainfed Agriculture (crop fields 80-50% of area)
5	Clustered Rainfed Agriculture (crop fields 50-20% of area)
	Isolated Rainfed Agriculture (crop fields 20-10% of area)
6	Herbaceous
7	Savanna (and other spaced Woody Vegetation)
8	Closed Shrubs (crown cover > 65%) - Thicket
9	General Open Shrubs (crown cover 65-15%) - Shrubland
10	General Open Trees (crown cover 65-15%) - Woodland
11	Closed Trees - Forest
12	Urban
13	Water Bodies
14	Bare Areas

4 METHODS

4.1 Somalia Automated Land Evaluation System (SOMALES)

For the purpose of physical land suitability evaluation SWALIM developed a tool called Somalia Automated Land Evaluation System (SOMALES). SOMALES is the application of the FAO Framework for Land Evaluation with the use of computer software called the Automated Land Evaluation System (ALES).

The FAO methodology for land evaluation was first published in "A Framework for Land Evaluation" (FAO, 1976). This document was followed up by a set of documents comprising guidelines for major kinds of land use, such as rainfed agriculture (FAO, 1983), forestry (FAO, 1984), irrigated agriculture (FAO, 1985) and extensive grazing (FAO, 1991). Recently, a revised framework for land evaluation was proposed (FAO, 2007).

ALES has been developed by the Department of Soil, Crop & Atmospheric Sciences of the Cornell University, USA (Rossiter & Van Wambeke, 1991, 1997). ALES allow land evaluators to build expert systems to evaluate land according to the FAO method of land evaluation. The entities evaluated are map units, which may be defined either broadly (as general feasibility studies) or narrowly (as in farm-scale planning). Since each model is build by a different evaluator to satisfy local needs, there is no fixed list of land use requirements by which land uses are evaluated, and no fixed list of land characteristics from which land qualities can be inferred. Instead, these lists are determined by the evaluator to suit local conditions and objectives.

The following sections explain how the FAO Framework has been applied in SOMALES. Details of ALES are not given here; they are sufficiently explained in the User's Manual of ALES Version 4.65 (Rossiter & Van Wambeke, 1997).

4.1.1 Objectives and principles of land evaluation

The FAO methodology for land evaluation is a system which assesses the suitability of a certain tract of land (Resource Base Unit) for a given use (Land Use Type). It goes a step further than general-purpose land capability assessment systems: it enables the planner not only to compare two different tracts of land, but also to compare the merits of and constraints of different land uses (down to the level of individual crops) on one and the same area of land.

Figure 4 shows the methodological framework the present study has followed. Different aspects of the methodology and how they are applied by SOMALES are explained in the following Sections.

The principle objective of land evaluation is to select the optimum land use for each defined land area, taking into account both physical and socio-economic considerations and the conservation of environmental resources for future use. Detailed objectives vary considerably according to the purpose and the scale of the land evaluation.

The evaluation process does not in itself determine the land use changes that are to be carried out. It provides data and recommendations on the basis of which the users can base their decisions with respect to planning, development or management. To be effective in this role, the output from an evaluation should give information on several potential forms of use for each area of land.

Land evaluation is based on the following principles:

- Land suitability is assessed and classified with respect to specified kinds of use. It may be defined in broad terms (e.g. rainfed agriculture) or more exactly (e.g. sorghum with a short growing period under smallholder management with low capital input).
- Evaluation requires a comparison of the outputs obtained and the inputs needed on different types of land[2].

[2] The revised framework for land evaluation (FAO, 2007) suggests a two-stage procedure, in which a physical

- Suitability refers to use on a sustained basis. The main implication of this principle is that suitability assessment should take account of soil erosion hazard and depletion of plant nutrients.
- Evaluation involves comparison of more than one kind of use. Evaluation is carried out for a number of land use types of which inputs and outputs can be compared.

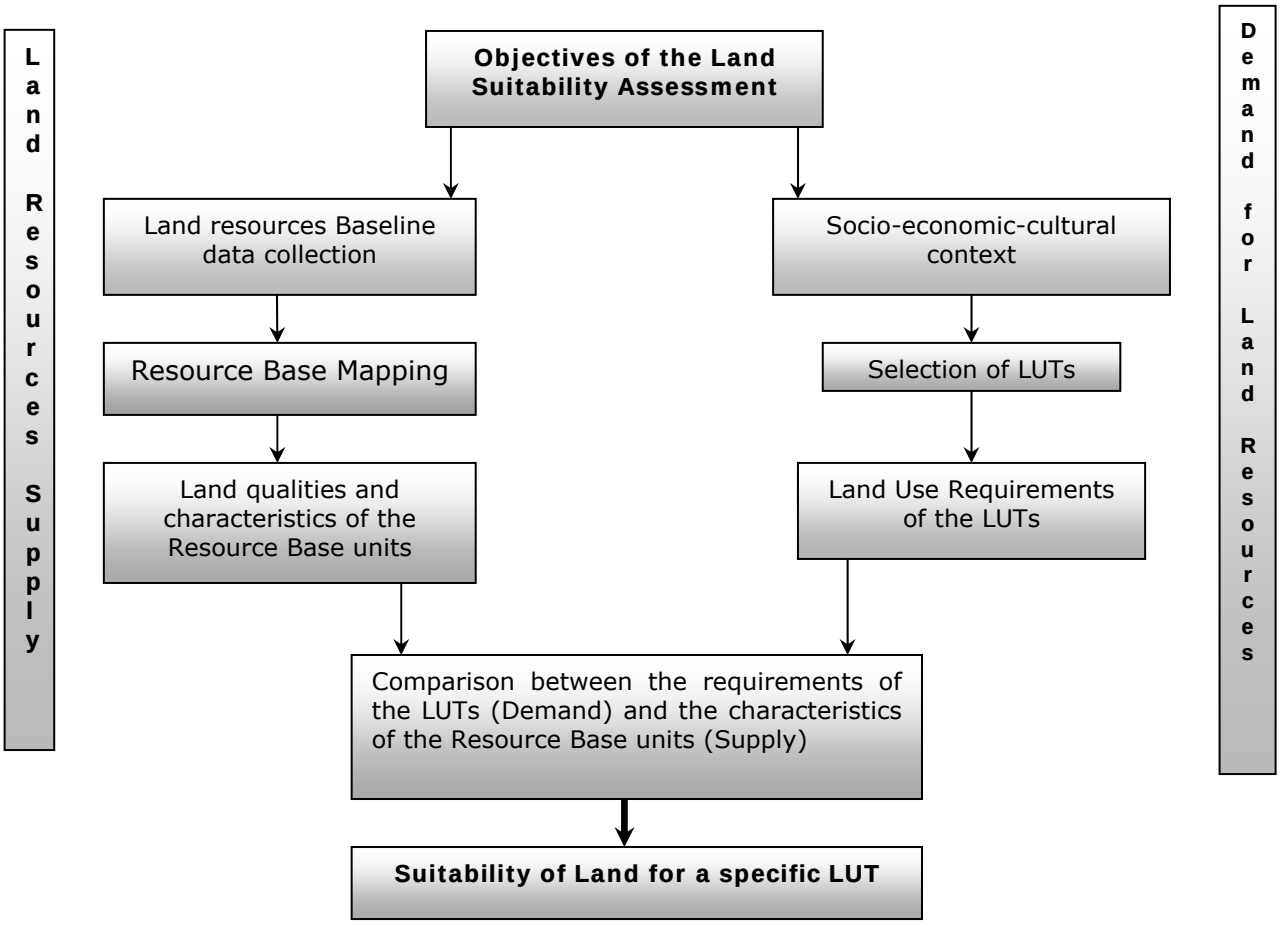


Figure 4: Methodological framework

4.1.2 Resource Base Units

Natural resource surveys form the basis of the land component of the land evaluation system and include inventories of agro-climate, landform, soils, landcover and present land use. SWALIM used multi-spatial and multi-temporal satellite images for mapping the land resources (landform, land cover/vegetation, soils and land use) in the study area. A combination of visual image interpretation techniques, remote sensing, and GIS tools and field survey were used for producing the different baseline data layers at 1:100 000 scale.

The basic unit of evaluation are Resource Base Units (RBU), which are defined as land areas, generally smaller than a region but considerably larger than a farm, with a definable combination of climate, relief, altitude, edaphic conditions and natural vegetation (George, *et al* 2006). The RBUs are generated by combining different spatial baseline data layers, including Length of Growing Period (LGP), landscape, vegetation, soil groups and altitude (Figure 5).

Forty-five RBUs have been defined for study (see Map 2) area and described in terms of more than 20 distinct land characteristics (Annex 1).

evaluation is carried out first (as in the present study), followed by a stage of economic evaluation.

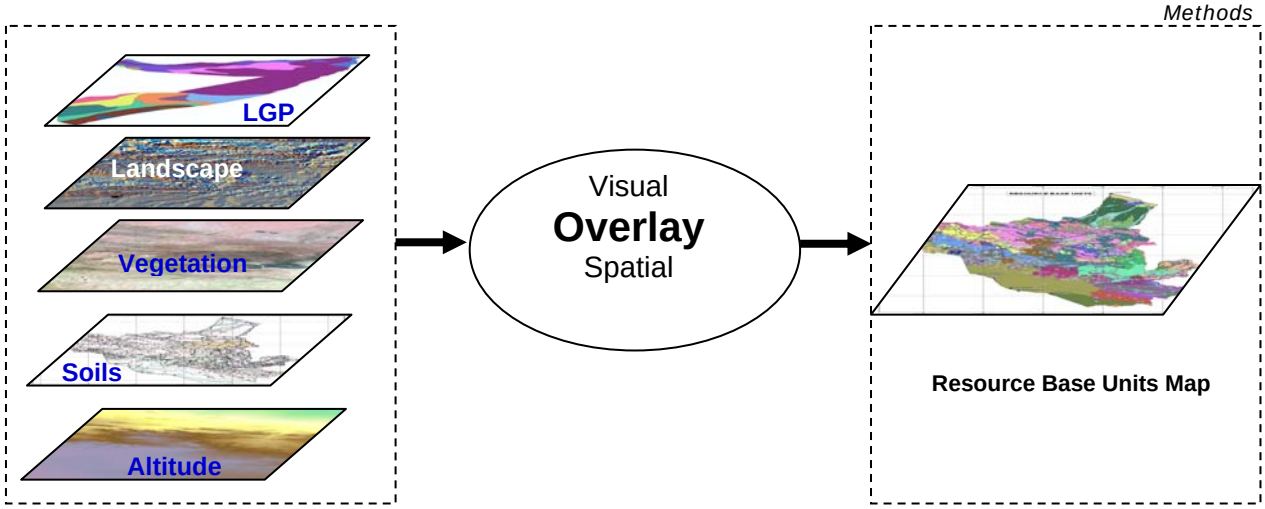


Figure 5: Identification of the RBU's

4.1.3 Land qualities and land characteristics

A land quality (LQ) is an attribute of land which acts in a distinct manner in its influence on the suitability of the land for a specific kind of use. Examples of LQs are moisture availability, rooting conditions and erosion hazard. A land characteristic (LC) is an attribute of land which can be measured or estimated. LCs are used as a means of describing; examples are mean monthly rainfall, slope angle, soil depth, soil reaction (pH) and salinity.

In practice only a limited number of LQs are used. Only those LQs are selected which are known to have a marked influence on the output from, or the required inputs of, a certain kind of land use and are called diagnostic land qualities. Each diagnostic LQ must be rated into classes and a critical value must be assigned to each class limit. The classes used must coincide with the suitability classes of the land use requirements.

Diagnostic land qualities used by SOMALES in the present study are given in the first column of Table 12 below.

4.1.4 Land use types and their requirements

The activities in land evaluation that are specifically concerned with land use comprise of two parts: (1) description of the kind of land use, and (2) assessment of the land use requirements.

Land use can be defined at two levels of detail. A major kind of land use is a major subdivision of rural land use such as rainfed agriculture, irrigated agriculture, forestry etc. A land utilization type (LUT) is a kind of land use defined in more detail, according to a set of technical specifications in a given socio-economic setting. A LUT is described at the level of detail as required by the purpose; the concept of LUT is flexible and its description can range between a summary of a few lines to a precise description of more than a page. As a minimum requirement, both the nature of produce (e.g. a single crop) and the socio-economic setting (e.g. improved smallholder) must be specified.

LUTs included in the present study are listed in Table 13 and described below.

R Rainfed Agriculture

Opportunities identified in rainfed agriculture include the introduction of improved and early maturing crop varieties and the use of both organic and inorganic fertilizer. The selection of LUTs for the present study reflects these opportunities. The main focus is on early maturing varieties of common food crops (Rs1-sorghum, Rm1-maize, Rc1-cowpea). For comparison, the traditional late maturing variety of sorghum (*Elmi Jama*) is also evaluated (Rs2-sorghum). Inputs levels assumed are medium for all LUTs, except for the traditional sorghum (Rs2). Inputs at medium level mainly consist of improved seed and use of modest quantities of manure and/or inorganic fertilizer.

I Irrigated Agriculture

Because of lack of surface water, most of the study area is not suitable for irrigation. The only opportunities for irrigation are found locally on the narrow floodplains of the major seasonal streams. However, the scale of the present study prevented the exact location of these potentially suitable areas and Irrigated Agriculture has not been evaluated systematically

P Transhumance Pastoralism (or Extensive Grazing)

Four LUTs were evaluated, which are the Extensive Grazing of Cattle (Pc), Camels (Pd), Goats (Pg) and Sheep (Ps). The suitability evaluation for Transhumance Pastoralism is somewhat problematic, as farmers do not confine themselves to one RBU but move their animals over long distance in accordance with the seasonal availability of pasture and water. The purpose of the land suitability evaluation in this case is to show overall and average availability of grazing resources throughout the study area. All four LUTs are considered to have low input.

F. Forestry

Apart from a few nurseries, there are very few forestry activities in the area. However, the need for tree plantation is great, particularly for the production of firewood and charcoal and for soil and water conservation purposes. Agro-forestry can also play a role in soil fertility improvement and in the production of fodder and pasture improvement. The selection of specific tree species for plantation depends very much on the purpose of the trees and on the environment. For this reason a large number of species has been evaluated, as listed in Table 13.

Land use requirements (LURs) are the conditions of the land necessary or desirable for the successful and sustained practice of a given LUT. LURs can be subdivided into crop requirements, management requirements and conservation requirements. LURs must be described in a parametric way, each parameter corresponding with a LQ (e.g. LUR "rooting requirements" versus LQ "rooting conditions"). The LURs used in the present study are listed in Table 12. More detailed "crop" requirements for various LUTs are given in Annex 3.

Map 2: Resource Base Units

RESOURCE BASE UNITS

LUGHAYE
Bown
Qulujeed
BORAMA
Dila
GEEILEY
Arabsiyo
Tog Wajaale
Ged Deeble
Awbarkhadle
HARGEYSA
Dam erabob
Allaybaday
Faraweyne
Agabar

290000 320000 350000 380000 410000 440000
1180000 1150000 1120000 1090000 1060000 1030000

LEGEND

Resource Base Units

1	16
2	16a
3	16b
4	17
5	18
5a	19
5b	20
5c	21
6	22
6a	22a
6b	23
7	24
7a	24a
8	25
8a	26
8b	27
9	28
9a	29
10	30
11	31
12	32
13	33
15	Settlement

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Rbu-N-A0l-A3-001
For copies of digital data please contact enquiries@faoswalim.org

Table 12: Diagnostic Land Qualities for selected major types of land use

Land Use Requirements (LUR) Land Qualities (LQ)		Major Types of Land Use		
		Rainfed Agriculture	**Pastoralism**	**Forestry**
a	accessibility (for animals)		√	
c	temperature regime		√	√
e	erosion hazard	√	√	
f	flood hazard (flashfloods)	√		
i	inundation hazard (flooding)	√		√
m	moisture availability	√	√	√
n	nutrient availability	√	√	
r	rooting conditions (soil depth)	√	√	√
u	excess of salts (sodicity)	√	√	
v	vegetation (genetic potential)		√	
w	oxygen availability (drainage)	√		
z	excess of salts (salinity)	√	√	

Table 13: Land Use Types

Major Kind of Land Use		Land Use Type (LUT)	
R	Rainfed Agriculture	Rs1	Rainfed sorghum; short GP (90-100 days); medium input
		Rs2	Rainfed "Traditional sorghum"; total GP 180 days (including "dormant" period of 50 days; low input
		Rc	Rainfed cowpea; short GP (80 days); low-medium input
		Rm1	Rainfed maize; short GP (80-90 days); medium input
P	Pastoralism	Pc	Extensive grazing of cattle; low input
		Pd	Extensive grazing of camels; low input
		Pg	Extensive grazing of goats; low input
		Ps	Extensive grazing of sheep; low input
F	Forestry	Fai	Azadirachta indica (neem)
		Fan	Acacia nilotica (maraa)
		Fat	Acacia tortilis (qurac)
		Fba	Balanites aegytiaca (quud)
		Fce	Casuariana equisetifolia (shawri)
		Fcl	Conocarpus lancifolius (damas, ghalab)
		Fdg	Dobera glabra (garas)
		Ffa	Faidherbia albida (garabi)
		Fti	Tamarindus inidica (raqai)

4.1.5 Matching land qualities with land use requirements

Matching is the process of comparing the requirements of a particular LUT with the diagnostic LQs of a particular RBU. Matching results in an assessment of land suitability for each combination of LUT and RBU.

4.1.5.1 Factor ratings; severity levels; limitations

Factor ratings or severity levels are sets of values which indicate how well each LUR is satisfied by particular conditions of the corresponding LQ; in other words, the limitation posed by the land quality for the specific land use. The following severity levels are distinguished[3]:

1. no limitation
2. slight limitation
3. moderate limitation
4. severe limitation (or prohibitive)

If the requirement for optimum performance of a given LUT is equal to or less demanding than a LQ of a given RBU, no limitation for this LUT occurs for this RBU with respect to that particular land quality, and a factor rating of "1" (no limitation) results. If the particular LQ does not match the requirement of the LUT, a more limiting factor rating of "2", "3" or "4" results. In case of ratings 2, 3 and for a suffix is added, indicating the relevant LQ. E.g. rating 3m means that a "moderate" limitation is caused by (insufficient) "moisture availability".

4.1.5.2 Decision trees, scoring

The matching procedure is carried out in two steps and facilitated by a number of models or decision trees.

The first step involves the determination of the severity level for each land quality. For example, if the temperature requirement of an LUT (crop) is known, it should be matched with the temperature qualities of an RBU. If the match is not perfect, some rules or models (decision trees) are needed to determine how severe the temperature limitation is. Decision trees used by SOMALES are given in Annexes 7, 8 and 9. Some decision trees involve the "scoring" for several land characteristics before the severity level of a land quality is determined. For example, to determine the severity level for LQ "moisture availability" the decision tree for this LQ gives individual scores for the land characteristics "LGP Zone", "Rainfall variability" and "Soil Group" respectively. The total of the three individual scores then determines the severity level.

The second step involves the evaluation of all factor ratings for a given LUT/RBU combination and the final determination of a suitability class. Various decision trees can be designed for this process, but SOMALES uses the simple "maximum limitation method", whereby the lowest or most severe limitation determines the land suitability class. For example, if the rating for a particular LUT/RBU combination is 2e, 3m, 2n, 2r and 2w respectively, the determining severity level is 3m. For a given LUT this procedure is followed for all RBUs.

[3] Severity levels as employed by SOMALES; the FAO Framework suggests various rating procedures

4.1.6 Land suitability classification

SOMALES has four Suitability Classes:

S1 = highly suitable (no limitations)

S2 = moderately suitable (most severe limitation is at level 2)

S3 = marginally suitable (most severe limitation is at level 3)

N = not suitable (most severe limitation is at level 4)

A number of Suitability Subclasses is distinguished, reflecting kinds of limitation, e.g. subclass S3z means "Marginally suitable due to high salinity".

4.1.7 Verification of preliminary results

The results of SOMALES are an approximation only, as they are based on simplified evaluation models and a limited knowledge of both the requirements of LUTs and the available land resources. Preliminary results of SOMALES were studied by SWALIM experts which local knowledge. Outcomes which seemed unlikely or contradictory to actual conditions were scrutinized and where necessary adjustments were made to the SOMALES decision trees. Updating of LUT requirements and adjustments of SOMALES decision trees is an ongoing process as more information becomes available.

5 RESULTS

5.1 Land suitability for rainfed agriculture

Tables 15 and 16 below show the physical land suitability of the study area for four LUTs, characterized by the production of individual crop varieties: Cowpea (Rc: short Growing Period), Maize (Rm1: short GP), Sorghum (Rs1: short GP) and sorghum (Rs2: long GP). Because of the arid and semi-arid conditions in the area, most attention has been paid to crops with a short GP. However in Somaliland a variety of sorghum is grown with a long GP of 180 days, called *Elmi Jama*. This variety is very drought resistant and can survive long dry periods. It is favoured by farmers because of its taste and because of its forage value (long stalks) and has also been included in the evaluation

Tables 15 and 16 show that there is not much difference between the suitability of the four crop varieties studied. This can be explained by the fact that large parts of the study area have severe and over-riding limitations for rainfed agriculture, notably very shallow and stony soils in the mountains and piedmont area and lack of moisture (desert and arid conditions) in the coastal zone. Remarkable also is the fact that there is not much difference between the overall suitability for sorghum with a short growing period (Rs1) and a long growing period (Rs2). However, an improved early maturing variety is likely to give a better yield then the traditional late maturing variety. Also, any early maturing crop variety gives the farmer the opportunity to plant a second sequential or relay crop on the same land within a year.

The study area has no land which is very suitable (class S1) for the four rainfed crops which have been analyzed. This is largely due to the fact that even in areas with relatively high mean annual rainfall (south-western plateau), long-term average crop yields will remain below their potential because of rainfall variability (both seasonal and annual), erosion hazard and low soil fertility. Although both erosion hazard and low soil fertility could be overcome by improved management and increased inputs, this would mean increased costs which are unlikely to be off-set by increased production.

About 14 % of the study area (185000 ha) is moderately suitable (class S2) for all four crop varieties analyzed. Most of the moderately suitable land is found on the plateau, around Gebiley (RBU 23). In this area, relatively high rainfall (around 500mm) and moderate LGP (90-120days) combines with deep soils (Vertisols).and gentle slopes to create favourable conditions for the cultivation of drought-resistant crops. Moderate limitations are posed by the variability in rainfall and Length of Growing Period and by erosion hazard, preventing the realization of sustained high yields.

One-third of the study area is marginally suitable (class S3) for the three of the four crop varieties analyzed (cowpea, and the two sorghum varieties). For maize (LUT Rm1), which has somewhat higher moisture requirements, only 15% has been classified as marginally suitable The main limitation is low moisture availability because of arid climatic conditions and/or shallow soils (RBUs 19, 21, 22, 22a, 24, 24a, 26 and 27). Many of the main alluvial plains and floodplains have also been classified as marginally suitable because of flooding hazard (RBUs 5, 5b, 5c, 9, 9a).

More than 50% of the study area is unsuitable (class N) for the rainfed production of cowpea and sorghum, and more than 70% is unsuitable for maize. Most of the study area poses severe limitations for these types of land uses because of arid or desert climatic conditions and/or shallow and stony soils with poor rooting conditions and very low water holding capacity.

The land suitability for sorghum (Rs1 and Rs2) and maize (Rm1) is shown on Maps 3 and 4 respectively. Since the suitability for Rs1 and Rs2 is very similar, both a shown on the same map.

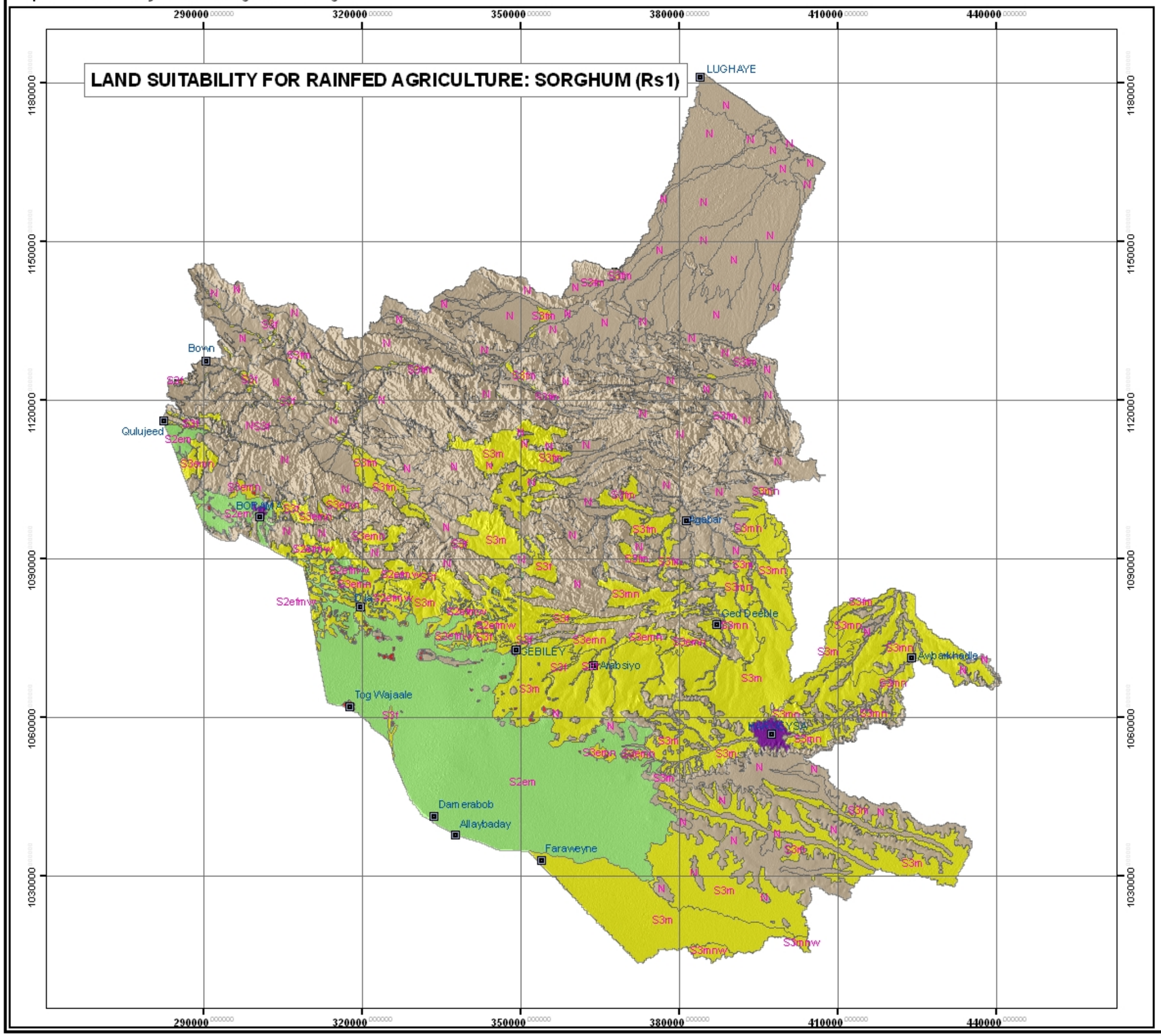
Table 14: Land Suitability for Rainfed Agriculture

RBU	Area		Rc cowpea short GP	Rm1 maize short GP	Rs1 sorghum short GP	Rs2 sorghum long GP "Elmi Jama"
	ha	%				
1	9111	0.7	N	N	N	N
2	3236	0.3	N	N	N	N
3	3663	0.3	N	N	N	N
4	62517	4.8	N	N	N	N
5	26482	2.1	S3fm	S3fmn	S3fm	S3fm
5a	23439	1.8	N	N	N	N
5b	7756	0.6	S3f	S3fn	S3f	S3f
5c	4042	0.3	S3f	S3fn	S3f	S3f
6	47122	3.6	N	N	N	N
6a	25289	2.0	N	N	N	N
6b	9800	0.8	N	N	N	N
7	92216	7.1	N	N	N	N
7a	109767	8.5	N	N	N	N
8	31492	2.4	N	N	N	N
8a	7474	0.6	N	N	N	N
8b	13389	1.0	N	N	N	N
9	19269	1.5	S3fm	S3fm	S3fm	S3fm
9a	3048	0.2	S3f	S3f	S3f	S3f
10	8472	0.7	N	N	N	N
11	3385	0.3	N	N	N	N
12	10500	0.8	N	N	N	N
13	8295	0.6	N	N	N	N
15	44519	3.4	N	N	N	N
16	42336	3.3	N	N	N	N
16a	12325	1.0	N	N	N	N
16b	5806	0.5	N	N	N	N
17	7198	0.6	N	N	N	N
18	9786	0.8	S2em	S2em	S2em	S2em
19	61977	5.0	S3mn	S3emn	S3emn	S3emn
20	11112	0.9	S2efmn	S2efmw	S2efmw	S2efmw
21	36235	2.8	S3m	S3mn	S3m	S3m
22	46251	3.6	S3mn	N	S3mn	S3mn
22a	23089	1.8	S3mn	N	S3mn	S3mn
23	163997	12.7	S2em	S2em	S2em	S2em
24	61666	4.8	S3m	N	S3m	S3m
24a	34463	2.7	S3m	S3m	S3m	S3m
25	12576	1.0	N	N	N	N
26	73305	5.7	S3m	N	S3m	S3m
27	9641	0.7	S3m	N	S3m	S3m
28	2547	0.2	N	N	S3mnw	S3mnw
29	66109	5.1	N	N	N	N
30	4322	0.3	N	N	N	N
31	28488	2.2	S3m	N	S3m	S3m
32	2281	0.2				
33	4120	0.3				
Total	1293908	100				
* numbering of RBUs not continuous due to late modifications in map legend						

Table 15: Land Suitability for Rainfed Agriculture (summary)

	Rc		**Rm1**		**Rs1**		**Rs2**	
	area (ha)	**%**	**area (ha)**	**%**	**area (ha)**	**%**	**area (ha)**	**%**
S1	0	0	0	0	0	0	0	0
S2	184895	14.3	184895	14.3	184895	14.3	184895	14.3
S3	426071	33.7	193273	14.9	428617	33.9	428617	33.9
N	682943	52.0	915741	70.8	680396	51.8	680396	51.8
total	1293909	100	1293909	100	1293909	100	1293909	100

Map 3: Land Suitability for Rainfed Agriculture: Sorghum



LEGEND

Suitability

- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

- e: erosion hazard
- f: flooding hazard
- m: moisture availability
- n: nutrient availability
- w: oxygen availability (drainage)

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Rs1-N-AOI-A3-001
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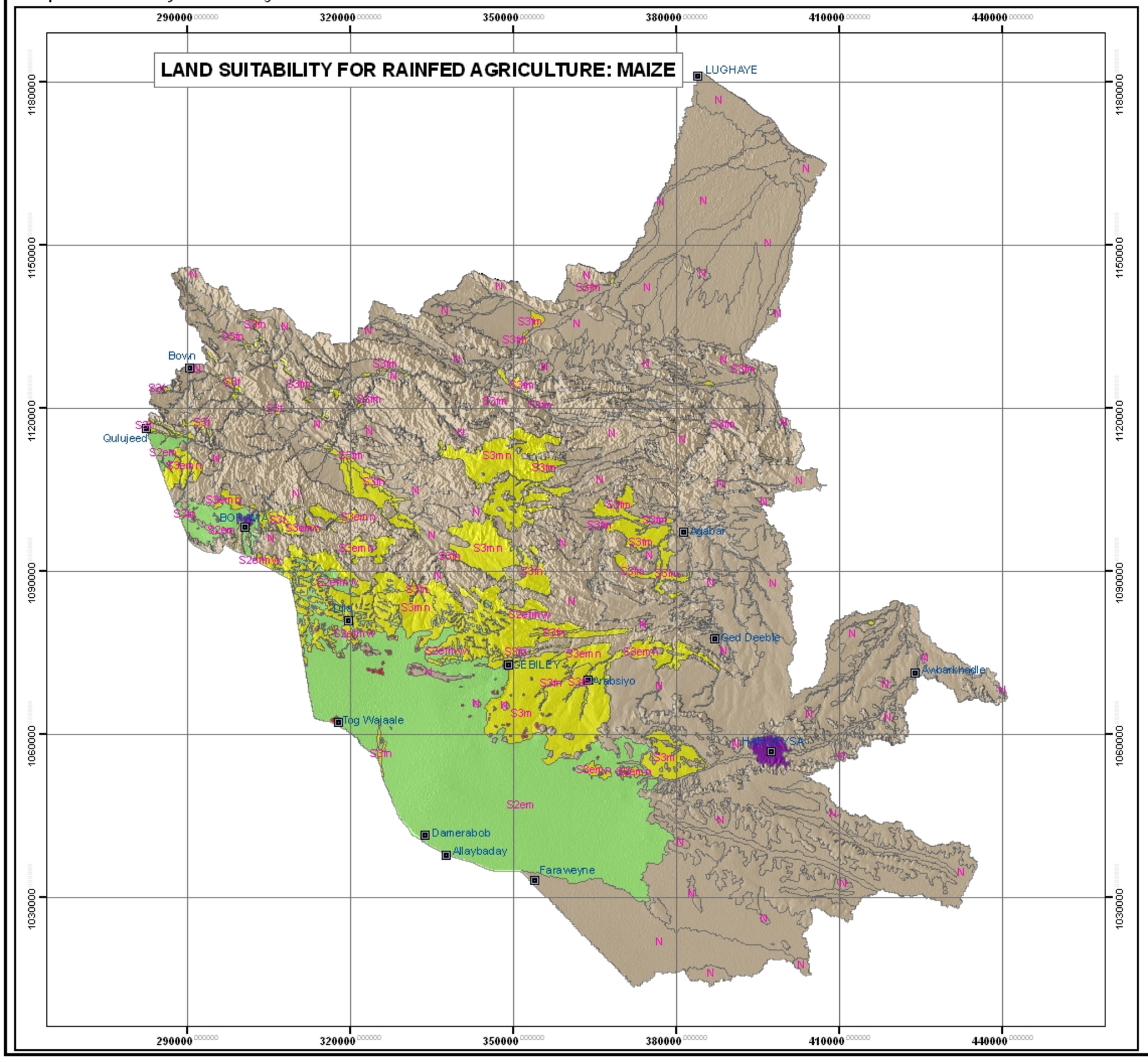
Map 4: Land Suitability for Rainfed Agriculture: Maize



LEGEND

Suitability

- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

- e: erosion hazard
- f: flooding hazard
- m: moisture availability
- n: nutrient availability
- w: oxygen availability (drainage)

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Rm1-N-AOI-A3-001
For copies of digital data please contact enquiries@faoswalim.org

5.2 Land suitability for irrigated agriculture (orchards)

No systematic land evaluation has been carried out for irrigated agriculture. There is no water available for irrigation in most of the study area. Even the construction of storage dams or the application of water harvesting techniques would not solve the problem of general water deficit in the area. As explained in Section 2.2, potential evapotranspiration (PET) greatly exceeds precipitation (P) throughout the year. Also there are no rivers bringing water from outside the study and no known significant underground water reservoirs.

However, small surface and underground water supplies exist locally along the major seasonal rivers (toggas), draining the mountains and the plateau. Small-scale irrigation is possible in these floodplains where water supplies occur close to pockets of deep soil. In fact, most of these areas are already used for irrigated gardens (orchards). Such scattered areas of irrigable land are usually not larger than half an hectare or less and used for the production of fruits (citrus, mango, papaya, guava) and vegetables.

The scale of the present study (1:100,000) does not make it possible to map out all the small pockets of land suitable for irrigation. However, a rough estimate can be made of irrigable land, based on the estimation that roughly 30% of the braided river plains of the plateau, mountains and piedmont have suitable land (see RBU description, Annex 1). Suitable land in this case means gently sloping, slightly elevated land with deep soils along the main sandy and/or stony river beds.

Table 16: Estimated total area of irrigable land in study area

RBU	Relief	LGP Zone	Total area RBU (ha)	Irrigable land (estimate) (ha)
5	Braided river plain in mountains and on plateau	3	26482	7940
5b	Braided river plain on plateau	11	7756	2330
5c	Braided river plain on plateau	12	4042	1210
Total				10480

Table 14 shows an estimate of irrigable land within RBUs 5, 5b and 5c[4]. The figures presented refer to the total area of irrigable land near a water source and is estimated to cover an area of 10480 ha, or 0.8% of the total study area. This figure should only been seen as an upper limit. It is not known whether there would be enough water to irrigate all the 10480 ha. Also, because of land fragmentation irrigation may be impractical or not cost-effective on some of the "suitable" land. More detailed study of RBUs 5, 5b and 5c is needed to reveal the true extent of irrigable land.

[4] These RBUs are included in the legend of Map 2, but difficult to identify on the hard-copy map included in this report because of its small scale.

5.3 Land suitability for extensive grazing (pastoralism)

Tables 17 and 18 below show the physical land suitability of the study area for extensive grazing (pastoralism). Four types of grazing (Land Use Types) have been considered: cattle (Pc), camels (Pd), goats (Pg) and sheep (Ps). The suitability for camels and goats is also presented on Maps 5 and 6 respectively.

Evaluating land for its suitability for pastoralism is somewhat complicated because pastoralists move there livestock over large areas and do not confine themselves to one RBU. Even on land which is itself provides very little grazing (e.g. coastal desert zone), livestock may be found roaming or passing through and finding some nourishment or water at least for some part of the year. Therefore a final evaluation should take into account all the land available for individual pastoralists or group of pastoralists and consider the dynamics of extensive grazing. The present study however, confines itself to the evaluation of individual RBUs.

Tables 17 and 18 show that there is not much difference between the suitability for the four types of grazing. This can be explained by the fact that most of the study area has an arid or semi-arid climate and low biomass production and low forage availability, affecting the suitability for all grazing and browsing animals.

The study area has a small area of land (13000 ha, or 1% of the study area) which is very suitable (class S1) for the four types of grazing analyzed. This land is found in RBUs 9a and 18, which represent depressions and plains of the plateau area near Borama in the extreme west of the study area.

Nearly one-third of the study area (around 410000 ha) is moderately suitable (class S2) for all four types of grazing. Most of the moderately suitable land is found on the plateau in the south-west of the study area (RBUs 19, 23, 26 and 31). In this area, relatively high rainfall (400 - 500mm) combines with deep soils (Vertisols).and gentle slopes to create favourable conditions for plant growth and movement of livestock. Moderate limitations are posed by the variability in rainfall and Length of Growing Period. Elsewhere, some of the valleys and alluvial plains have also been classified as moderately suitable (RBUs 5, 5b, 5c, 9 and 27).

One-third of the study area is marginally suitable (class S3) for cattle, camels and sheep. For goats (LUT Pg), which are somewhat more tolerant to adverse conditions, the situation is better with almost 45% marginally suitable. The main limitations are (1) low biomass production because of low rainfall and/or poor soils, and (2) locally poor accessibility for cattle, camels and sheep because of steep and stony terrain.

Around 30% of the study area is unsuitable (class N) for the production of cattle, camels and sheep, and 22% is unsuitable for the production of goats. Unsuitable areas include the northern desert zone (RBUs 1, 2, 3 & 4), mountainous areas (RBUs 15, 16, 16a, 16b) and severely degraded areas (RBUs 22, 22a). For goats the situation is slightly more favourable, as they can also access the steep mountain slopes.

Table 17: Land Suitability for Extensive Grazing

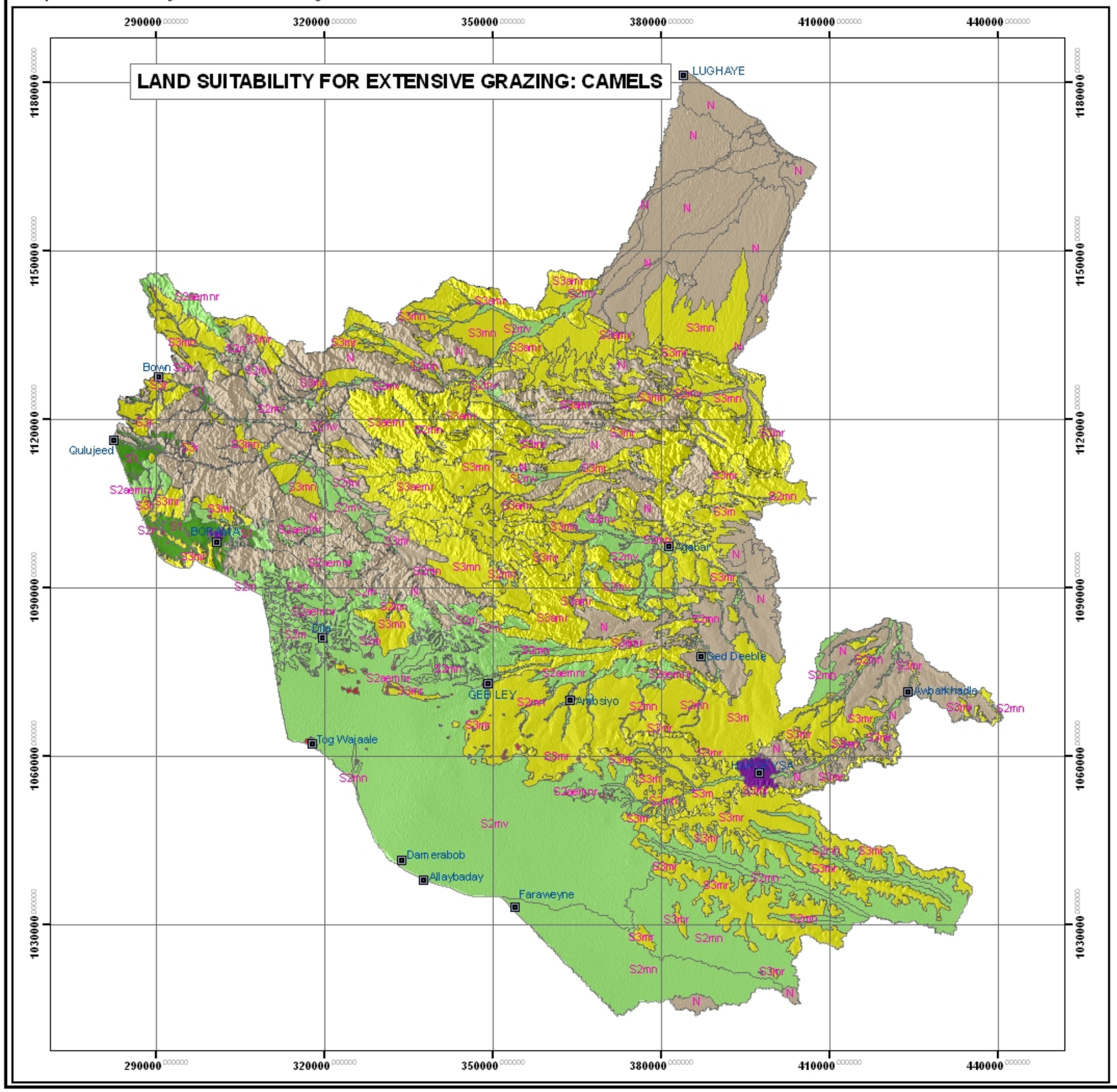
RBU*	Area		Pc Cattle	Pd Camels	Pg Goats	Ps Sheep
	ha	%				
1	9111	0.7	N	N	N	N
2	3236	0.3	N	N	N	N
3	3663	0.3	N	N	N	N
4	62517	4.8	N	N	N	N
5	26482	2.1	S2mnv	S2mn	S2mn	S2mnv
5a	23439	1.8	N	N	N	N
5b	7756	0.6	S2mn	S2mn	S2mn	S2mn
5c	4042	0.3	S2n	S2n	S2n	S2n
6	47122	3.6	S3mn	S3mn	S3mn	S3mn
6a	25289	2.0	S3mn	S3mn	S3mn	S3mn
6b	9800	0.8	S3mn	S3mn	S3mn	S3mn
7	92216	7.1	S3amr	S3amr	S3mr	S3mr
7a	109767	8.5	N	N	N	N
8	31492	2.4	S3amr	S3mr	S3mr	S3amr
8a	7474	0.6	S3amr	S3mr	S3mr	S3amr
8b	13389	1.0	S3amr	S3mr	S3mr	S3amr
9	19269	1.5	S2mv	S2mv	S2mv	S2mv
9a	3048	0.2	S1	S1	S1	S1
10	8472	0.7	S3amr	S3mr	S3mr	S3amr
11	3385	0.3	S3amr	S3mr	S3mr	S3amr
12	10500	0.8	S3m	S3m	S3m	S3m
13	8295	0.6	S3mr	S3mr	S3mr	S3mr
15	44519	3.4	N	N	S3emr	N
16	42336	3.3	N	N	S3er	N
16a	12325	1.0	N	N	S3er	N
16b	5806	0.5	N	N	S3er	N
17	7198	0.6	S3ar	S3r	S3r	S3ar
18	9786	0.8	S1	S1	S1	S1
19	61977	5.0	S2aemnr	S2aemnr	S2emnr	S2emnr
20	11112	0.9	S2m	S2m	S2m	S2m
21	36235	2.8	S3mn	S3mn	S3mn	S3mn
22	46251	3.6	N	N	N	N
22a	23089	1.8	N	N	N	N
23	163997	12.7	S2mv	S2mv	S2mv	S2mv
24	61666	4.8	S3m	S3m	S3m	S3m
24a	34463	2.7	S3m	S3m	S3m	S3m
25	12576	1.0	S3mr	S3mr	S3mr	S3mr
26	73305	5.7	S2mnv	S2mn	S2mn	S2mnv
27	9641	0.7	S2mnv	S2mn	S2mn	S2mnv
28	2547	0.2	N	N	N	N
29	66109	5.1	S3mr	S3mr	S3mr	S3mr
30	4322	0.3	S3a	S2aemnr	S2emnr	S2emnr
31	28488	2.2	S2mnv	S2mn	S2mn	S2mnv
32	2281	0.2	N	N	N	N
33	4120	0.3	N	N	N	N
Total	1293908	100				

* numbering of RBUs not continuous due to late modifications in map legend

Table 18: Land Suitability for Extensive Grazing (summary)

	Pc (cattle)		**Rd (camels)**		**Pg (goats)**		**Ps (sheep)**	
	area (ha)	**%**	**area (ha)**	**%**	**area (ha)**	**%**	**area (ha)**	**%**
S1	12834	1.0	12834	1.0	12834	1.0	12834	1.0
S2	406070	31.4	410391	31.7	4100391	31.7	410391	31.7
S3	480001	37.1	475679	36.8	580664	44.9	475679	36.8
N	395004	30.5	395004	30.5	290018	22.4	395004	30.5
total	1293909	100	1293908	100	1293907	100	1293908	100

Map 5: Land Suitability for Extensive Grazing: Camels



LEGEND

Suitability

- S1: Highly Suitable
- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

a: accessibility (for animals)

e: erosion hazard

m: moisture availability

n: nutrient availability

r: rooting conditions

v: vegetation (fodder availability)

Projection UTM Zone 38 N
Datum WGS 84

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Pd-N-AOI-A3-001
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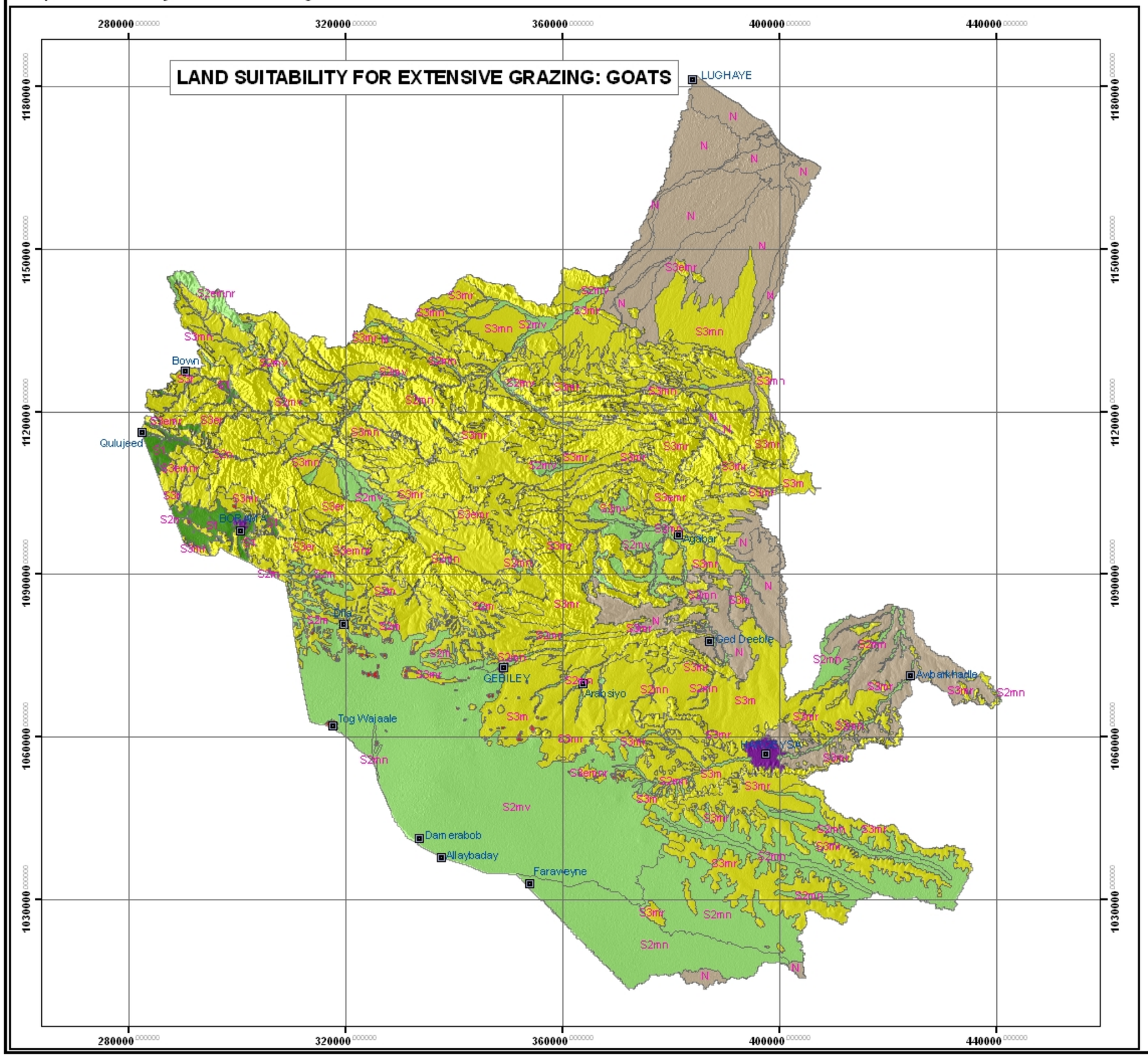
Map 6: Land Suitability for Extensive Grazing: Goats



LEGEND

Suitability

- S1: Highly Suitable
- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

e: erosion hazard

m: moisture availability

n: nutrient availability

r: rooting conditions

v: vegetation (fodder availability)

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Pg-N-AOI-A3-001
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5.4 Land suitability for forestry

Tables 19 and 20 below show the physical land suitability of the study area for nine forestry species. Five of the nine species evaluated are indigenous in the area, namely "Qurac" (*Acacia tortilis*), "Quud" (*Balanites aegyptiaca*), "Damas" or "Ghalab" (*Conocarpus lancifolius*) , "Garas" (*Dobera glabra*) and "Garabi" (*Faidherbia albida* , previously known as *Acacia albida*). Four others are exotic, namely "Maraa" (*Acacia nilotica*), "neem" (*Azadirachta indica*), "Shawri" (*Casuarina equisitifolia*) and "Raqai" (*Tamarindus indica*). The requirements of the various species and possible uses are given in Annexes 4 and 6 respectively. The suitability for *Azadirachta indica*, *Acacia nilotica* and *Conocarpus lancifolius* is also presented on Maps 7, 8 and 9 respectively. Suitability maps for these species are included in this report to demonstrate the variability in the area in terms of suitability.

The fact that a species is indigenous to the area and/or that is found growing there does not necessarily mean that it is highly suitable as a forestry species. Some trees may be survivors or remnants of a past period when conditions were more favourable, or the trees may grow, but only slowly and not to their full potential. In the present study forestry species are evaluated as to the extent at which all their requirements are met by the resource base and to what degree they can reach their full genetic potential.

A more meaningful evaluation for forestry species could be made if the precise purpose of planned tree plantation was known. For example, if the main purpose is soil and water conservation the actual speed of growth and biomass production would be less important than in the case of a plantation for fuel wood or timber production.

Only for one species (*Acacia nilotica*) a small area (RBU 9a, 3048 ha) was found to be highly suitable (class S1). Otherwise there is no highly suitable land. The main reason for this is the relatively low rainfall and high potential evapotranspiration in the area and the lack of shallow groundwater tables.

The area of moderately suitable land (class S2) varies from nearly 15000 ha (1.1% of study area) to more than 220000 ha (17.2%), depending on the species.

More than 36% of the study area is unsuitable (class N) for all species and another 6% is unsuitable for all species except one (only *Conocarpus lancifolius* was classified as marginally suitable in the coastal desert zone). Main limitations are low rainfall in the desert zone and low rainfall in combination with very shallow soils.

Table 19: Land Suitability for Forestry

RBU*	Area		Land Utilization Type (LUT)								
			Fai	**Fan**	**Fat**	**Fba**	**Fce**	**Fcl**	**Fdg**	**Ffa**	**Fti**
			Azadirachta inidica	*Acacia nilotoca*	*Acacia tortilis*	*Balanites aegyptiaca*	*Casuarina equisetifolia*	*Conocarpus lancifolius*	*Dobera glabra*	*Faidherbia albida*	*Tamarindus inidica*
	ha	**%**	agro-pastoral	pastoral	agro-pastoral	pastoral	agro-pastoral	agro-pastoral	pastoral	pastoral	agro-pastoral
1	9111	0.7	N	N	N	N	N	S3m	N	N	N
2	3236	0.3	N	N	N	N	N	S3m	N	N	N
3	3663	0.3	N	N	N	N	N	S3m	N	N	N
4	62517	4.8	N	N	N	N	N	S3m	N	N	N
5	26482	2.1	S3m	S3m	S2imr	S3m	S3m	S2imr	S3m	S3m	S3m
5a	23439	1.8	N	S3m	S2imr	N	N	S2imr	S3m	N	S3m
5b	7756	0.6	S2imr	S2r	S2cir	S2ir	S2imr	S2cir	S2ir	S2imr	S2cir
5c	4042	0.3	S2imr	S2r	S2cir	S2ir	S2imr	S2cir	S2ir	S2imr	S2cir
6	47122	3.6	N	S3m	S2mr	S3m	N	S2mr	S3m	S3m	S3m
6a	25289	2.0	N	S3m	S2mr	S3m	S3m	S2mr	S3m	S3m	S3m
6b	9800	0.8	N	S3m	S2mr	S3m	S3m	S2mr	S3m	S3m	S3m
7	92216	7.1	N	N	N	N	N	N	N	N	N
7a	109767	8.5	N	N	N	N	N	N	N	N	N
8	31492	2.4	N	N	N	N	N	N	N	N	N
8a	7474	0.6	N	N	N	N	N	N	N	N	N
8b	13389	1.0	N	N	N	N	N	N	N	N	N
9	19269	1.5	S3m	S3m	S2im	S3m	S3m	S2im	S3m	S3m	S3m
9a	3048	0.2	S2im	S1	S2ci	S2i	S2im	S2ci	S2i	S2im	S2ci
10	8472	0.7	N	N	N	N	N	N	N	N	N
11	3385	0.3	N	N	N	N	N	N	N	N	N
12	10500	0.8	N	N	N	N	N	N	N	N	N
13	8295	0.6	N	N	N	N	N	N	N	N	N
15	44519	3.4	N	N	N	N	N	N	N	N	N
16	42336	3.3	N	N	N	N	N	N	N	N	N
16a	12325	1.0	N	N	N	N	N	N	N	N	N

* numbering of RBUs not continuous due to late modifications in map legend

Table 19: Land Suitability for Forestry (cont.)

RBU	Area		Land Utilization Type (LUT)								
			Fai	**Fan**	**Fat**	**Fba**	**Fce**	**Fcl**	**Fdg**	**Ffa**	**Fti**
			Azadirachta inidica	*Acacia nilotoca*	*Acacia tortilis*	*Balanites aegyptiaca*	*Casuarina equisetifolia*	*Conocarpus lancifolius*	*Dobera glabra*	*Faidherbia albida*	*Tamarindus inidica*
	ha	**%**	agro-pastoral	pastoral	agro-pastoral	pastoral	agro-pastoral	agro-pastoral	pastoral	pastoral	agro-pastoral
16b	5806	0.5	N	N	N	N	N	N	N	N	N
17	7198	0.6	N	N	N	N	N	N	N	N	N
18	9786	0.8	S3m	S2m	S2c	S2m	S3m	S2c	S2m	S3m	S2cm
19	61977	5.0	N	N	S3m	N	N	S3m	N	N	N
20	11112	0.9	S3m	S2m	S3c	S2m	S3m	S3c	S2cm	S3m	S3c
21	36235	2.8	S3m	S3m	S2cm	S3m	S3m	S2cm	S3m	S3m	S3m
22	46251	3.6	N	N	S3m	N	N	S3m	N	N	N
22a	23089	1.8	N	N	S3m	N	N	S3m	N	N	N
23	163997	12.7	S3m	S2m	S3c	S2m	S3m	S3c	S2cm	S3m	S3c
24	61666	4.8	N	N	S3m	N	N	S3m	N	N	N
24a	34463	2.7	S3m	S3m	S3m	S3m	S3m	S3m	S3m	S3m	S3m
25	12576	1.0	N	N	N	N	N	N	N	N	N
26	73305	5.7	N	N	S3m	N	N	S3m	N	N	N
27	9641	0.7	N	N	S2m	S3m	S3m	S2m	S3m	S3m	S3m
28	2547	0.2	N	N	S3m	N	N	S3m	N	N	N
29	66109	5.1	N	N	N	N	N	N	N	N	N
30	4322	0.3	N	N	3m/r	N	N	3m/r	N	N	N
31	28488	2.2	N	N	3m	N	N	3m	N	N	N
32	2281	0.2									
33	4120	0.3									
Total	1293908	100									

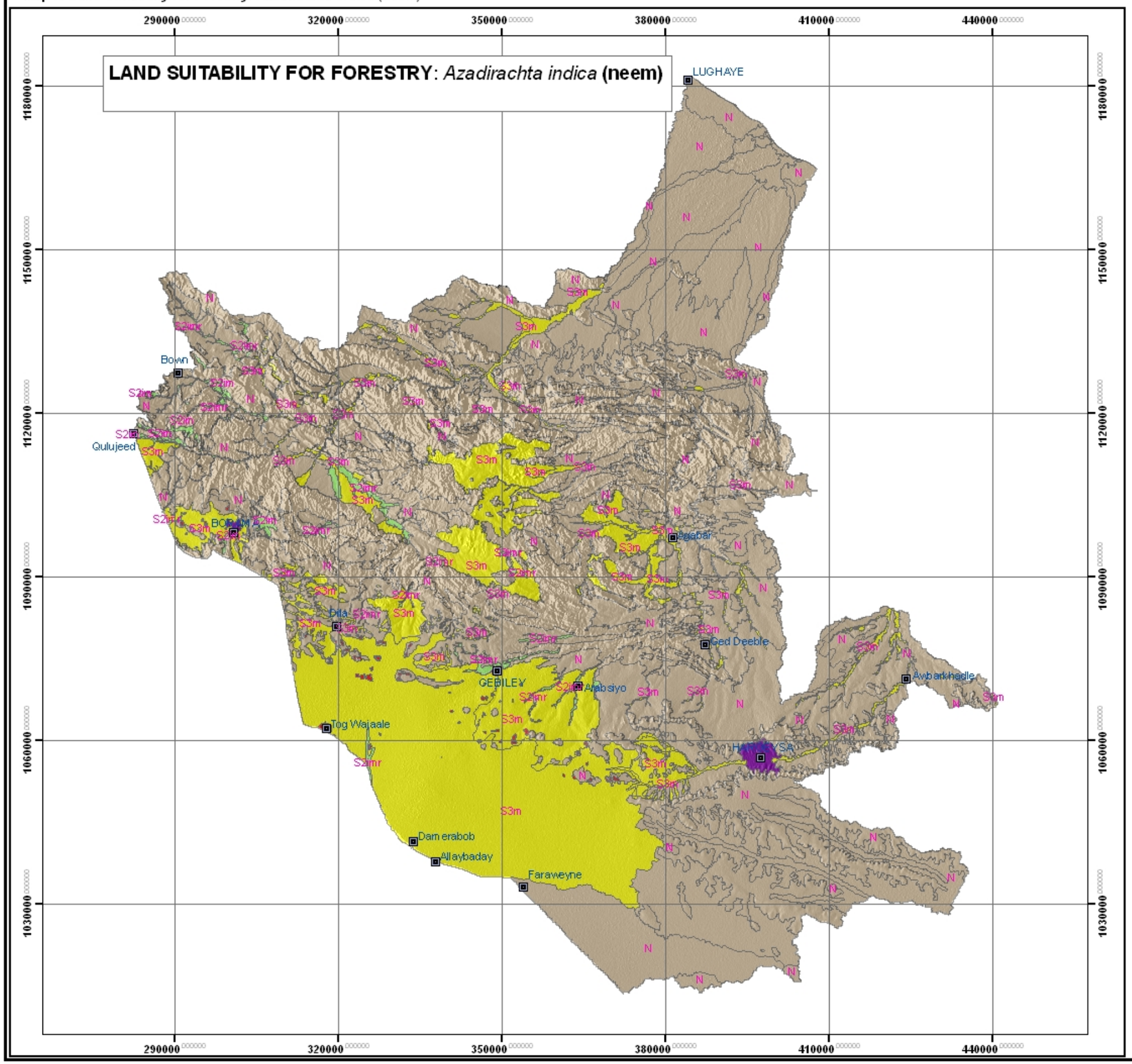
Table 20: Land Suitability for Forestry (Summary)

	Fai		Fan		Fat		Fba		Fce	
	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
S1	0	0	3048	0.2	0	0	0	0	0	0
S2	14846	1.1	196693	15.2	221909	17.2	199741	15.4	14846	1.1
S3	301344	23.3	222098	17.2	511215	39.5	208300	16.1	346074	26.7
N	977718	75.6	872069	67.4	560785	43.3	885867	68.5	932989	72.1
total	1293908	100	1293908	100	1293909	100	1293908	100	1293909	100

Table 20: Land Suitability for Forestry (Summary) (cont)

	Fcl		Fdg		Ffa		Fti	
	area (ha)	%	area (ha)	%	area (ha)	%	area (ha)	%
S1	0	0	0	0	0	0	0	0
S2	221909	17.2	199741	15.4	14846	1.1	24632	1.9
S3	589742	45.6	231739	17.9	393195	30.4	406848	31.4
N	482258	37.3	862428	66.7	885867	68.5	862428	66.7
total	1293909	100	1293908	100	1293908	100	1293908	100

Map 7: Land Suitability for Forestry: *Azadirachta indica* (neem)



LEGEND

Suitability

- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

i: inundation (flooding) hazard

m: moisture availability

r: rooting conditions

Projection UTM Zone 38 N
Datum WGS 84

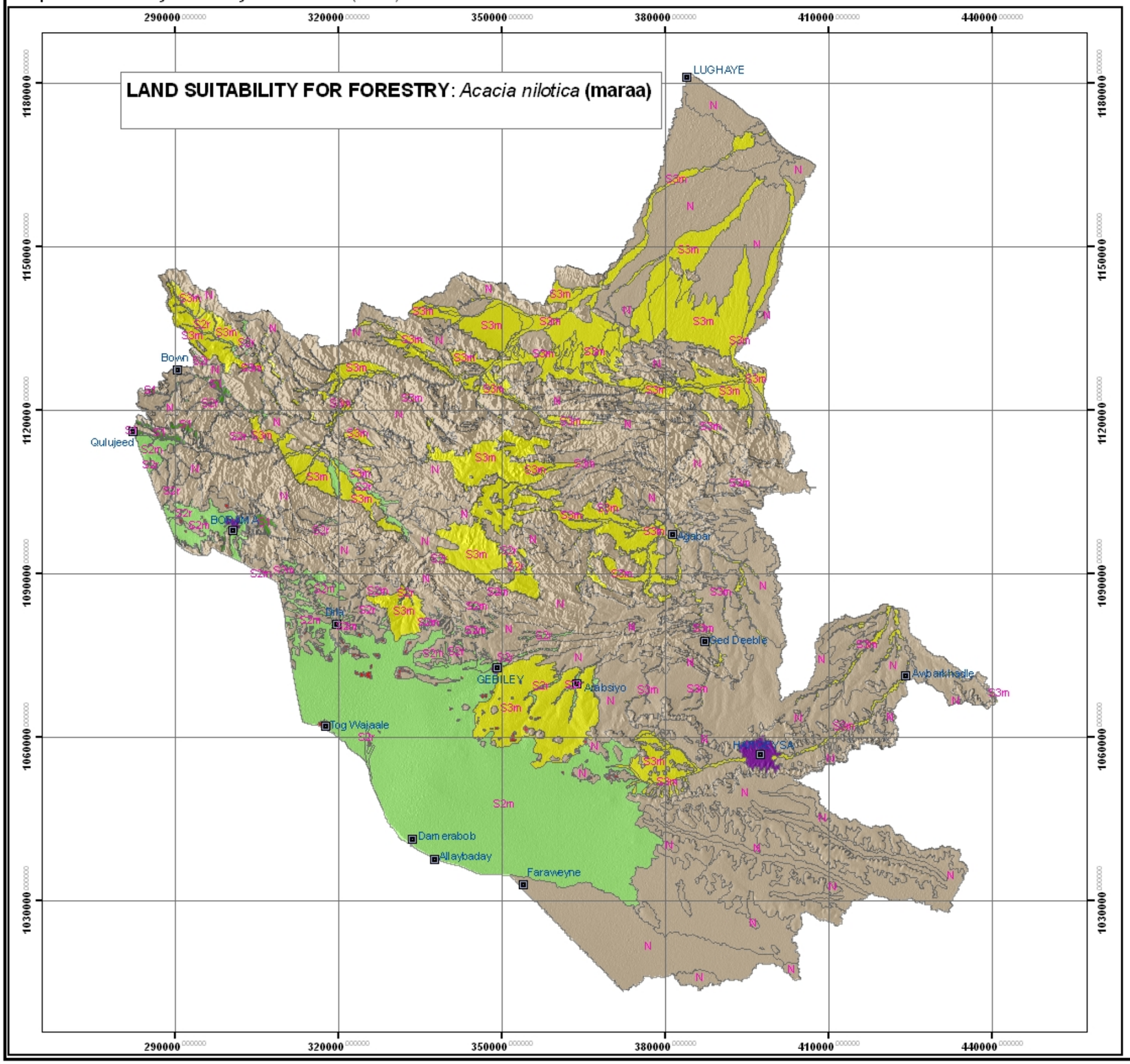
Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Fai-NAOLA3-001
For copies of digital data please contact enquiries@faoswalim.org

Map 8: Land Suitability for Forestry: *Acacia nilotica* (maraa)



LEGEND

Suitability

- S1: Highly Suitable
- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

m: moisture availability

r: rooting conditions

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Fan-N-AOLA 3-001
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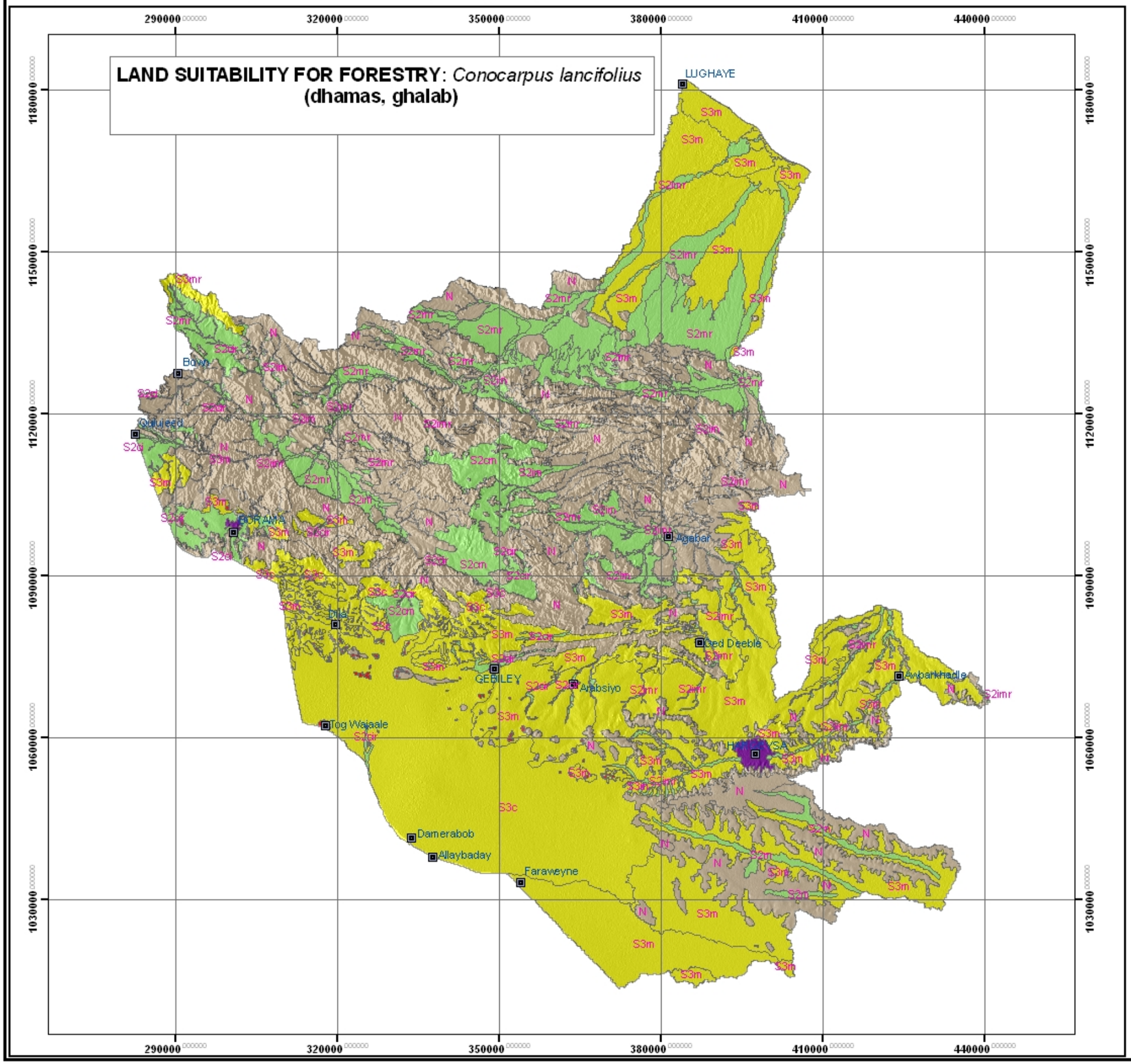
Map 9: Land Suitability for Forestry: *Conocarpus lancifolius* (dhamas, ghalab)



LEGEND

Suitability

- S2: Moderately Suitable
- S3: Marginally Suitable
- N: Not Suitable
- Rural Settlement
- Urban Area
- Settlement

Limitations

c: temperature regime

i: inundation (flooding) hazard

m: moisture availability

r: rooting conditions

Projection UTM Zone 38 N
Datum WGS 84

N

Scale 1:700 000

10 5 0 10 20 30 40 Kilometers

SWALIM

Map Reference: SUITABILITY-20070614-Fcl-N-AOI-A3-001
For copies of digital data please contact enquiries@faoswalim.org

5.5 Summary of suitability for the major types of land use

Because the present physical land evaluation exercise does not include a cost/benefit analysis for the various LUTs it is difficult to compare the suitability of the major land uses, i.e. rainfed agriculture (R), irrigated agriculture (I), extensive grazing (P), and forestry (F). However, some qualitative assessments can be made.

Rainfed Agriculture: Not surprisingly, only the plateau area with relatively high rainfall, is (moderately) suitable for rainfed crops. This area has two short growing periods (Gu and Deyr respectively), separated by a short dry period (Xagaa). Farmers can follow two strategies: either grow a crop with a very short growing period in the Gu and/or Deyr period, or plant a drought resistant crop with a long growth cycle which can make use of both Gu and Deyr. Presently farmers in the area follow the latter strategy and grow a sorghum variety (Elmi Jama) with a growing period of 180 days. However, an improved early maturing variety is likely to give a better yield then the traditional late maturing variety. Also, any early maturing crop gives the farmer the opportunity to plant a second sequential or relay crop on the same land within a year.

Irrigated Agriculture: The area of irrigable land in the study area is estimated at slightly over 10000 ha. This figure refers to the total area of irrigable land near a water source and comprises a great number the small patched of irrigable land in the narrow valleys in the mountain and plateau area. Although more detailed study is needed, it is likely that most suitable land is already used for irrigation and that future development of irrigated agriculture should focus on improved management of orchards, rather than expansion.

Pastoralism: Not much difference was found between the suitability for respectively cattle, camels and sheep because of over-riding limitations such as low biomass production (particularly in arid and desert zone in the north of the study area), and steep slopes with shallow/stony soils (particularly in central and southern mountains). The suitability for goats is slightly better, as they can also access steep slopes.

Forestry: For nearly every environment a tree species can be found that will survive, particularly if it well looked after during the first year after planting. Exceptions are areas with very shallow soils and/or extremely low rainfall. However, tree planting may be costly, as the plantations have to be protected for long periods and may only provide benefits after a number of years. Tree planting by outside agencies should only be considered if welcomed and protected by local communities. Probably less problematic would be the tree planting by individuals near their homestead and on land that they call their own.

In most cases farmers have income or sustenance from many activities, including various types of agriculture, trade, wages and donations. Like everybody else they also have their traditions, beliefs, prejudices and risk assessments. Any recommendations based on land suitability assessments should take this into account, as farmers may not always put all their efforts in what outsiders may consider the most obvious and profitable land use.

6 FURTHER DEVELOPMENT OF LAND EVALUATION PROCEDURE

Some limitations of the present physical land suitability assessment and suggestions for further development are mentioned below.

Limitations:

- The land resources inventory, on which the assessment is based, is of a general nature and does not allow for detailed land evaluation. For example, the mapping of Resource Base Units was not detailed enough to map out the very small areas which are suitable for irrigation.
- Climatic data, which are an important input in land evaluation, are scarce in Somalia and often not up-to-date. The agro-climatic zonation (LGP) used in this study is therefore of a general nature and does not always capture existing climatic variability and long-term trends and patterns. This is the main reason why the land suitability for two types of Rainfed sorghum (i.e. Rs1: sorghum with a short growing period and Rs2: sorghum with a long growing period respectively) came out the same.
- The evaluation does not capture the dynamics of pastoralism. The suitability of individual RBUs was established, whereas pastoralists move their livestock from one RBU to another and are rarely confined to one RBU.
- The evaluation was carried out for a limited number of land use types only. Many more crops could have been considered, as well as other major land uses such as nature conservation (wildlife).

Development:

The method of land suitability evaluation applied and explained in this report (SOMALES) is based on internationally accepted methods and easily allows for expansion and refinement. Suggested refinements, further development and future applications of SOMALES include the following:

- Evaluation for more land use types, particularly at specific requests from the field
- Evaluation of other areas (in addition to present study area)
- Refinement of resource data and Land Use Type requirements
- Validation of results and fine-tuning of SOMALES decision trees
- More detailed study of irrigable land along major seasonal rivers (RBUs 5, 5b and 5c).

Second stage:

As mentioned in the Introduction (Chapter 1), the present first phase of physical land evaluation should ideally be followed up by a second stage of economic evaluation. However, such an economic evaluation does not fall under the present SWALIM mandate.

The findings of the present study should be considered as the initial stage of a future land use planning exercise in the context of sustainable natural resources management.

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List of FAO-SWALIM Technical Land Reports

L-01 Field Survey Manual *(FAO-SWALIM, 2007)*

L-02 Landform of selected areas in Somaliland and Southern Somalia *(Paron, P. and Vargas, R.R., 2007)*

L-03 Land cover of selected areas in Somaliland and Southern Somalia *(Monaci, L., Downie, M. and Oduori, S.M., 2007)*

L-04 Land use characterization of a selected study area in Somaliland *(Oduori, S.M., Vargas, R.R. and Alim, M.S., 2007)*

L-05 Soil survey of a selected study area in Somaliland *(Vargas, R.R. and Alim, M.S., 2007)*

L-06 Land suitability assessment of a selected study area in Somaliland *(Venema, J.H. and Vargas, R.R., 2007)*

L-07 Land use characterization of the Juba and Shabelle riverine areas in Southern Somalia *(Oduori, S.M., Vargas, R.R. and Alim, M.S., 2007)*

L-08 Soil survey of the Juba and Shabelle riverine areas in Southern Somalia *(Vargas, R.R. and Alim, M.S., 2007)*

L-09 Land suitability assessment of the Juba and Shabelle riverine areas in Southern Somalia *(Venema, J.H. and Vargas, R.R., 2007)*

L-10 Land degradation assessment of a selected study area in Somaliland *(Vargas, R.R., Omuto, C. and Njeru, L., 2007)*

L-11 Application of remote sensing techniques for the assessment of pastoral resources in Puntland, Somalia *(Oroda, A. and Oduori, S.M.)*

L-12 Potentialities and limitations in the use of remote sensing tools in detecting and monitoring environmental changes in the Horn of Africa. Proceedings of Workshop held in Nairobi 12-13 June 2007. *(Vargas, R.R., Pellikka, P. and Paron, P.)*

L-13 Land resources assessment of Somalia *(Venema, J.H., 2007)*

Annex 1: Resource Base Units

RBU	Relief	Soil Group	Slope %	LGP Zone	Land cover	Pa	Alt m Ta °C	Dr	pH top	Ca CO3 top	Cfr top	Salin. top	CEC top	OC top	Soil depth	Ca top	Mg top	ESP top	Tex top	Name
1	Sandy coast	Haplic Arenosol	0-4	1	Bare Savanna	DE	7-34 28-30 °C	4	VA	V	VF	NS	L	VL	DD	L	L	NS	SL	Desert; sandy coast
2	Delta	Haplic Fluvisol	0-4	1	Closed trees	DE	3-29 28-30 °C	3	AL	V	N	SS	M	LO	DD	M	H	MS	Si	Desert; delta
3	Delta	Calcic Endosalic Fluvisol	0-4	1	Bare	DE	6-63 28-30 °C	4	AL	V	N	SA	M	LO	DD	M	M	MS	Si	Desert; salty delta
4	Alluvial plain	Haplic Regosol	0-4 4-10	1	Savanna	DE	17-359 28-30 °C	3	AL	S	F	NS	L	LO	DD	M	M	MS	SL	Desert; pre-coastal piedmont (fluvial)
5	Braided river plain	Haplic Fluvisol	0-4	3	Bare Open trees Orchard	LO	306-1469 20-28	4	AL	M	F	NS	L	LO	MD	M	M	MS	L	Dry semiarid & arid; sandy seasonal river
5a	Braided river plain	Haplic Fluvisol (Skeletic)		1, 2	Bare Open trees	LO	6-845 24-30 °C													Desert; sandy seasonal river
5b	Braided river plain	Haplic Fluvisol	0-4	11	Bare Open trees Orchard	LO	996-1633 20-24 °C	4	AL	M	F	NS	L	LO	MD	M	M	MS	L	Dry-moist semiarid; sandy seasonal river (70%) & alluvial plains (30%)
5c	Braided river plain	Haplic Fluvisol Fluvic Cambisol	0-4	12	Bare Open trees Orchard	MO	1049-1596 20-23 °C	4	AL	M	F	NS	L	LO	MD	M	M	MS	L	Dry-moist semiarid; sandy seasonal river (70%) & alluvial plains (30%)
6	Pediment; Dissected pediment	Haplic Regosol & Leptosols	0-4	3	Savanna Herbaceous	LO	308-1481 21-28 °C	4	AL	S	C	NS	L	VL	MD	M	L	NS	SL	Dry semiarid & arid; alluvial and stony piedmont; savanna
6a	Pediment; Dissected pediment	Haplic Regosol & Leptosols	0-4	3	Grassland Open trees	LO	118-829 24-29 °C	4	AL	S	C	NS	L	VL	MD	M	L	NS	SL	Arid; alluvial and stony piedmont; open trees
6b	Pediment; Dissected pediment	Haplic Regosol & Leptosols	0-4	3	Grassland Open shrubs	LO	496-998 24-27 °C	4	AL	S	C	NS	L	VL	MD	M	L	NS	SL	Arid; alluvial and stony piedmont; open shrubs
7	Hill; Hill complex; Ridge; Inselberg	Hyperskeletic Leptosol Lithic Leptosol	25-100	3	Savanna	LO	235-1340 21-28 °C	5	AL	M	D	NS			VS				S	Dry semiarid & arid; stony mountain; savanna
7a	Hill; Hill complex; Ridge; Inselberg	Hyperskeletic Leptosol Lithic Leptosol	25-100	3	Grassland Open trees	LO	179-1614 20-29 °C	5	AL	M	D	NS			VS				S	Dry semiarid & arid; stony mountain; open trees

Annex 1a: Resource Base Units (cont ……)

RBU	Relief	Soil Group	Slope %	LGP Zone	Land cover	Pa	Alt m Ta °C	D	pH top	CaCO3 top	Cfr top	Salin. top	CEC top	OC top	Soil depth	Ca top	Mg top	ESP top	Tex top	Name
8	Depression; denudational surface	Haplic Leptosol; mainly skeletic	0-25	3	Savanna	LO	322-1686 19-28 °C	4	AL	M	A	NS							S	Dry semiarid & arid; stony; mountain; savanna
8a	Depression; denudational surface	Haplic Leptosol; mainly skeletic	0-25	3	Grassland Open trees	LO	385-1249 22-28 °C	4	AL	M	A	NS							S	Arid; stony; mountain; savanna
8b	Depression; denudational surface	Haplic Leptosol; mainly skeletic	0-25	3	Grassland Open shrubs	LO	538-1821 18-26 °C	4	AL	M	A	NS							S	Dry semiarid & arid; stony; mountain; open trees
9	Flood plain; Alluvial plain; Dissected pediment; Pediment	Haplic & Calcic Fluvisol; Fluvic Cambisol; Luvic Calcisol	0-4	3	Herbaceous Orchards	MO	421-1334 22-28 °C	4	AL	M	N	NS	H	LO	DD	M	M	MS	L	Arid; alluvial plains; orchards
9a	Depression	Fluvic Cambisol; Haplic Luvisol	0-4	12	Herbaceous Orchards	MO	1052-1699 19-23 °C	4	AL	M	N	NS	H	LO	DD	M	M	MS	L	Dry-moist semiarid; alluvial plains; orchards
10	Talus slope	Hyperskeletic Leptosol	0-10	3	Grassland Open trees	LO	355-721 26-28 °C	6	AL		D	NS			VS				S	Arid; eroded rocky slopes
11	Escarpment	Lithic Leptosol	10-25	3	Savanna	LO	917-1157 22-24 °C	6	AL		D	NS			VS				S	Arid; basaltic plateau; savanna
12	Denudational surface	Hyperskeletic Leptosol	0-4	3	Savanna Grassland Open trees	LO	1026-1300 22-24 °C	6	AL	H	C	NS	H	LO	MD	H	M	NS	SCL	Arid; basaltic plateau; open trees
13	Denudational surface	Hyperskeletic Leptosol	0-10	3	Savanna Bare	LO	1278-1715 19-22 °C	4	AL		D	NS			VS				S	Dry semiarid & arid; basaltic slopes; savanna

Note: numbering of RBUs not continuous due to late modifications in map legend

Annex 1b: Resource Base Units (cont ……)

RBU	Relief	Soil Group	Slope %	LGP Zone	Land cover	Pa	Alt m Ta °C	D	pH top	CaCO3 top	Cfr top	Salin. top	CEC top	OC top	Soil depth	Ca top	Mg top	ESP top	Tex top	Name
15	Hill complex; Dissected ridge	Haplic Regosol & Leptosol Lithic Leptosol	10-100	3	Savanna	LO MO	733-1735 19-25	6	AL	V	D	NS			VS				S	Dry semiarid & arid; very eroded limestone hilland; savanna
16	Mountain; Dissected ridge	Lithic Leptosol Hyperskeletic Lithic Leptosol	25-100	12	Savanna	MO	1130-1616 20-23 °C	5	AL		D	NS			VS				S	Dry-moist semiarid; very eroded schist mountain; savanna
16a	Mountain; Dissected ridge	Lithic Leptosol Hyperskeletic Lithic Leptosol	25-100	11	Grassland Open trees	MO	1314-1788 18-22 °C	5	AL		D	NS			VS				S	Dry-moist semiarid; very eroded schist mountain; open trees
16b	Mountain; Dissected ridge	Lithic Leptosol Hyperskeletic Lithic Leptosol	25-100	12	Grassland Open shrubs	MO	1352-1674 19-21 °C	5	AL		D	NS			VS				S	Dry-moist semiarid; very eroded schist mountain; open shrubs
17	Planation surface; Denudational surface	Haplic Regosol (Skeletic)	0-10	12	Grassland Open trees	MO	1228-1738 19-22 °C	4	AL		D	NS			VS				S	Dry-moist semiarid; Piedmont; open trees
18	Plain	Calcic Grumic Vertisol	0-4	12	Shrubs Herbaceous Crops	MO	1360-1590 20-21 °C	4	AL	H	VF	NS	H	ME	VD	M	M	MS	C	Dry-moist semiarid; plain; Vertisols.
19	Dissected plateau; Hill complex	Haplic Leptosol	4-25	11	Savanna Shrubs Rainfed crops	MO	1202-1765 19-22 °C	4	VA	S	C	NS	L	LO	DD	M	M	MS	SL	Dry-moist semiarid; dissected plateau; shallow soils
20	Flat floor valley	Haplic Vertisol. Vertic Calcisol	0-4	11	Herbaceous Isolated fields	MO	1402-1695 19-21 °C	2	AL	H	N	NS	M	ME	DD	M	M	MS	C	Dry-moist semiarid; valleys; Vertisols
21	Dissected pediment	Haplic Regosol Fluvic Cambisol	0-10	3	Grassland Open trees Herbaceous Fields	MO	1130-1613 20-23 °C	4	AL	M	C	NS	L	VL	DD	M	M	NS	SL	Dry semiarid & arid; dissected plateau; shallow soils
22	Badland; Denudational surface	Haplic Regosol Haplic Calcisol	0-10	3	Bare Savanna	LO	967-1366 21-24 °C	4	AL	V	C	NS	L	VL	SS	H	M	MS	SCL	Arid; very eroded; calcaric piedmont; bare
22a	Badland; Denudational surface	Haplic Regosol Haplic Calcisol	0-10	3	Open shrubs & trees	LO	974-1239 22-24 °C	4	AL	V	C	NS	L	VL	SS	H	M	MS	SCL	Arid; very eroded; calcaric piedmont; open shrubs.
23	Plateau	Vertisol	0-4	11	Rainfed crops Shrubs	MO	1343-1716 19-21 °C	3	AL	H	N	NS	H	ME	DD	M	M	MS	C	Dry-moist semiarid; plateau; Vertisols; rainfed crops & shrubs.

Anex 1c: Resource Base Units (cont ……)

RBU	Relief	Soil Group	Slope %	LGP Zone	Land cover	Pa	Alt m Ta °C	Dr	pH top	CaCO3 top	Cfr top	Salin. top	CEC top	OC top	Soil depth	Ca top	Mg top	ESP top	Tex top	Name
24	Denudational surface; Pediment	Calcisols	0-4	3	Savanna Crops Shrubs	LO MO	1044-1517 20-23 °C	3	AL	M	VF	NS	M	ME	MD	M	M	MS	SCL	Dry semiarid & arid; dissected plateau; Calcisols & Leptosols
24a	Denudational surface; Pediment	Calcisols	0-4	11	Savanna Crops Shrubs	LO MO	1321-1605 20-22 °C	3	AL	M	VF	NS	M	ME	MD	M	M	MS	SCL	Dry-moist semiarid; dissected plateau; Calcisols & Leptosols
25	Plateau; Mesa	Haplic Regosol (skeletic)	0-4	3	Savanna	LO	1244-1576 20-22 °C	4	AL		D	NS			VS				S	Dry semiarid & arid; residual plateau; shallow stony soils; savanna
26	Valley; Pediment	Calcic Vertisol	0-4	3	Very open trees Herbaceous Crops	LO	1067-1443 21-23 °C	4	AL	H	N	NS	M	LO	VD	M	M	MS	C	Arid; pediment; Vertisols; Tiger Bush & some fields
27	Straight river plain	Haplic Vertisol	0-4	3	Grassland Isolated crops	LO	1147-1418 21-23 °C	3	AL	H	N	NS	M	LO	VD	L	M	MS	C	Arid; alluvial plain; Vertisols; grassland
28	Playa	Haplic Solonchak	0-4	3	Bare Very open trees	LO	1224-1305 22-23 °C	1	VA	M	N	VS	L	LO	DD	M	M	SO	C	Arid; salted playas
29	Denudational slopes and hills	Hyperskeletic Leptosol	0-4	3	Grassland Open shrubs & trees Savanna	LO	1024-1643 19-23 °C	4	AL		D	NS			VS				S	Dry semiarid & arid; residual plateau slopes; stony shallow soils; sparse vegetation
30	Hill complex; Dissected ridge	Lithic Leptosol	10-100	12	Closed shrubs	MO	1271-1616 20-22 °C	4	AL	V	C	NS			SS				S	Dry-moist semi-arid; steep limestone hilland; closed shrubs
31	Plateau	Vertisol	0-4	3	Open trees Isolated crops	LO	1234-1425 21-22 °C	3	AL	H	VF	NS	M	LO	MD	H	M	MS	C	Arid; plateau; Vertisols; open trees
32	Plateau						1385-1705 19-21 °C													Rural settlements
33	Plateau						1237-1486 21-22 °C													Urban area

RBU Resource Base Unit LGP Length of Growing Period Pa Mean annual rainfall Ta Mean annual temperature
Cfr Coarse fragments Salin. Salinity CEC Cation Exchange Capacity OC Organic Carbon;
Ca Exchangeable Calcium Mg Exchangeable Magnesium ESP Exchangeable Sodium Percentage Tex Texture
Alt Altitude
For meaning of class symbols see Table 4 in main text

Annex 2: Resource Base Units, subsoil properties

RBU	CaCO3 (a)	Coarse fragments (b)	Salinity (c)	Sodicity (d)	Texture (e)	Soil Profile Code (f)
1	S	N	NS	VS	SL	104
2	V	F	SS	NS	Si	206
3	M	N	SA	VS	Si	103
4	S	C	NS	NS	SL	105
5	M	C	NS	NS	L	106, 113, 206
6	S	F	NS	NS	SL	107, 200,201
7		D	NS	NS	S	21, 22, 23, 30, 40
8		D	NS	NS	S	34, 39
9	S	N	NS	SO	L	114
10		D			S	
11		D			S	
12	H	C	NS	NS	C	35, 36, 42, 317
13		D			S	38
14		D		NS	S	
15	H	D			S	
16		D			S	
17		C			SL	26
18	M	N	NS	NS	C	109, 203, 301
19	M	C	NS	NS	SL	29
20	M	N	NS	NS	C	115
21	M	N	SS	MS	SCL	108
22	H	C	SS	MS	C	37, 41, 129, 135, 316
23	H	N	NS	MS	C	120, 121, 122, 123, 125, 302, 303, 308, 325, 326, 328, 329
24	H	F	NS	NS	L	118, 119, 124, 137, 138, 310
25		D			S	44
26	H	N	NS	MS	C	102, 307, 321
27	H	N	NS	MS	C	101, 323
28	H	N	VS	SO	C	
29		D			S	45, 47, 48
30	H	D			S	
31	H	N	NS	MS	C	306, 309

(a) S-slightly calcareous, M-moderately calcareous, H-highly calcareous
(b) Coarse fragments: N-none, F-few, C-common, A-Abundant, D-dominant
(c) NS-non saline, MS-moderately saline, SO-saline, VS-very saline, extremely saline
(d) NS-non sodic, MS-moderately sodic, SO-sodic, VS-very sodic, ES-extremely sodic
(e) C-clay, L-loam, Si-silt, S-sand, SL-sandy loam, SCL-sandy clay loam
(f) see SWALIM report L-05 for details

Annex 3: Crop requirements

Common name	Variety	Scientific name	Main Uses	Tempera-ture	Moisture	Drought tolerance	LGP (days)	Nutrient	Soil depth	Salinity tolerance dS/m	Rooting (Stoniness 0-50cm)	Yield (kg/ha) *
Sorghum	Gadam or KAR1	Sorghum bicolor / vulgare?	food (grain)	wide range	450-650	mod	85-100	mod	deep	mod 0-8	tolerant	1700-4500
Sorghum	traditional Elmi Jama	Sorghum bicolor / vulgare?	food (grain) + fodder	wide range	450-650 mod.	mod	150-180	mod	deep	mod 0-8	tolerant	?
Pearl Millet	KAT PM-1	Pennisetum glaucum	food (grain) + fodder	< 2400m 30-35 °C (15-45)	low	mod/high	80-90	low	deep	low/mod 0-6	tolerant	2800
Maize	short GP	Zea mays	food (fresh = "badhayse") + grain	wide range	500-800 high	low	80-90 100-105 (grain)	high	deep	low/mod 0-6	tolerant	1000-2000
Beans (common)		Phaseolus vulgaris	food, fodder	15-27 °C	400-600 low-mod.	mod	90-110 dry	mod	mod	very low 0-2	mod. tolerant	500-1500
Cowpea	M66 or Katumani 80	Vigna unguiculata	food (seed, leaves); fodder; soil cover	25-30 °C (10-35)	low (200-400mm)	mod	80-90	low-mod	mod	low 0-5	tolerant	800-1700
Groundnut		Arachis hypogaea	food (seed, oil), animal feed (cake)	20-30 °C	500-700 mod	low	100-120	mod	mod - deep	low 0-5	not tolerant	1000-2000
Pigeon pea	? short GP	Cajanus cajan	food, fodder, soil improvement	25-30 °C (10-35)	mod	high	130-190	low-mod	deep	low	tolerant	500-1000
Jugo bean Bambara g.nut	?	Vigna subterranea	food (seed)		mod	high	120	low	deep	low	not tolerant	550-850
Cluster bean or Guar	?	Cyamopsis tetragonoloba	industry (oil), fodder, food		mod	high	120 green 60	low	deep	high	tolerant	600-800
Simsim	white & brown (local)	Sesamum indicum / radiatum	food (seed, oil), animal feed (cake)	< 1500m 25-30 °C (10-35)	500-700 mod.	mod.	100-140	mod	deep	low	tolerant	500-600
Cassava	? short GP	Manihot esculenta	Food (tuber), animal feed	25-30 °C (10-35)	high	mod-high	240-360	low	mod	mod	not tolerant	?
Cotton		Gossypium hirsutum	Industrial	> 24 °C	600-1200	high	150-180		deep	high 0-12	tolerant	1000-1500 (4000 irrigated)

* Attainable yield for smallholder with medium input (fertilizer mostly). Rainfed unless otherwise stated. Approximate figures from literature.

Annex 4: Requirements forestry species

LUT	Species	Ecology						
		Moisture req.	**Altitude**	**Soils**	**Landform**	**pH**	**CaCO3**	**General**
Fan	*Acacia nilotica* **maraa, tugaar**	drought resistant 200-1270mm 250-1500mm	< 1800m < 1340m	alluvial; coastal sands to Vertisols, etc.	plains, ravines, streams	5.0-8.0 tolerant of alkaline & saline cond.	?	no shade prefers periodic inundation considered a weed in SA
Fat	*Acacia tortilis* **qurac**	very drought resistant (taproot) 100-1000mm; 40-1200mm	< 1000m lowlands	Well drained; sand dunes, sandy loams; grows fairly well in shallow soils		tolerates salinity; 6.5-8.5	not tolerant	tolerates seasonal water logging;
Fai	*Azadirachta indica* **geed hindi, neem**	semi-arid tropics & subtropics 450-1200mm	< 1500m 14-38 °C	tolerant of most soil types;	plains	tolerant of alkaline conditions	tolerant	intolerant to water logging; groundwater within 9-12m from surface
Fba	*Balanites aegyptiaca*	arid to semi-arid 200-800mm	< 2000m	deep sandy loam sand, clay, Vertisols	alluvial			open woodland (no shade)
Fce	*Casuarina equisetifolia* **shawri**	semi-arid to subhumid 200-3500mm 750-2500mm	< 1400m 18-25°C	well drained, coarse textured coastal sand dunes	coastal sand dunes	tolerant of slightly alkaline soils	tolerant	intolerant of prolonged waterlogging; Invasive in Australia
Fcl	*Conocarpus lancifolius* **dhamas, ghalab**	drought tolerant 250-600mm < 100mm once established	< 1220 m (0-800m) 24-30°C	sand, clay, shallow soils; does well on poor soils	along watercourses in semi-desert coastal zone	tolerant of salt		tolerates flooding prefers groundwater within 7m
Fdg	*Dobera glabra* **garas**	100-600mm	< 1500m	various, incl. rocky soils, saline riverbeds		tolerates salinity	tolerant	tolerates short-term water logging
Ffa	*Faidherbia albida*		< 2700	prefers coarse textured soils	riverine	tolerates salinity		tolerates seasonal water logging
Fti	*Tamarindus indica* **raqay**	drought hardy semi-arid 600-1000mm	< 1500m < 1000m > 20°C	wide range	riverine in dry areas	salt tolerant		adaptable

Annex 5: Use forestry species

Species	**Uses**						**INFO**
	Fodder	**Food**	**Timber, poles**	**Fuel**	**Soil conservation**	**Other**	
Acacia nilotica **tugaar, maraa**	pods, leaves	tender pots, shoots. seeds	hardwood, but difficult to work	good firewood & charcoal	live fence; windbreak; soil fertility;	beekeeping; fibre; gum & resin; tannin; medicine;	worldagroforestrycentre; Edible wild plants of Tanzania newforestproject.com
Acacia tortilis **qurac**	leaves, pods	pods, seeds	not durable	good firewood & charcoal	soil fertility; dune stabilization	tannin, medicine, branches for fencing	worldagroforestrycentre; newforestproject.com
Azadirachta indica **geed hindi, neem**	leaves (mod. value)		termite-resistant poles, carvings, timber	firewood, charcoal	green manure (leaves); windbreaks; "calcium mining"	tannin, gum; shade; beekeeping; pesticides; medicine	www.haryana-online.com; fao.org/docrep/u8520e09.htm, Trees of Somalia
Balanites aegyptiaca	leaves, fruits, sprouts	fruit, leaves, flowers	utensils	good firewood & charcoal		gum, resin; medicine	worldagroforestrycentre
Casuarina equisetifolia **shawri**			hardwood, durable	good firewood & charcoal	sanddune fixation; windbreak; soil fertility; reclamation	tannin; medicine; boundary planting; fibre;	worldagroforestrycentre; www.nps.gov/plants/alien
Conocarpus lancifolius **damas, ghalab**	shoots (goats, camels)		strong poles, timber, shipbuilding	good for charcoal; firewood;	re-forestation windbreaks; soil improvement;	shade	www.en.wikipedia.org agroforesttrees.cisat.jmu.edu, Trees of Somalia
Dobera glabra **garas**	leaves	fruits, seeds (boiled)	soft wood (furniture, carvings)	planted for firewood		shade	worldagroforestrycentre, Trees of Somalia
Faidherbia albida	leaves, pods	seeds	furniture, utensils	plantstems (low charcoal yield)		beekeeping; medicine	worldagroforestrycentre
Tamarindus indica **raqay**	leaves	fruits, drinks	hard, heavy wood, furniture	good for firewood, charcoal	windbreak	medicine; shade; beekeeping	Edible wild plants of Tanzania, Arid zone forestry (FAO)

Annex 6: SOMALES: Severity level decision trees for Rainfed Agriculture

Land Use Types (LUT):

- **Rs1: Rainfed sorghum, short GP, 90-100 days, medium input**
- **Rs2: Rainfed "traditional sorghum" total GP 150-180 days (incl. "dormant" period of 50 days), low input**
- **Rc: Rainfed cowpea, short GP, 80 days, low-medium input**
- **Rm1: Rainfed maize, short GP, 80-90 days, medium input**

Decision tree rainfed 1: (e) Erosion hazard **(Rs1, Rs2, Rm1)**

Land characteristics						**Severity level (1-4)**	
Slope class		**Soil Group (class)**		**LGP Zone**			
	score		score		score	total score	level
0-4%	1	1,2	1	1,2,2a	1	3	**1**
	1		1	3,4,5	1.5	3.5	**1**
	1		1	6-15	2	4	**2**
	1	3,4,5,6	2	1,2,2a	1	4	**2**
	1		2	3,4,5	1.5	4.5	**2**
	1		2	6-15	2	5	**2**
4-16%	2	1,2	1	1,2,2a	1	4	**2**
	2		1	3,4,5	1.5	4.5	**2**
	2		1	6-15	2	5	**2**
	2	3,4,5,6	2	1,2,2a	1	5	**2**
	2		2	3,4,5	1.5	5.5	**3**
	2		2	6-15	2	6	**3**
> 16%	3	1,2	1	1,2,2a	1	5	**2**
	3		1	3,4,5	1.5	5.5	**3**
	3		1	6-15	2	6	**3**
	3	3,4,5,6	2	1,2,2a	1	6	**3**
	3		2	3,4,5	1.5	6.5	**4**
	3		2	6-15	2	7	**4**

Assumptions:
- erosion hazard by water increases with slope.
- shallow soils (class 3), Vertisols (class 4), Solonchaks (class 5) and Arenosols (class 6) are more erodible than Calcisols (class 1) and Cambisols and Fluvisols (class 2).
- erosion hazard is low in zones without LGP (zones 1,2,2a) and increases (slightly) with increasing LGP.

3-3.5	1
4-5.0	2
5.5-6	3
6.5-7	4

Decision tree rainfed 2: (e) Erosion hazard **(Rc)**

Land characteristics						**Severity level (1-4)**	
Slope class		**Soil Group (class)**		**LGP Zone**			
	score		score		score	Total score	Level
0-4%	1	1,2	1	1,2,2a	1	3	**1**
	1		1	3,4,5	1.5	3.5	**1**
	1		1	6-15	2	4	**2**
	1	3,4,5,6	1.5	1,2,2a	1	3.5	**1**
	1		1.5	3,4,5	1.5	4	**2**
	1		1.5	6-15	2	4.5	**2**
4-16%	2	1,2	1	1,2,2a	1	4	**2**
	2		1	3,4,5	1.5	4.5	**2**
	2		1	6-15	2	5	**2**
	2	3,4,5,6	1.5	1,2,2a	1	4.5	**2**
	2		1.5	3,4,5	1.5	5	**2**
	2		1.5	6-15	2	5.5	**3**
> 16%	3	1,2	1	1,2,2a	1	5	**2**
	3		1	3,4,5	1.5	5.5	**3**
	3		1	6-15	2	6	**3**
	3	3,4,5,6	1.5	1,2,2a	1	5.5	**3**
	3		1.5	3,4,5	1.5	6	**3**
	3		1.5	6-15	2	6.5	**4**

Assumptions:
- erosion hazard by water increases with slope.
- shallow soils (class 3), Vertisols (class 4), Solonchaks (class 5) and Arenosols (class 6) are more erodible than Calcisols (class 1) and Cambisols and Fluvisols (class 2).
- erosion hazard is low in zones without LGP (zones 1,2,2a) and increases (slightly) with increasing LGP.

Total score	Level
3-3.5	1
4-5.0	2
5.5-6	3
6.5-7	4

Decision tree rainfed 3: (f) Flooding hazard (flash-flooding) **(Rs1, Rs2, Rc, Rm1)**

Land characteristics				**Severity level (1-4)**	
Relief (classes)		**Soil Group**			
	score		score	total score	level
1, 3, 4	1	1,3,6	1	2	**1**
	1	4,5	2	3	**1**
	1	2	4	5	**2**
2a	2	1,3,6	1	3	**1**
	2	4,5	2	4	**1**
	2	2	4	6	**3**
2b	3	1,3,6	1	4	**1**
	3	4,5	2	5	**2**
	3	2	4	7	**3**
Assumptions: - Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b). - Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (SG4) are likely to have periodically high groundwater table.				2-4	1
				5	2
				6-7	3

Decision tree rainfed 4: (i) Inundation (flooding) hazard **(Rs1, Rs2, Rc, Rm1)**

Land characteristics				**Severity level (1-3)**	
Relief (classes)		**Soil Group**			
	score		score	total score	level
1, 3, 4	1	1,3,6	1	2	**1**
	1	5	2	3	**1**
	1	4	3	4	**2**
	1	2	4	5	**2**
2b	2	1,3,6	1	3	**1**
	2	5	2	4	**2**
	2	4	3	5	**2**
	2	2	4	6	**3**
2a	3	1,3,6	1	4	**2**
	3	5	2	5	**2**
	3	4	3	6	**3**
	3	2	4	7	**3**
Assumptions: - Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b). - Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (SG4) are likely to have periodically high groundwater table.				2-3	1
				4-5	2
				6-7	3

Decision tree rainfed 5: (m) Moisture availability **(Rs1, Rc)**

Land characteristics						**Severity level (1-4)**	
LGP Zone		**Rainfall variability**		**Soil Group**			
	score		score		score	total score	level
1	10	H	5	3, 6	4	19	**4**
	10	H	5	1,4,5	2	17	**4**
	10	H	5	2	1	16	**4**
2	5	H	5	3, 6	4	14	**4**
	5	H	5	1,4,5	2	12	**4**
	5	H	5	2	1	11	**4**
3	4	L	2	3,6	4	10	**4**
	4	L	2	1,4,5	2	8	**3**
	4	L	2	2	1	7	**3**
4, 5, 6	4	M	3	3, 6	4	11	**4**
	4	M	3	1,4,5	2	9	**3**
	4	M	3	2	1	8	**3**
7, 8, 9	3	M	3	3, 6	4	10	**4**
	3	M	3	1,4,5	2	8	**3**
	3	M	3	2	1	7	**3**
10	2	M	3	3, 6	4	9	**3**
	2	M	3	1,4,5	2	7	**3**
	2	M	3	2	1	6	**2**
11, 12, 13	2	L	2	3, 6	4	8	**3**
	2	L	2	1,4,5	2	6	**2**
	2	L	2	2	1	5	**2**
14, 15	1	L	2	3, 6	4	7	**3**
	1	L	2	1,4,5	2	5	**2**
	1	L	2	2	1	4	**2**
Assumptions: - Sorghum with short GP (90 days) grown in the longest rainy season (Gu or Deyr). - Shallow and sandy soils have low waterholding capacity (SG 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position.						4-6 7-9 10-19	2 3 4

Decision tree rainfed 6: (m) <u>Moisture availability</u> (Rm1)

Land characteristics						**Severity level (1-4)**	
LGP Zone		**Rainfall variability**		**Soil Group**			
	score		score		score	total score	level
1	10	H	5	3, 6	4	19	**4**
	10	H	5	1,4,5	2	17	**4**
	10	H	5	2	1	16	**4**
2	8	H	5	3, 6	4	17	**4**
	8	H	5	1,4,5	2	15	**4**
	8	H	5	2	1	14	**4**
3	6	L	2	3,6	4	12	**4**
	6	L	2	1,4,5	2	10	**4**
	6	L	2	2	1	9	**3**
4	6	M	3	3, 6	4	13	**4**
	6	M	3	1,4,5	2	11	**4**
	6	M	3	2	1	9	**3**
5	6	M	3	3, 6	4	13	**4**
	6	M	3	1,4,5	2	11	**4**
	6	M	3	2	1	10	**4**
6	5	M	3	3, 6	4	12	**4**
	5	M	3	1,4,5	2	10	**4**
	5	M	3	2	1	9	**3**
7, 8, 9	4	M	3	3, 6	4	11	**4**
	4	M	3	1,4,5	2	9	**3**
	4	M	3	2	1	8	**3**
10	2	M	3	3, 6	4	9	**3**
	2	M	3	1,4,5	2	7	**3**
	2	M	3	2	1	6	**2**
11	2	L	2	3, 6	4	8	**3**
	2	L	2	1,4,5	2	6	**2**
	2	L	2	2	1	5	**2**
12	2	L	2	3, 6	4	8	**3**
	2	L	2	1,4,5	2	6	**2**
	2	L	2	2	1	5	**2**
13	2	L	2	3, 6	4	8	**3**
	2	L	2	1,4,5	2	6	**2**
	2	L	2	2	1	5	**2**
14	1	L	2	3, 6	4	7	**3**
	1	L	2	1,4,5	2	5	**2**
	1	L	2	2	1	4	**2**
15	1	L	2	3, 6	4	7	**3**
	1	L	2	1,4,5	2	5	**2**
	1	L	2	2	1	4	**2**
<u>Assumptions</u>: - Maize with short GP (90 days) grown in the longest rainy season (Gu or Deyr). - Shallow and sandy soils have low waterholding capacity (SG 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position.						4-6 7-9 10-19	2 3 4

Decision tree rainfed 7: (m) Moisture availability **(Rs2)**

Land characteristics						**Severity level (1-4)**	
LGP Zone		**Rainfall variability**		**Soil Group**			
	score		score		score	total score	level add
1	10	H	5	3, 6	4	19	**4**
	10	H	5	1,4,5	2	17	**4**
	10	H	5	2	1	16	**4**
2	8	H	4	3, 6	4	16	**4**
	8	H	4	1,4,5	2	13	**4**
	8	H	4	2	1	12	**4**
3	6	L	1	3,6	4	11	**4**
	6	L	1	1,4,5	2	9	**3**
	6	L	1	2	1	8	**3**
4	6	M	2	3, 6	4	12	**4**
	6	M	2	1,4,5	2	10	**4**
	6	M	2	2	1	9	**3**
5	6	M	2	3, 6	4	12	**4**
	6	M	2	1,4,5	2	10	**4**
	6	M	2	2	1	9	**3**
6, 7	4	M	2	3, 6	4	10	**4**
	4	M	2	1,4,5	2	8	**3**
	4	M	2	2	1	7	**3**
8, 9, 10	3	M	2	3, 6	4	9	**3**
	3	M	2	1,4,5	2	7	**3**
	3	M	2	2	1	6	**2**
11	3	L	1	3, 6	4	8	**3**
	3	L	1	1,4,5	2	6	**2**
	3	L	1	2	1	5	**2**
12	2	L	1	3, 6	4	7	**3**
	2	L	1	1,4,5	2	5	**2**
	2	L	1	2	1	4	**2**
13	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,5	2	4	**2**
	1	L	1	2	1	3	**1**
14	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,5	2	4	**2**
	1	L	1	2	1	3	**1**
15	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,5	2	4	**2**
	1	L	1	2	1	3	**1**
Assumptions: - "Traditional sorghum with long GP (150-180 days) grown over both rainy seasons (Gu or Deyr), including a dry spell during which the crop almost remains dormant (total GP including dormancy around 180 days). - Shallow and sandy soils have low waterholding capacity (SG 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position.						3 4-6 7-9 10-19	1 2 3 4

Decision tree rainfed 8: (n) Nutrient availability **(Rs1, Rs2)**

Land characteristics						**Severity level (1-3)**	
pH(H2O)		**CEC (25-75cm)**		**Ca/Mg (see Table 4)**			
	score		score		score	total score	level
NE	1	L <16	3	VL, VH	3	7	**3**
6.6-7.5	1		3	L, H	2	6	**2**
	1		3	M	1	5	**1**
	1	M 16-24	2	VL, VH	3	6	**2**
	1		2	L, H	2	5	**1**
	1		2	M	1	4	**1**
	1	H >24	1	VL, VH	3	5	**1**
	1		1	L, H	2	4	**1**
	1		1	M	1	3	**1**
AL	2	L	3	VL, VH	3	8	**3**
7.5-8.5	2		3	L, H	2	7	**3**
	2		3	M	1	6	**2**
	2	M	2	VL, VH	3	7	**3**
	2		2	L, H	2	6	**2**
	2		2	M	1	5	**1**
	2	H	1	VL, VH	3	6	**2**
	2		1	L, H	2	5	**1**
	2		1	M	1	4	**1**
VA	3	L	3	VL, VH	3	9	**3**
>8.5	3		3	L, H	2	8	**3**
	3		3	M	1	7	**3**
	3	M	2	VL, VH	3	8	**3**
	3		2	L, H	2	7	**3**
	3		2	M	1	6	**2**
	3	H	1	VL, VH	3	7	**3**
	3		1	L, H	2	6	**2**
	3		1	M	1	5	**1**
Assumptions:							
- nutrient availability decreases with increasing pH (from neutral to very alkaline).						3-5	1
- nutrient availability increases with increasing cation exchange capacity (CEC).						6	2
- nutrient availability decreases in case of (very) low and (very) high Ca/Mg ratios.						7-9	3

Decision tree rainfed 9: (n) Nutrient availability **(Rm1)**

Land characteristics						**Severity level (1-3)**	
pH(H2O) (topsoil)		**CEC (25-75cm) (topsoil)**		**Ca/Mg (see Table 4) (topsoil)**			
	score		score		score	total score	level
NE	1	L <16	4	VL, VH	3	8	**3**
6.6-7.5	1		4	L, H	2	7	**3**
	1		4	M	1	6	**2**
	1	M 16-24	4	VL, VH	3	6	**2**
	1		2	L, H	2	5	**1**
	1		2	M	1	4	**1**
	1	H >24	2	VL, VH	3	5	**1**
	1		1	L, H	2	4	**1**
	1		1	M	1	3	**1**
AL	3	L	1	VL, VH	3	10	**3**
7.5-8.5	3		4	L, H	2	9	**3**
	3		4	M	1	8	**3**
	3	M	4	VL, VH	3	8	**3**
	3		2	L, H	2	7	**3**
	3		2	M	1	6	**2**
	3	H	2	VL, VH	3	7	**3**
	3		1	L, H	2	6	**2**
	3		1	M	1	5	**1**
VA	5	L	1	VL, VH	3	12	**3**
>8.5	5		4	L, H	2	11	**3**
	5		4	M	1	10	**3**
	5	M	4	VL, VH	3	10	**3**
	5		2	L, H	2	9	**3**
	5		2	M	1	8	**3**
	5	H	2	VL, VH	3	9	**3**
	5		1	L, H	2	8	**3**
	5		1	M	1	7	**3**
Assumptions: - nutrient availability decreases with increasing pH (from neutral to very alkaline). - nutrient availability increases with increasing cation exchange capacity (CEC). - nutrient availability decreases in case of (very) low and (very) high Ca/Mg ratios.							1
						3-5	1
						6	2
						7-12	3

Decision tree rainfed 10: (n) Nutrient availability **(Rc)**

Land characteristics						**Severity level (1-3)**	
pH(H2O)		**CEC (25-75cm)**		**Ca/Mg (see Table 4**			
	score		score		score	Total score	level
NE	1	L <16	3	VL, VH	3	7	**3**
6.6-7.5	1		3	L, H	2	6	**2**
	1		3	M	1	5	**1**
	1	M 16-24	2	VL, VH	3	6	**2**
	1		2	L, H	2	5	**1**
	1		2	M	1	4	**1**
	1	H >24	1	VL, VH	3	5	**1**
	1		1	L, H	2	4	**1**
	1		1	M	1	3	**1**
AL	2	L	3	VL, VH	3	8	**3**
7.5-8.5	2		3	L, H	2	7	**3**
	2		3	M	1	6	**2**
	2	M	2	VL, VH	3	7	**3**
	2		2	L, H	2	6	**2**
	2		2	M	1	5	**1**
	2	H	1	VL, VH	3	6	**2**
	2		1	L, H	2	5	**1**
	2		1	M	1	4	**1**
VA	4	L	3	VL, VH	3	10	**3**
>8.5	4		3	L, H	2	9	**3**
	4		3	M	1	8	**3**
	4	M	2	VL, VH	3	9	**3**
	4		2	L, H	2	8	**3**
	4		2	M	1	7	**3**
	4	H	1	VL, VH	3	8	**3**
	4		1	L, H	2	7	**3**
	4		1	M	1	6	**2**
Assumptions: - nutrient availability decreases with increasing pH (from neutral to very alkaline). - nutrient availability increases with increasing cation exchange capacity (CEC). - nutrient availability decreases in case of (very) low and (very) high Ca/Mg ratios.							
						3-5	1
						6	2
						7-10	3

Decision tree rainfed 11: Ca/Mg ratio

Land characteristics				
Ca++ me/100g	**Mg++ me/100g**	**Ca/Mg (ranges)**		**Classes**
L < 10	L <1	10		**M**
	M 1-5	1-0.2	2-10	**L**
	H 5-10	<2	<1	**L**
	V >10	1	0.05	**VL**
M 10-25	L <1	>25	10-25	**H**
	M 1-5	10-25	2-5	**M**
	H 5-10	2-5	1-2.5	**M**
	V >10	1-2.5	< 1	**L**
H 25-50	L <1	>50		**VH**
	M 1-5	25-50	5-10	**H**
	H 5-10	5-10	2.5-5	**M**
	V >10	2.5-5	< 2.5	**L**
V > 50	L <1	>50		**VH**
	M 1-5	50-10	> 20	**VH**
	H 5-10	10-5	20-10	**H**
	V >10	5		**M**
		< 1.2		VL
		1.2-2.3		L
		2.3-9.9		M
		10-24.9		H
		> 25		VH

Decision tree rainfed 12: (r) Rooting conditions **(Rs1, Rs2, Rm1)**

Land characteristics						**Severity level (1-4)**	
Soil depth		**Coarse fragments (topsoil)**		**Coarse fragments (subsoil)**			
	score		score		score	total score	level
VS	10	F	1	n/a	3	14	**4**
< 25cm	10	M	2	n/a	3	15	**4**
	10	A	3	n/a	3	16	**4**
SS	4	F < 5%	1	F	1	6	**1**
25-50cm	4		1	M	2	7	**2**
	4		1	A	3	8	**2**
	4	M 5-40	2	F	1	7	**2**
	4		2	M	2	8	**2**
	4		2	A	3	9	**2**
	4	A >40%	3	F	1	8	**2**
	4		3	M	2	9	**2**
	4		3	A	3	10	**3**
MD	3	F <5%	1	F	1	5	**1**
50-100	3		1	M	2	6	**1**
	3		1	A	3	7	**2**
	3	M 5-40	2	F	1	6	**1**
	3		2	M	2	7	**2**
	3		2	A	3	8	**2**
	3	A >40%	3	F	1	7	**2**
	3		3	M	2	8	**2**
	3		3	A	3	9	**2**
DD	2	F <5%	1	F	1	4	**1**
100-150	2		1	M	2	5	**1**
	2		1	A	3	6	**1**
	2	M 5-40	2	F	1	5	**1**
	2		2	M	2	6	**1**
	2		2	A	3	7	**2**
	2	A >40	3	F	1	6	**1**
	2		3	M	2	7	**2**
	2		3	A	3	8	**2**
VD	1	F <5	1	F	1	3	**1**
> 150	1		1	M	2	4	**1**
	1		1	A	3	5	**1**
	1	M 5-40	2	F	1	4	**1**
	1		2	M	2	5	**1**
	1		2	A	3	6	**1**
	1	A >40%	3	F	1	5	**1**
	1		3	M	2	6	**1**
	1		3	A	3	7	**2**
Assumptions: - Sorghum (and other cereals) not so sensitive to adverse rooting conditions (unlike tubers, groundnuts, etc.).						3-6	1
						7-9	2
						10-13	3
						14-16	4

Decision tree rainfed 13: (r) Rooting conditions **(Rc)**

Land characteristics						**Severity level (1-4)**	
Soil depth		**Coarse fragments topsoil**		**Coarse fragments subsoil**			
	score		score		score	total score	level
VS	5	F	1	n/a	3	9	**4**
< 25cm	5	M	2	n/a	3	10	**4**
	5	A	3	n/a	3	11	**4**
SS	2	F < 5%	1	F	1	4	**1**
25-50cm	2		1	M	2	5	**1**
	2		1	A	3	6	**1**
	2	M 5-40	2	F	1	5	**1**
	2		2	M	2	6	**1**
	2		2	A	3	7	**2**
	2	A >40%	3	F	1	6	**1**
	2		3	M	2	7	**2**
	2		3	A	3	8	**3**
MD	1	F <5%	1	F	1	3	**1**
50-100	1		1	M	1	3	**1**
	1		1	A	1	3	**1**
	1	M 5-40	2	F	1	4	**1**
	1		2	M	1	4	**1**
	1		2	A	1	4	**1**
	1	A >40%	3	F	1	5	**1**
	1		3	M	1	5	**1**
	1		3	A	1	5	**1**
DD	1	F <5%	1	F	1	3	**1**
100-150	1		1	M	1	3	**1**
	1		1	A	1	3	**1**
	1	M 5-40	2	F	1	4	**1**
	1		2	M	1	4	**1**
	1		2	A	1	4	**1**
	1	A >40	3	F	1	5	**1**
	1		3	M	1	5	**1**
	1		3	A	1	5	**1**
VD	1	F <5	1	F	1	3	**1**
> 150	1		1	M	1	3	**1**
	1		1	A	1	3	**1**
	1	M 5-40	2	F	1	4	**1**
	1		2	M	1	4	**1**
	1		2	A	1	4	**1**
	1	A >40%	3	F	1	5	**1**
	1		3	M	1	5	**1**
	1		3	A	1	5	**1**
Assumptions: - Cowpea not so sensitive to adverse rooting conditions (unlike tubers, groundnuts, etc.) and deep rooting cereals.						3-6	1
						7	2
						8	3
						9-11	4

Decision tree rainfed 14: (u) Excess of salts (sodicity) **(Rs1, Rs2, Rc, Rm1)**

Land Characteristic	Severity level (1-4)
Sodicity (topsoil) (ESP)	
NS < 6%	1
MS 6-15%	1
SO 15-25%	2
VS 25-40%	3
ES > 40%	4

Decision tree rainfed 15: (w) Oxygen availability (drainage) **(Rs1, Rs2, Rc, Rm1)**

Land Characteristic Drainage class	Severity level (1-3)
6,5,4,3	1
2	2
1, 0	3

Decision tree rainfed 16: (z) Excess of salts (salinity) **(Rs1, Rs2)**

Land Characteristic	Severity level (1-4)
Salinity (topsoil) (EC) dS/m	
NS < 2	1
SS 2-3	1
MS 3-5	1
SA 5-8	1
VS 8-12	2
ES > 12	3

Decision tree rainfed 17: (z) Excess of salts (salinity) **(Rc, Rm1)**

Land Characteristic	Severity level (1-4)
Salinity (topsoil) (EC) dS/m	
NS < 2	1
SS 2-3	1
MS 3-5	2
SA 5-8	3
VS 8-12	4
ES > 12	4

Annex 7: SOMALES Severity level decision trees for Pastoralism

Land Use Types (LUT):

- **Pc: Extensive grazing of cattle**
- **Pd: Extensive grazing of camels**
- **Pg: Extensive grazing of goats**
- **Ps: Extensive grazing of sheep**

Decision tree pastoralism 1: (a) Accessibility (for animals) **(Pc, Pd, Pg, Ps)**

Land characteristics		**Severity level (1-4)**			
		Land Use Type			
Slope class	**Coarse fragments (topsoil)**	**Pg** Goats	**Ps** Sheep	**Pd** Camels	**Pc** Cattle
0-4%	F	**1**	**1**	**1**	**1**
	M	**1**	**1**	**1**	**1**
	D	**1**	**2**	**2**	**2**
4-10%	F	**1**	**1**	**1**	**1**
	M	**1**	**1**	**2**	**2**
	D	**1**	**2**	**2**	**3**
10-25%	F	**1**	**1**	**2**	**2**
	M	**1**	**1**	**2**	**3**
	D	**2**	**2**	**3**	**3**
> 25%	F	**1**	**3**	**4**	**4**
	M	**2**	**3**	**4**	**4**
	D	**2**	**4**	**4**	**4**

Decision tree pastoralism 2: (c) Temperature regime **(Pc, Pd, Pg, Ps)**

Land Characteristic		**Severity level (1-3)**		
Mean Annual Temperature	**Altitude**	**Pd**	**Pg, Ps**	**Pc**
30-28 °C	0-300 masl	**2**	**2**	**3**
28-26 °C	300-600	**1**	**2**	**2**
26-24 °C	600-900	**1**	**1**	**2**
24-22 °C	900-1250	**1**	**1**	**1**
22-20 °C	1250-1550	**1**	**1**	**1**
20-18 °C	1550-1875	**1**	**1**	**1**
Close relationship between Ta and Altitude (see IGAD study).				

Decision tree pastoralism 3: (e) Erosion hazard **(Pc, Pd, Pg, Ps)**

Land Characteristic	**Severity level (1-3)**
Slope class (%)	
0-4	**1**
4-25	**2**
> 25	**3**

Decision tree pastoralism 4: (m) Moisture availability (for herbaceous plant growth) **(Pc, Pd, Pg, Ps)**

Land characteristics						**Severity level (1-4)**	
LGP Zone		**Rainfall variability**		**Soil Group**			
	score		score		score	total score	level
1	10	H	5	3	4	19	**4**
	10	H	5	1,4	2	17	**4**
	10	H	5	2,5	1	16	**4**
	10	H	5	6	0	15	**3**
2	8	H	4	3, 6	4	16	**4**
	8	H	4	1,4	2	13	**3**
	8	H	4	2,5	1	12	**3**
3	6	L	1	3,6	4	11	**3**
	6	L	1	1,4	2	9	**3**
	6	L	1	2,5	1	8	**2**
4	6	M	2	3, 6	4	12	**3**
	6	M	2	1,4	2	10	**3**
	6	M	2	2,5	1	9	**3**
5	6	M	2	3, 6	4	12	**3**
	6	M	2	1,4	2	10	**3**
	6	M	2	2,5	1	9	**3**
6, 7	4	M	2	3, 6	4	10	**3**
	4	M	2	1,4	2	8	**2**
	4	M	2	2,5	1	7	**2**
8, 9, 10	3	M	2	3, 6	4	9	**3**
	3	M	2	1,4	2	7	**2**
	3	M	2	2,5	1	6	**2**
11	3	L	1	3, 6	4	8	**2**
	3	L	1	1,4	2	6	**2**
	3	L	1	2, 5	1	5	**2**
12	2	L	1	3, 6	4	7	**2**
	2	L	1	1,4	2	5	**2**
	2	L	1	2,5	1	4	**1**
13	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4	2	4	**1**
	1	L	1	2,5	1	3	**1**
14	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4	2	4	**1**
	1	L	1	2,5	1	3	**1**
15	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4	2	4	**1**
	1	L	1	2,5	1	3	**1**
Assumptions: - Shallow and sandy soils have low waterholding capacity (SG 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position); locally some sweet groundwater in deep sandy soils of coastal zone (supporting succulents and few trees).						3-4 5-8 9-15 16-19	1 2 3 4

Decision tree pastoralism 5: (n) Nutrient availability (for herbaceous plant growth) **(Pc, Pd, Pg, Ps)**

Land characteristics				**Severity level (1-3)**	
Organic Carbon (topsoil)		**CEC (topsoil)**			
	score		score	total score	level
VL	4	L <16	3	7	**3**
	4	M 16-24	2	6	**2**
	4	H >24	1	5	**2**
LO	3	L <16	3	6	**2**
	3	M 16-24	2	5	**2**
	3	H >24	1	4	**1**
ME	2	L <16	3	5	**2**
	2	M 16-24	2	4	**1**
	2	H >24	1	3	**1**
Assumptions: - nutrient availability increases with increasing organic carbon content. - nutrient availability increases with increasing cation exchange capacity (CEC).					
				3-4	1
				5-6	2
				7	3

Decision tree pastoralism 6: (r) Rooting conditions (for herbaceous and tree growth) **(Pc, Pd, Pg, Ps)**

Land characteristics						**Severity level (1-3)**	
Soil depth		**Coarse fragments (topsoil)**		**Coarse fragments (subsoil)**			
	score		score		score	total score	level
VS	10	F	1	n/a	3	14	**3**
< 25cm	10	M	2	n/a	3	15	**3**
	10	D	3	n/a	3	16	**3**
SS	4	F < 5%	1	F	1	6	**1**
25-50cm	4		1	M	2	7	**2**
	4		1	D	3	8	**2**
	4	M 5-40	2	F	1	7	**2**
	4		2	M	2	8	**2**
	4		2	D	3	9	**2**
	4	D >40%	3	F	1	8	**2**
	4		3	M	2	9	**2**
	4		3	D	3	10	**3**
MD	3	F <5%	1	F	1	5	**1**
50-100	3		1	M	2	6	**1**
	3		1	D	3	7	**2**
	3	M 5-40	2	F	1	6	**1**
	3		2	M	2	7	**2**
	3		2	D	3	8	**2**
	3	D >40%	3	F	1	7	**2**
	3		3	M	2	8	**2**
	3		3	D	3	9	**2**
DD	2	F <5%	1	F	1	4	**1**
100-150	2		1	M	2	5	**1**
	2		1	D	3	6	**1**
	2	M 5-40	2	F	1	5	**1**
	2		2	M	2	6	**1**
	2		2	D	3	7	**2**
	2	D >40	3	F	1	6	**1**
	2		3	M	2	7	**2**
	2		3	D	3	8	**2**
VD	1	F <5	1	F	1	3	**1**
> 150	1		1	M	2	4	**1**
	1		1	D	3	5	**1**
	1	M 5-40	2	F	1	4	**1**
	1		2	M	2	5	**1**
	1		2	D	3	6	**1**
	1	D >40%	3	F	1	5	**1**
	1		3	M	2	6	**1**
	1		3	D	3	7	**2**
						3-6	1
						7-9	2
						10-16	3

Decision tree pastoralism 7: (u) Excess of salts (sodicity) (for herbaceous and tree growth) **(Pc, Pd, Pg, Ps)**

Land Characteristic	**Severity level (1-4)**
Sodicity (topsoil) (ESP)	
1 (< 6%)	**1**
2 (6-15%)	**1**
3 (15-25%)	**2**
4 (15-40%)	**3**
5 (> 40%)	**4**

Decision tree pastoralism 8: (v) Vegetation / Land cover (fodder availability) **(Pd, Pg)**

Land characteristics					**Severity level (1-4)**	
Land Cover (simplified classes)		**Bioclimatic Zone (or LGP Zone)**				
	score	Bioclimatic Zone	LGP Zone	score	score add	level
12,13,14 (no cover)	10	*not applic.*			10+	**4**
1-5 (agric)	5	Coastal	1	5	10	**3**
	5	Sub-coastal	2	10	15	**4**
	5	*A. bussei*	3	3	8	**2**
	5	*A. etbaica*	11,12	2	7	**2**
6,7 (herb)	4	Coastal	1	5	9	**2**
	4	Sub-coastal	2	10	14	**4**
	4	*A. bussei*	3	3	7	**2**
	4	*A. etbaica*	11,12	2	6	**1**
9,10 (open wood)	2	Coastal	1	5	7	**2**
	2	Sub-coastal	2	10	12	**3**
	2	*A. bussei*	3	3	5	**1**
	2	*A. etbaica*	11,12	2	4	**1**
8,11 (closed wood)	2	Coastal	1	5	7	**2**
	2	Sub-coastal	2	10	12	**3**
	2	*A. bussei*	3	3	5	**1**
	2	*A. etbaica*	11,12	2	4	**1**

Notes:

- Carrying Cap: Coast 20-25 ha/LSU; Subcoast 50-100 ha/LSU; A.bussei Zone 5-20 ha/LSU; A.etbaica Zone 5-10 ha/LSU.
- Bioclimatic zones correspond more or less with SWALIM LGP zones (as indicated).
- Bioclimatic zones and carrying capacity from SOGREAH, Report 6.
- Seasonal movement of livestock between various zones assumed.
- In agricultural land some grazing available between fields and also crop residues and weeds.
- Some combinations of land cover and bioclimatic zone do not occur in reality.

4-6	1
7-9	2
10-12	3
> 12	4

Decision tree pastoralism 9: (v) Vegetation / Land cover (fodder availability) **(Pc, Ps)**

Land characteristics					**Severity level (1-4)**	
Land Cover (simplified classes)		**Bioclimatic Zone (or LGP Zone)**				
	score	Bioclimatic Zone	LGP Zone	score	score add	level
12,13,14 (no cover)	10	*not applic.*		10+		**4**
1-5 (agric)	5	Coastal	1	5	10	**3**
	5	Sub-coastal	2	10	15	**4**
	5	*A. bussei*	3	3	8	**2**
	5	*A. etbaica*	11,12	2	7	**2**
6,7 (herb)	2	Coastal	1	5	9	**2**
	2	Sub-coastal	2	10	14	**4**
	2	*A. bussei*	3	3	7	**2**
	2	*A. etbaica*	11,12	2	6	**1**
9,10 (open wood)	4	Coastal	1	5	9	**2**
	4	Sub-coastal	2	10	14	**4**
	4	*A. bussei*	3	3	7	**2**
	4	*A. etbaica*	11,12	2	6	**1**
8,11 (closed wood)	4	Coastal	1	5	9	**2**
	4	Sub-coastal	2	10	14	**4**
	4	*A. bussei*	3	3	7	**2**
	4	*A. etbaica*	11,12	2	6	**1**

Notes:

- Carrying Cap: Coast 20-25 ha/LSU; Subcoast 50-100 ha/LSU; A.bussei Zone 5-20 ha/LSU; A.etbaica Zone 5-10 ha/LSU.
- Bioclimatic zones correspond more or less with SWALIM LGP zones (as indicated).
- Bioclimatic zones and carrying capacity from SOGREAH, Report 6.
- Seasonal movement of livestock between various zones assumed.
- In agricultural land some grazing available between fields and also crop residues and weeds (cut & carry in orchards).
- Some combinations of land cover and bioclimatic zone do not occur in reality.

4-6	1
7-9	2
10-12	3
13-15	4

Decision tree pastoralism 10: (y) Water availability (for animals) **(Pd, Pc, Pg, Ps)**

Land Characteristic	**Severity level (1-4)**		
Number of waterpoints	**LUT**		
	Pd	**Pg, Ps**	**Pc**
None	**2**	**3**	**4**
Few	**1**	**2**	**3**
Common	**1**	**1**	**1**
Many	**1**	**1**	**1**

(not presently applied in SOMALES)

Decision tree pastoralism 11: (z) Excess of salts (salinity) (for herbaceous and tree growth) **(Pc, Pd, Pg, Ps)**

Land Characteristic	Severity level (1-4)
Salinity (topsoil) (EC) dS/m	
NS < 2	**1**
SS 2-3	**1**
MS 3-5	**1**
SA 5-8	**1**
VS 8-12	**2**
ES > 12	**3**

Annex 8: SOMALES: Severity level decision trees for Forestry

Land Use Types (LUTs):

- **Fai:** ***Azadirachta indica*** **(timber, fuel, pesticides, medicines)**
- **Fan:** ***Acacia nilotica*** **(fodder, timber, fuel, soil conservation)**
- **Fat:** ***Acacia tortilis*** **(fodder, fuel, soil conservation)**
- **Fba:** ***Balanites aegyptiaca*** **(fodder, fuel)**
- **Fce:** ***Casuarina equisetifolia*** **(timber, fuel, soil conservation)**
- **Fcl:** ***Conocarpus lancifolius*** **(fodder, timber, fuel, soil cons.)**
- **Fdg:** ***Dobera glabra*** **(fodder, fuel)**
- **Ffa:** ***Faidherbia albida*** **(fodder)**
- **Fti:** ***Tamarindus indica*** **(fodder, timber, fuel)**

Decision tree forestry 1: (c) Temperature conditions **(Fai, Fan, Fat, Fba, Fce, Fcl, Fdg, Ffa, Fti)**

Land characteristics		**Severity level (1-4)**		
		Land Use Type		
Altitude (masl)	**Ta (°C)**	**Fan, Fat, Fcl, Fti**	**Fai, Fce, Fdg**	**Fba, Ffa**
0-300	VH (28-30)	**1**	**2**	**2**
300-900	HO (24-28)	**1**	**1**	**1**
900-1550	VW (20-24)	**2**	**1**	**1**
1550-1875	WA (18-20)	**3**	**2**	**1**
Note: In literature requirements of certain species is sometimes expressed in terms of a preferred altitude range. SOMALES makes the assumption that "altitude" in this case is an indirect reference to mean temperatures.				

Decision tree forestry 2: (i) Inundation (flooding) hazard **(Fai, Fce)**

Land characteristics				**Severity level (1-3)**	
Relief (classes)		**Soil Group**			
	score		score	total score	level
1, 3, 4	1	1,3,6	1	2	**1**
	1	5	2	3	**1**
	1	4	3	4	**2**
	1	2	4	5	**2**
2b	2	1,3,6	1	3	**1**
	2	5	2	4	**2**
	2	4	3	5	**2**
	2	2	4	6	**2**
2a	3	1,3,6	1	4	**2**
	3	5	2	5	**2**
	3	4	3	6	**2**
	3	2	4	7	**3**
Assumptions:					
- Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b).				2-3	1
				4-6	2
- Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (SG4) are likely to have periodically high groundwater table.				7	3

Decision tree forestry 3: (i) Inundation (flooding) hazard **(Fat, Fba, Fcl, Fdg, Ffa, Fti)**

Land characteristics	**Severity level**

Relief (classes)		**Soil Group**		**(1-3)**	
	score		score	total score	level
1, 3, 4	1	1,3,6	1	2	**1**
	1	5	2	3	**1**
	1	4	3	4	**1**
	1	2	4	5	**1**
2b	2	1,3,6	1	3	**1**
	2	5	2	4	**1**
	2	4	3	5	**1**
	2	2	4	6	**2**
2a	3	1,3,6	1	4	**1**
	3	5	2	5	**1**
	3	4	3	6	**2**
	3	2	4	7	**2**
Assumptions:					
- Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b).				2-3	1
- Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (Soil Group 4) are likely to have periodically high groundwater table.				4-6	2

Decision tree forestry 4: (i) Inundation (flooding) hazard **(Fan)**

Land characteristics		**Severity level (1-3)**
Relief (classes)	**Soil Group**	
		level
1, 2a, 2b, 3, 4	1,2,3,4,5,6	**1**
Note: Acacia nilotica thrives well under periodic inundation		

Decision tree forestry 5: (m) Moisture availability **(Fai, Fan, Fat, Fba, Fcl, Fdg, Fti)**

Land characteristics				total score	**Severity level (1-4)**		
					Land Use Type		
LGP Zone		**Soil Group**			**Fat, Fcl**	**Fdg, Fan, Fba, Fti**	**Fai**
	score		score				
1	8	2	1	9	**3**	**4**	**4**
	8	6	2	10	**3**	**4**	**4**
	8	1,4,5	3	11	**4**	**4**	**4**
	8	3	6	14	**4**	**4**	**4**
2	7	2	1	8	**2**	**3**	**4**
	7	6	2	9	**3**	**4**	**4**
	7	1,4,5	3	10	**3**	**4**	**4**
	7	3	6	13	**4**	**4**	**4**
3	6	2	1	7	**2**	**3**	**3**
	6	6	2	8	**2**	**3**	**4**
	6	1,4,5	3	9	**3**	**4**	**4**
	6	3	6	12	**4**	**4**	**4**
4, 5	5	2	1	6	**1**	**2**	**3**
	5	6	2	7	**2**	**3**	**3**
	5	1,4,5	3	8	**2**	**3**	**4**
	5	3	6	11	**4**	**4**	**4**
6, 7	4	2	1	5	**1**	**2**	**2**
	4	6	2	6	**1**	**2**	**3**
	4	1,4,5	3	7	**2**	**3**	**3**
	4	3	6	10	**3**	**4**	**4**
8 - 12	3	2	1	4	**1**	**1**	**2**
	3	6	2	5	**1**	**2**	**2**
	3	1,4,5	3	6	**1**	**2**	**3**
	3	3	6	9	**3**	**4**	**4**
13, 14	2	2	1	3	**1**	**1**	**1**
	2	6	2	4	**1**	**1**	**2**
	2	1,4,5	3	5	**1**	**2**	**2**
	2	3	6	8	**2**	**3**	**4**
15	1	2	1	2	**1**	**1**	**1**
	1	6	2	3	**1**	**1**	**1**
	1	1,4,5	3	4	**1**	**1**	**2**
	1	3	6	7	**2**	**3**	**3**

A. tortilis and *Conocarpus lancifolius* considered very drought tolerant; *Dobera glabra, Acacia nilotica, Balanites aegyptiaca* and *Tamarindus indicus* considered drought tolerant. *Azadirachta indica* relatively high moisture requirements. All species growing on wide range of soils.

score	rating	score	rating	score	rating
2-6	1	2-4	1	2-3	1
7-8	2	5-6	2	4-5	2
9-10	3	7-8	3	6-7	3
11-14	4	9-14	4	8-14	4

Decision tree forestry 6: (m) Moisture availability **(Fce, Ffa)**

Land characteristics				total score	**Severity level (1-4)**
LGP Zone		**Soil Group**			**Fce, Ffa**
	score		score		
1	8	2	2	10	**4**
	8	6	1	9	**4**
	8	1,4,5	5	13	**4**
	8	3	6	14	**4**
2	7	2	2	9	**4**
	7	6	1	8	**3**
	7	1,4,5	5	12	**4**
	7	3	6	13	**4**
3	6	2	2	8	**3**
	6	6	1	7	**3**
	6	1,4,5	5	11	**4**
	6	3	6	12	**4**
4, 5	5	2	2	7	**3**
	5	6	1	6	**2**
	5	1,4,5	5	10	**4**
	5	3	6	11	**4**
6, 7	4	2	2	6	**2**
	4	6	1	5	**2**
	4	1,4,5	5	9	**4**
	4	3	6	10	**4**
8 - 12	3	2	2	5	**2**
	3	6	1	4	**1**
	3	1,4,5	5	8	**3**
	3	3	6	9	**4**
13, 14	2	2	2	4	**1**
	2	6	1	3	**1**
	2	1,4,5	5	7	**3**
	2	3	6	8	**3**
15	1	2	2	3	**1**
	1	6	1	2	**1**
	1	1,4,5	5	6	**2**
	1	3	6	7	**3**

Casuarina equisetifolia and *Faidherbia albida* considered drought tolerant. Both species prefer coarse-textured soils.

score	rating
2-4	1
5-6	2
7-8	3
9-14	4

Decision tree forestry 7: (r) Rooting conditions **(Fai, Fan, Fat, Fba, Fce, Fcl, Fdg, Ffa, Fti)**

Land characteristics						total score	**Severity level (1-4)**	
							Land Use Type	
Soil depth		**Coarse fragments (topsoil)**		**Coarse fragments (subsoil)**			**Fan, Fba, Fce, Ffa**	**Fat, Fai, Fcl, Fdg, Fti**
	score		score		score			
VS	10	F	1	n/a	3	14	**4**	**4**
< 25cm	10	M	2	n/a	3	15	**4**	**4**
	10	A	3	n/a	3	16	**4**	**4**
SS	7	F < 5%	1	F	1	9	**3**	**2**
25-50cm	7		1	M	2	10	**3**	**2**
	7		1	D	3	11	**3**	**2**
	7	M 5-40	2	F	1	10	**3**	**2**
	7		2	M	2	11	**3**	**2**
	7		2	D	3	12	**3**	**3**
	7	A >40%	3	F	1	11	**3**	**2**
	7		3	M	2	12	**3**	**3**
	7		3	D	3	13	**3**	**3**
MD	5	F <5%	1	F	1	7	**2**	**1**
50-100	5		1	M	2	8	**2**	**2**
	5		1	D	3	9	**3**	**2**
	5	M 5-40	2	F	1	8	**2**	**2**
	5		2	M	2	9	**3**	**2**
	5		2	D	3	10	**3**	**2**
	5	A >40%	3	F	1	9	**3**	**2**
	5		3	M	2	10	**3**	**2**
	5		3	D	3	11	**3**	**2**
DD	3	F <5%	1	F	1	5	**1**	**1**
100-150	3		1	M	2	6	**2**	**1**
	3		1	D	3	7	**2**	**1**
	3	M 5-40	2	F	1	6	**2**	**1**
	3		2	M	2	7	**2**	**1**
	3		2	D	3	8	**2**	**2**
	3	A >40	3	F	1	7	**2**	**1**
	3		3	M	2	8	**2**	**2**
	3		3	D	3	9	**3**	**2**
VD	1	F <5	1	F	1	3	**1**	**1**
> 150	1		1	M	2	4	**1**	**1**
	1		1	D	3	5	**1**	**1**
	1	M 5-40	2	F	1	4	**1**	**1**
	1		2	M	2	5	**1**	**1**
	1		2	D	3	6	**2**	**1**
	1	A >40%	3	F	1	5	**1**	**1**
	1		3	M	2	6	**2**	**1**
	1		3	D	3	7	**2**	**1**

Fat, Fai, Fcl, Fdg, Fti do fairly well on stony soils				
	3-5	1	3-7	1
	6-8	2	8-11	2
	9-13	3	12-13	3
	14-16	4	14-16	4