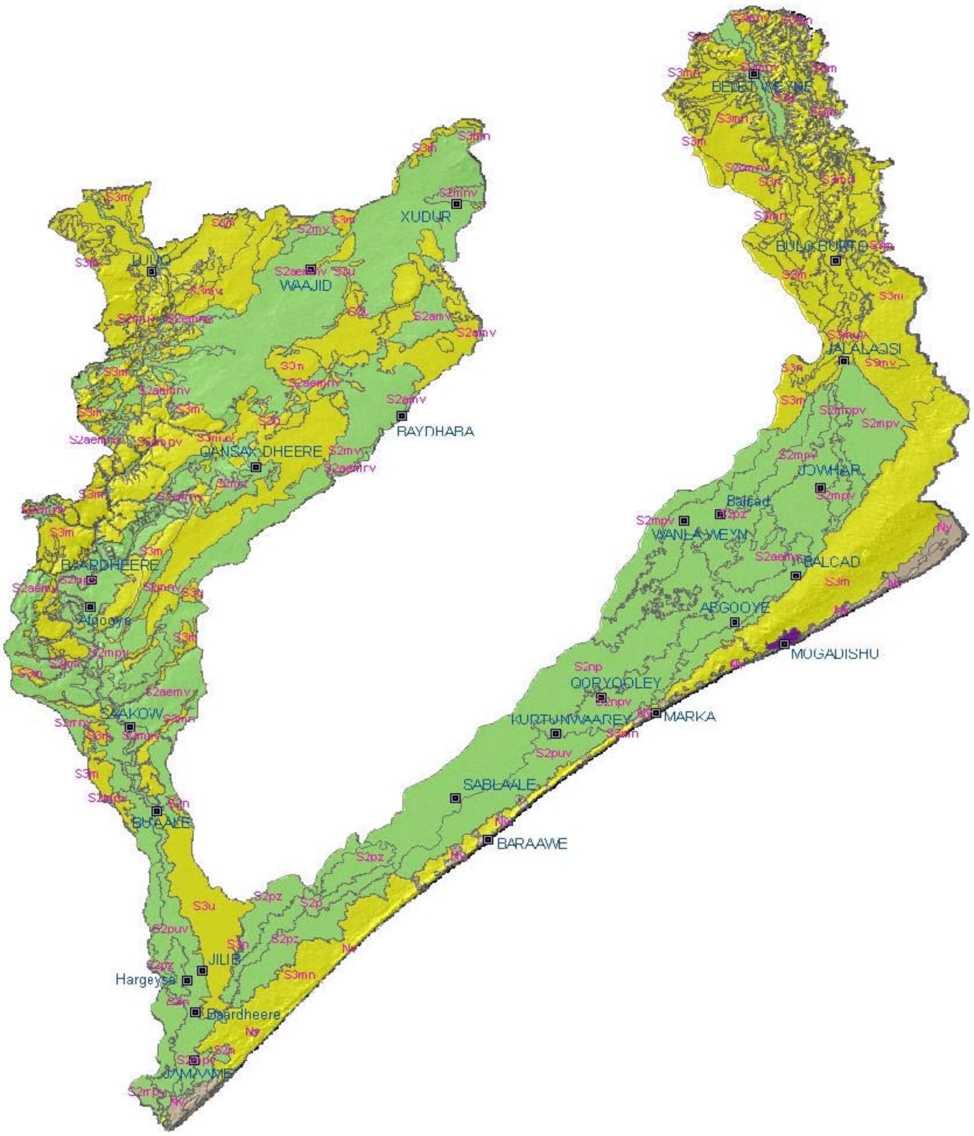
Land Suitability Assessment of the Juba and Shabelle Riverine Areas in Southern Somalia



Project Report No L-09
July 2007

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Funded by the European Union and implemented by the Food and Agriculture Organization of the United Nations

This document should be cited as follows:

Venema, J.H. and Vargas, R., 2007. Land suitability assessment of the Juba and Shabelle riverine areas in Southern Somalia. FAO-SWALIM. Project Report No. L-09. Nairobi, Kenya.

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List of acronyms

ALES	Automated Land Evaluation System
FAO	Food and Agriculture Organization
FSAU	Food Security Analysis Unit
GIS	Geographical Information System
GP	Growing Period
LC	Land Characteristic
LGP	Length of Growing Period
LQ	Land Quality
LUR	Land Use Requirement
LUT	Land Use Type
masl	meters above sea level
P	Precipitation
PET	Potential Evapotranspiration
RBU	Resource Base Unit
SOMALES	Somalia Automated Land Evaluation System
SWALIM	Somalia Water and Land Information Management
UNDP	United Nations Development Programme

ACKNOWLEDGMENTS

The authors wish to acknowledge the considerable support given by the Project Task Force.

Thanks should be addressed to Prof. Musse Shaie Alim for his contribution in the crop requirements and the validation of the results.

Finally we want to express our acknowledgment to all technical and administrative SWALIM staff, especially to Antony O. Ndubi for his valuable work in the edition of the maps.

1 INTRODUCTION

One of the objectives of the SWALIM project was to produce an assessment of physical land suitability and agricultural production potential for a study area in southern Somalia. Such a study was carried out early 2007 and this report gives the methodology and results. The study could be considered as the first of a two-stage procedure, whereby the present physical evaluation is followed by an economic evaluation (FAO, 2007).

The present study is based on land resource data collected by the SWALIM team in the period 2005 – 2007 as detailed in various SWALIM Land Reports and uses established and tested FAO methodology to assess land suitability for various types of 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. These results do not constitute a land use plan, but form one of the many inputs in 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 socio-economic and cultural considerations, 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 presents details of the Somalia Automated Land Evaluation System (SOMALES). This system is also applied for a SWALIM study area in western Somaliland and can be used for similar exercises in the future.

2 STUDY AREA

2.1 Location and delineation

The Study area lies between 41°53' and 46°09' east of the Prime Meridian; and between 0°16' south of the Equator and 5°04' north of the Equator. It extends for almost 88 000 square kilometers (8 793 596 hectares) covering the whole Juba River watershed, in its Somali tract, and the greater part of the Shabelle River watershed in Somalia (see Figure 1).

The area has an estimated rural population of approximately 2 million, which is more than 40% of the total rural population of Somalia. The major urban centres of the area are Mogadishu, Kismayo and Marka, all three situated near the coast. Details of the administrative Regions and Districts included in the study area and their estimated population are given in Table 3 of Section 2.6.

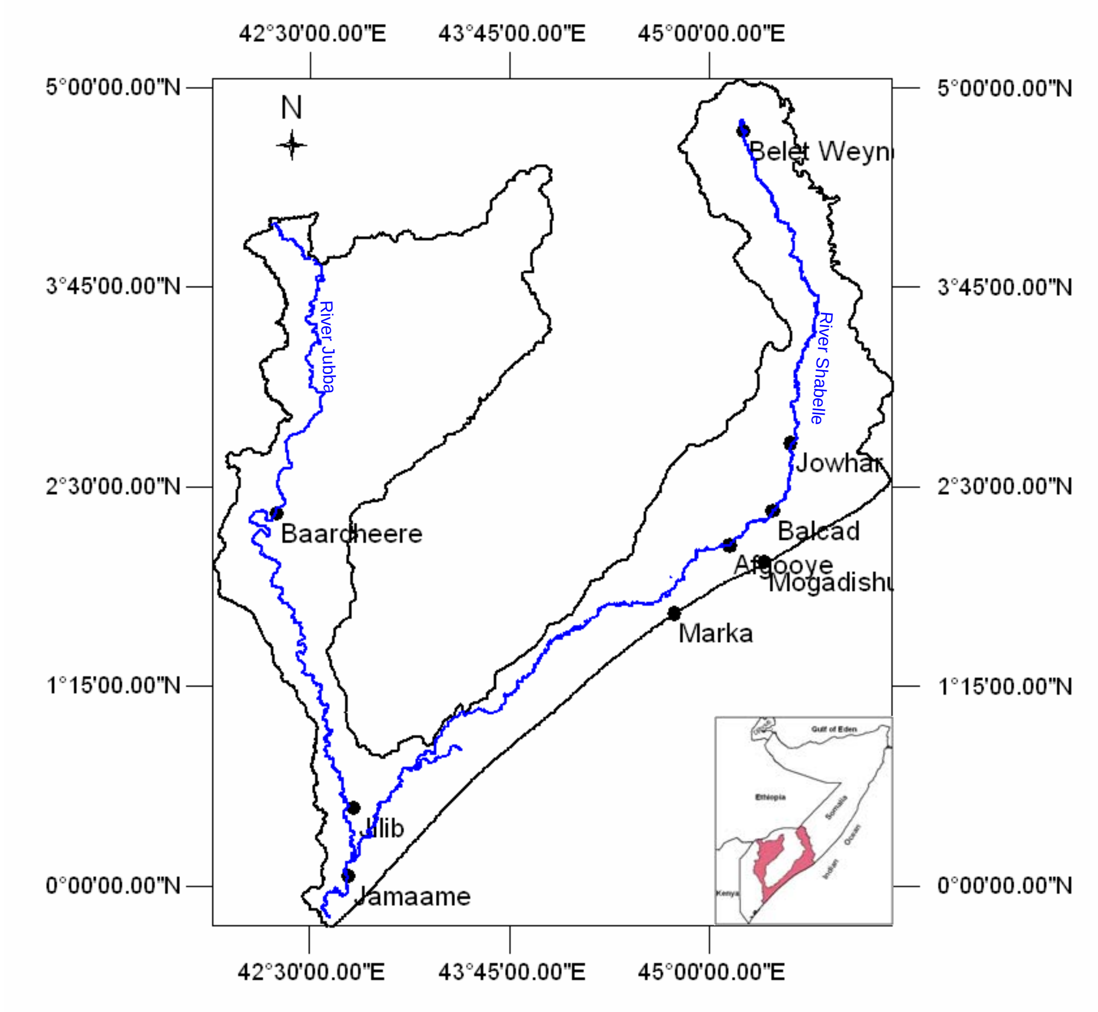


Figure 1: Study area

2.2 Climate

The climate of the river basin areas of southern Somalia is tropical arid to moist semi-arid and is influenced by the north-easterly and south-easterly air flows of the Intertropical Convergence Zone (ITCZ). North-easterly and south-easterly air masses meet in the Intertropical Front (ITF) and raise air upwards to produce rain. The annual movement of the ITCZ from north to south across Africa and back gives rise to four different seasons in Somalia, comprising two distinguishable rainy seasons alternating with two marked dry seasons, as follows:

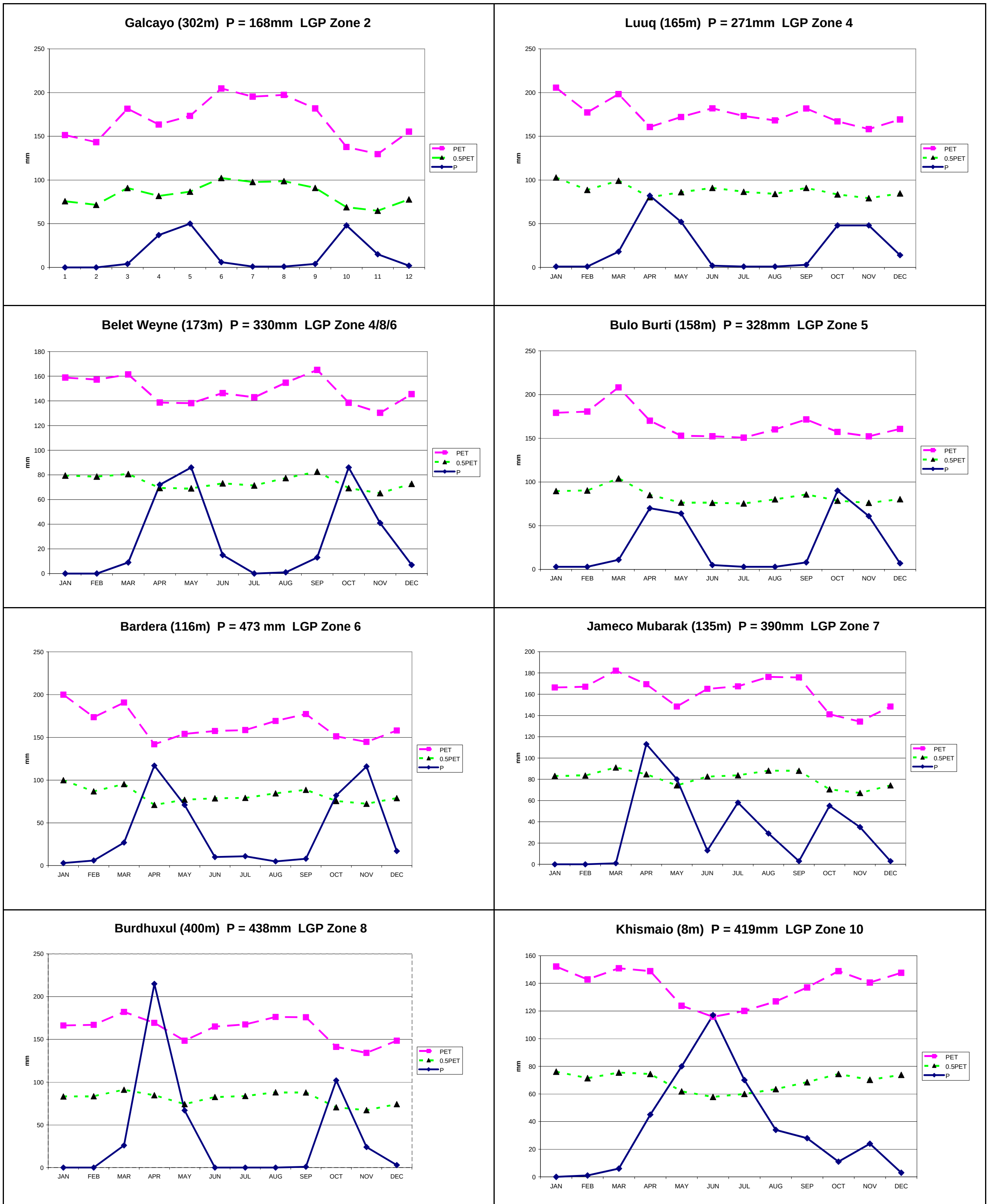
- *Gu*: April to June, the main rainy season for all over the country
- *Xagaa*: July to September, littoral showers, but dry and cool in the hinterland
- *Deyr*: October to December, second rainy season for all over the country
- *Jilaal*: January to March, longer dry season for all over the country

Rainfall in the study area is erratic, with a bimodal pattern except in the southern riverine areas close to the coast where some showers may occur even during the *Xagaa*. (see rainfall pattern for Kismaayo in Figure 2). Rainfall varies considerably over the study area, with the *Gu* delivering about 60% of total mean annual rainfall. Total mean annual rainfall ranges from 200 - 400 mm in areas bordering Ethiopia in Hiiraan, Gedo and Bakool regions (see Luuq and Belet Weyne in Figure 2) and 400 - 500 mm in the central Bay and northern part of Middle and Lower Shabelle Regions. A small area with rainfall of more than 600 mm occurs in the Middle Juba region, around Jilib. Rainfall is characterized by intense and short rainstorms. The study area has a high inter-annual rainfall variation and is subject to recurrent drought every 3-4 years, and more severe dry periods every 7-9 years.

Air temperatures are influenced by altitude and by the strength of seasonal winds, with the mean annual temperature ranging from 23 to 30°C. In the first dry season (*Xagaa*) days are often cool and cloudy all over the region, with light showers in areas close to the coast. The minimum temperature in Baardheere is 24°C in July. In the second dry season (*Jilaal*) days are hot, or very hot and dry. The hottest months are March and April, with a maximum temperature of 41°C in March (Baardheere).

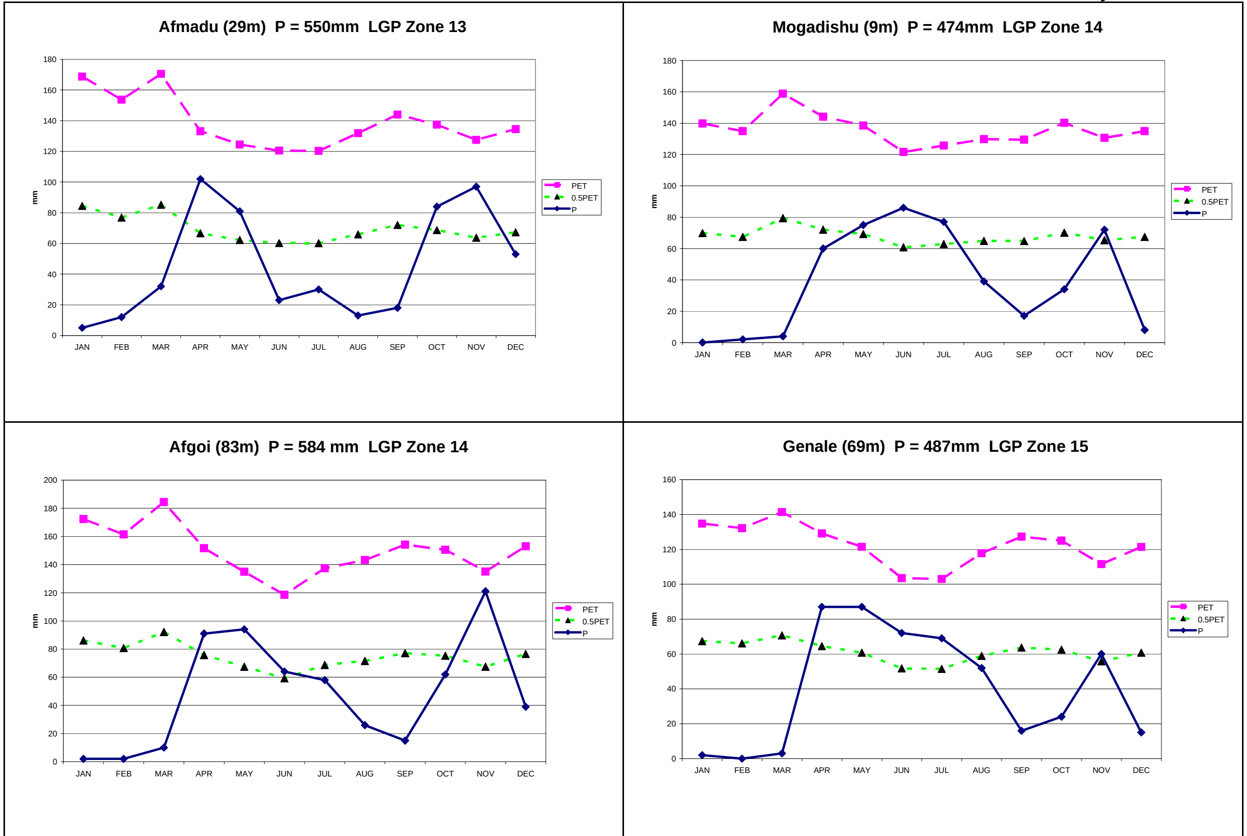
In areas near the major rivers the relative humidity is high, ranging from about 70-80%, but further inland away from the rivers the air is much drier. Relative humidity is the highest in the coastal areas, where it usually exceeds 87%. Normally, the high relative humidity is compounded by higher temperatures.

The major winds are in response to the north and south seasonal movement of the Intertropical Convergence Zone, and in particular the Intertropical front. In the study area the winds persistently blow from the northeast during *Jilaal* (December to February), and blow in dust from the Arabian Peninsula when the weather is hot or very hot. During *Xagaa*, (June to August), when the weather is cool and cloudy, winds come from the southwest. The weather is hot and calm between the monsoons (part or whole of April and part or whole of September).



Note: vertical scale varies from graph to graph

Figure 2: Mean monthly P and PET patterns in the study area (1963-1990)



Note: vertical scale varies from graph to graph

Figure 2: Mean monthly P and PET patterns in the study area (1963-1990) (cont.)

Evapotranspiration is consistently high throughout the study area and varies between 1500 – 2000 mm/yr. Throughout the study area, mean annual rainfall (P) is far below mean annual potential evapotranspiration (PET) and there is a significant moisture deficit for most of the year (see Figure 2). For the study area, eleven zones have been distinguished with a distinct "Length of Growing Period" (LGP)[1], as shown in Figure 3. Details of these zones are given in Section 3.1.2 (Tables 6 and 7) and also in FAO-SWALIM Technical Report No. L-13.

Three broad climatic zones may be recognized, characterized by differences in patterns of rainfall and the Length of Growing Period (see also Figure 3).

- The moist semi-arid coastal zone with significant amount of rain occurring from July -August (*Xagaa* rains) that lengthen the *Gu* season.(LGP Zones 10, 13, 14, 15).
- A dry semi-arid intermediate zone with two strongly defined rainy seasons and an additional light rainy season that may occur during July-August (LGP Zones 7, 8 and 9).
- The northern and north-western arid and dry semi-arid zone with a lower annual rainfall and a prolonged dry period between June and September (LGP Zones 2, 4, 5 and 6).

[1] The Length of Growing Period (LGP) is the time in days that precipitation (P) exceeds half Potential Evapotranspiration (PET). Fifteen LGP zones have been distinguished for Somalia. Details of these zones and the methodology used can be found in FAO-SWALIM Technical Report No. L-13.

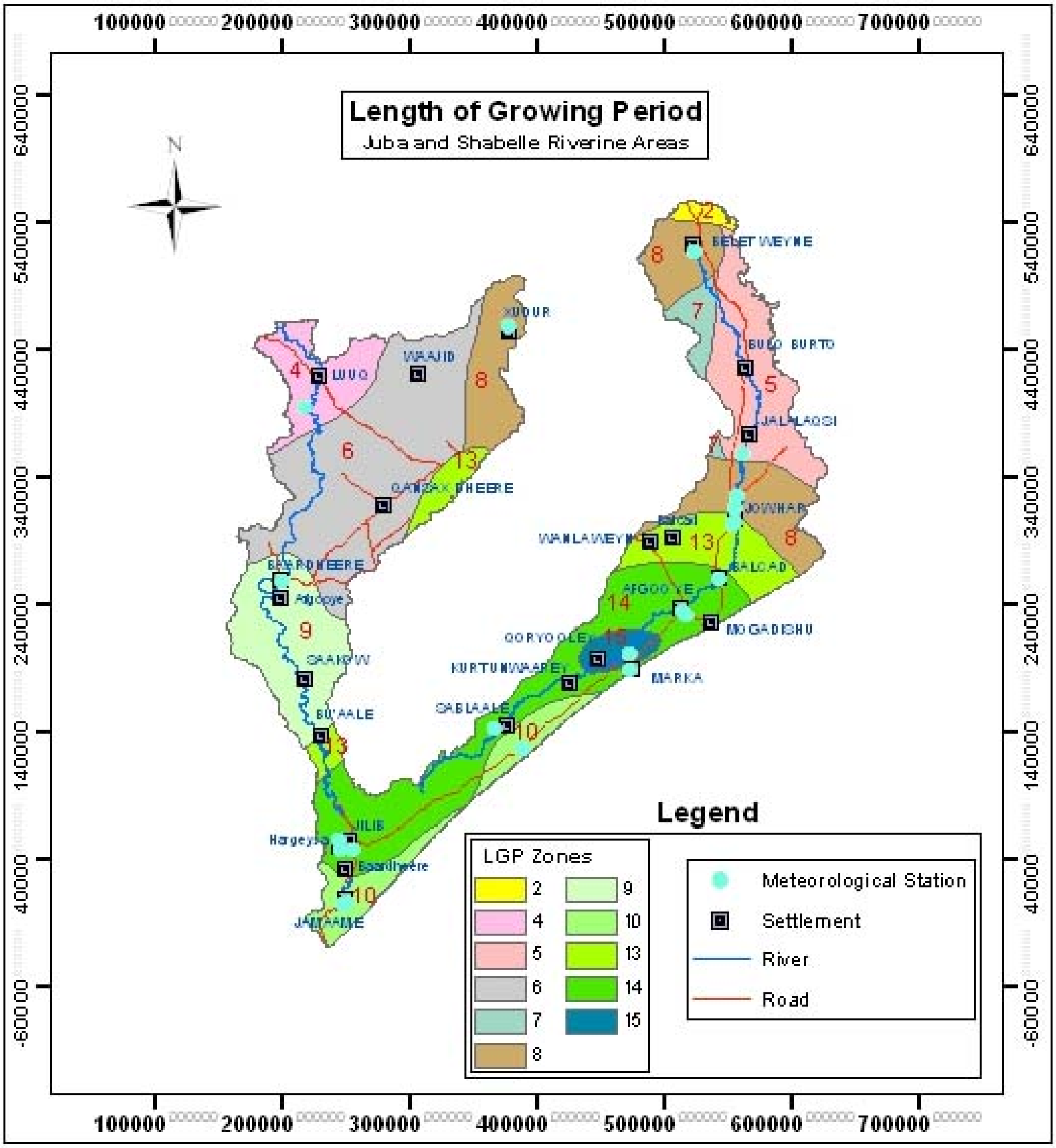


Figure 3: Length of Growing Period Zones

2.3 Geology / Lithology

The study area is characterized by the outcropping of the metamorphic basement complex, made up of migmatites and granites. Sedimentary rocks such as limestones, sandstones, gypsiferous limestones and sandstone are present, and a huge and wide coastal sand dune system. Basaltic flows are present in the northwest part of the study area. From a tectonic point of view, this study area is characterized by a fault system in the alluvial area parallel to the coast, and by a system of northwest-southeast oriented faults in the basement complex.

Some late Tertiary fluvio-lagunal deposits occur on the Lower Juba plain and part of the southern Shabelle, consisting of clay, sandy clay, sand, silt and gravel. Recent fluvial deposits are common alongside two major rivers, the Juba and the Shabelle, consisting of sand, gravel, clay and sandy clay. Other Recent alluvial deposits occur in small valleys in Gedo and Bakool Regions and in the Buur area, and consist of gravelly sand or red sandy loam materials. A wide coastal dune system occurs along the coast.

2.4 Landform and Soils

Details of landform and soils are given in FAO-SWALIM Technical Reports Nos L-02 and L-08 respectively. The study area is dominated by the presence of the two main perennial rivers of the Horn of Africa, which flow from the highlands of Ethiopia toward the Indian Ocean and passing through Somalia. They are the Juba River (2000 km long, of which 700 km are within Somalia,) and the Shabelle River (1 800 km long, of which 1560 km are within Somalia,). The Juba river is joined by the Shabelle river in a frequently flooded area a few kilometres away from the Indian Ocean near Kismaayo. Only at times of very high flood do the rivers discharge any water into the Indian Ocean.

Three major landscapes can be distinguished:

1. the wide and almost level valleys of the Juba and Shabelle Rivers
2. the hilly terrain in the middle and the north, particularly in the Juba catchment
3. the coastal dune complex, known as the Merka red dunes which follows the coast from beyond the Kenyan border, separating the narrow coastal belt from the Shabelle alluvial plain.

The soils in the alluvial plains are characterized by stratified fluvial deposits which, because of the semi-arid climate, have been little-affected by soil-forming processes. Despite their variability, most of these soils share the characteristics of heavy texture (clay) and low permeability, and with a tendency to poor drainage. They have been classified as Vertisols and Fluvisols mainly.

The hilly terrain and associated pediments, piedmonts and erosion surfaces predominantly have shallow and stony soils of medium texture (loamy), classified as Leptosols, Regosols and Calcisols. Pockets of deep Cambisols also occur.

The soils of the dune complex are sandy and classified as Arenosols.

2.5 Land cover

Land cover in the study area consists mainly of (degraded) natural vegetation. The natural vegetation consists of riparian forest, bush lands and grasslands. Woody and herbaceous species include *Acacia bussei*, *A. seyal*, *A. nilotica*, *A. tortilis*, *A. senegal*, *Chrysopogon auchieri* var. *quinqueplumis*, *Suaeda fruticosa* and *Salsola foetida*. Other cover types include Crop fields (both rainfed and irrigated), Urban and Associated Areas (Settlement/Towns and Airport), Dunes and Bare lands and Natural Water bodies. Details of land cover are given in FAO-SWALIM Technical Report No L-03.

2.6 Land Use

Map 1 shows the present land use in the study area. This map, and land use in general, are described in detail in FAO-SWALIM Technical report No. L-07. Main land use types are Transhumance Pastoralism, Rainfed Agriculture and Irrigated Agriculture. Semi Sedentary Pastoralism also occurs. Pastoralism is often combined with Wood Collection, either as firewood or for charcoal production

2.6.1 Rainfed Agriculture

Rainfed agriculture is characterized by the intercropping of sorghum, maize, cowpea, sesame, mung bean, and various vegetables. The area in between the Juba and Shabelle rivers is the main sorghum producing zone of Somalia, whereas maize is predominant in the lower Shabelle. Because of the bi-modal rainfall pattern in the area, two and locally three planting opportunities occur during the year, as demonstrated in the crop calendar of Table 1. Locally land improvements have been made for the purpose of water harvesting, including soil bunding, the construction of wells and water reservoirs, ponds and terraces. Input levels are generally low, and mainly consist of the hire of tractors for ploughing. In areas away from the floodplains and the tsetse fly, oxen are also used for land preparation. Some resource-poor farmers prepare the land manually. The crops are produced for food, market and fodder for animals. Usually, livestock is let into harvested fields to graze on crop residues. Crops that have failed to mature due to moisture stress are sold to pastoralists and used as fodder.

The performance of crops is generally poor. In areas with relatively high rainfall (500-600mm), average yields are 700-800 kg/ha for maize, 400-500 kg/ha for sorghum and cowpea, and 300-400 kg/ha for sesame (FSAU, Livelihood Baseline Profile for Lower and Middle Juba). Main limitations are lack of moisture, due to low and erratic rainfall, pests, floods, low soil fertility and poor farm management. There are no agricultural extension services in the area and most farmers have not received any training.

The performance of rainfed agriculture can be improved through the provision farmer education, the introduction of drought resistant crop varieties and improved seed, the use of organic and inorganic fertilizer, and the rehabilitation and construction of water reservoirs and shallow wells.

Table 1: Crop calendar for Rainfed Agriculture

CROP	JILAAL (dry season)			GU (long rains)			XAGAA (locally short rains in July / Aug)			DEYR (short rains)		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st Maize												
2nd Maize												
Sorghum												
1st Sesame												
2nd Sesame												
Cowpea												

Note:
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 short rains of X*agaa.* A third planting opportunity exists at the beginning of the short rains of *Deyr.*

2.6.2 Irrigated Agriculture

2.6.2.1 Controlled and flood irrigation

Irrigated Agriculture is practiced on the alluvial plains in the area, in a narrow strip close to the Juba and Shabelle rivers. Two main types of irrigation are practised: controlled irrigation and flood irrigation, and in both cases water is either diverted from the river, and flows by gravity, or is lifted by diesel pumps. Under controlled irrigation water is channelled through canals and furrows all the way to individual trees. Under flood irrigation, natural depressions or level fields enclosed by artificial embankments are submerged for certain periods, saturating the soil. Before the outbreak of civil war in Somalia, there were at least 34 irrigation schemes in the Juba and Shabelle valleys, covering more than 200 000 ha. Out of these, less than 50% were operational in 2007 (SWALIM, 2007). Large commercial schemes of irrigated sugarcane, rice, banana, citrus and other fruit crops used to operate in the

Shabelle between Jowhar and Sablaale, and in the Juba upstream and downstream of Jilib.

In small irrigated plots the main crops are maize, sesame, fruits and vegetable while the few large scale plantations mainly have fruit trees such as banana, guava, lemon, mango and papaya. Paddy rice is also grown under irrigation. Table 2 shows the crop calendar for the various irrigated crops in the study area.

Land improvements in irrigated agriculture consist of the construction of soil bunds, irrigation and drainage canals, river embankments, terraces, dams and wells. Farming practices and input levels are similar to those of rainfed cropping, although locally limited quantities of fertilizer and pesticides may be used. Some farmers own diesel pumps. Farm labour is mainly from own family members but occasionally hired labour is used, particularly for weeding

Although maize yields of up to 2000 kg/ha are locally achieved during a single crop cycle, irrigated cropping is often characterized by poor crop performance or even crop failure. Main limitations are flooding, scarcity of water, low soil fertility, pests, lack of tillage capacity, market inaccessibility, loss of irrigation infrastructure, and poor farming practices.

Irrigated agriculture can be improved through the rehabilitation of irrigation infrastructure, provision of credit, restoration of security, appropriate use of pesticides and organic and inorganic fertilizer, improved seed and planting material, improved markets for farm produce, farmer education and secure land tenure.

2.6.2.2 Flood recession cultivation

Flood Recession Cultivation is practiced in natural depressions (*desheks*) in the flood plain of the Juba River. They are seasonally and naturally flooded by water from rivers, and may in addition have shallow groundwater or receive runoff from adjacent areas. After the floods recede, the soils in the *desheks* retain enough moisture to support one crop. Main crops grown in *desheks* are sesame, maize, beans, peas, water melon, vegetables and occasionally groundnuts.

2.6.3 Transhumance Pastoralism

Transhumance Pastoralism is the most common type of grazing system in the area, whereby the animals are moved in a well designed pattern that is associated with the availability of water and forage. One of the main pastures of Somalia is located in the north-western part of the study area (upper Juba). Little land improvement is associated with this type of land use, except for the construction of boreholes and wells. The animals kept are sheep, goats, cattle, camels and donkeys. Produce include milk, meat, skin and ghee, both for domestic and commercial use.

Constraints associated with livestock production include animal diseases, water shortage or high cost of water, poor quality pasture in the dry periods, low market prices for produce, and poor management

Performance of pastoralism can be improved by the provision of veterinary services, improved security, construction and/or rehabilitation of water points, improved markets for livestock and livestock products, and farmer education.

Transhumance pastoralism is often practiced in combination with cropping and wood collection for charcoal burning.

Table 2: Crop calendar for Irrigated Agriculture

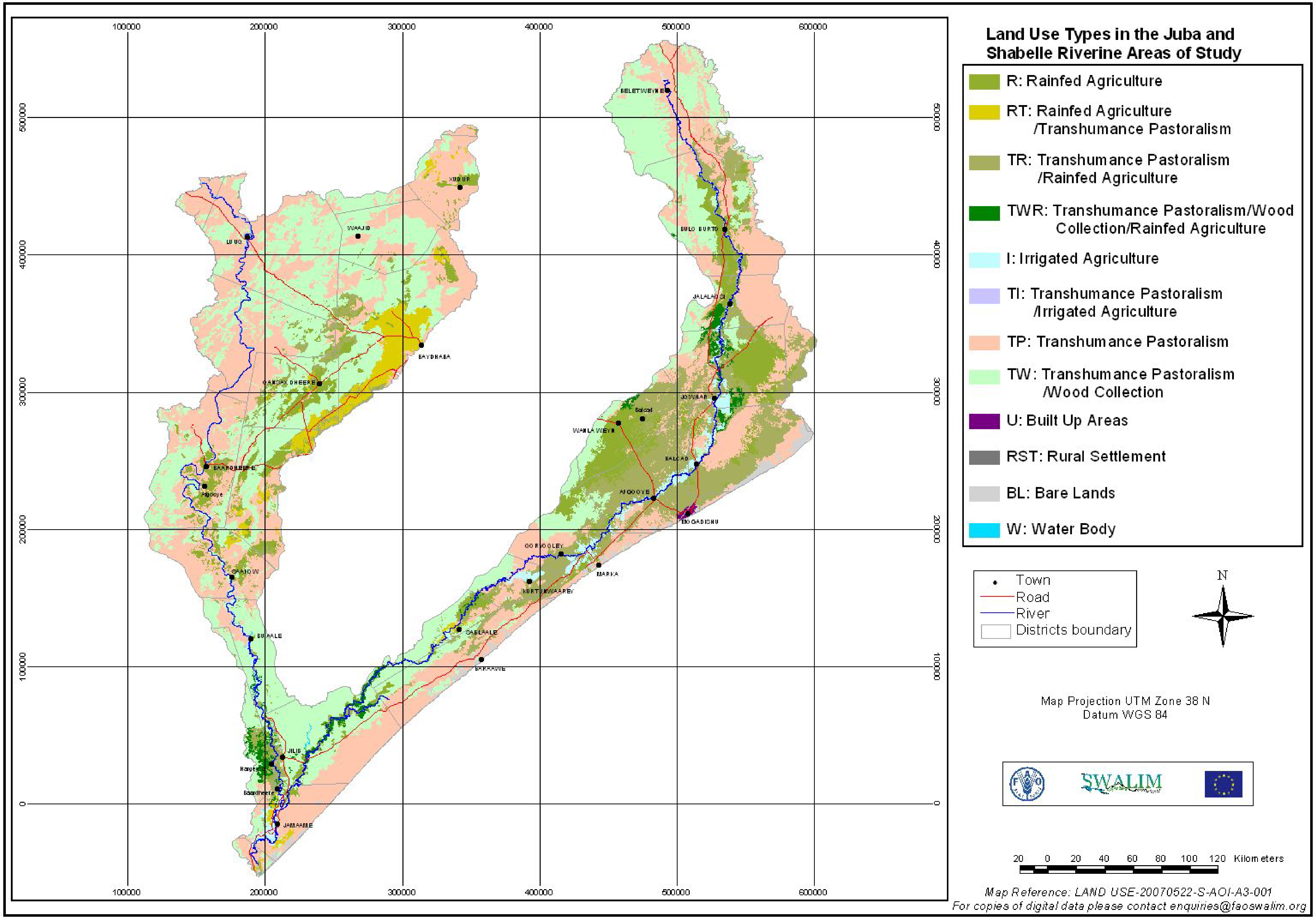
CROP	JILAAL (dry season)			GU (long rains)			HAGAA (locally short rains in July / Aug)			DEYR (short rains)		
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Fruit Trees												
Tomato												
Maize												
Sesame												
Groundnuts												
Rice												
Cowpea												
Vegetables												

Note:
Irrigated crops may be grown all year round so long as water is available. Irrigation allows crop production in the *Jilaal* dry period. In some years, flooding and waterlogging limits cropping in the *Gu* season.

2.6.4 Wood Collection for Charcoal Burning

Charcoal burning is common in the area and occurs wherever there are trees, especially *Acacia bussei*, *Acacia nilotica* and *Acacia seyal*. Other tree species cut for charcoal burning include *Acacia tortilis*, *Terminalia prunoides and Prosopis juniflora.* Charcoal production is associated with increased soil erosion, reduced grazing land and reduced biodiversity. The practice is illegal and is done against the wishes of the pastoralist communities and the government. The trees are cut live and the charcoal burning kiln is mostly the mound type, with rare cases of the pit and trench types. The high demand for charcoal comes from major towns such Mogadisho, Baidoa, Barbera, Kisimayo, and Belet Weyne. Some of the charcoal is then exported to nearby countries.

Map 1: Land Use of the Juba and Shabelle Riverine areas



2.7 Population

The zones, regions and districts wholly or partially included in the study area, together with population estimates for 2005 (draft data, UNDP Somalia, 2007) are listed in Table 3. The total rural population is estimated at nearly 2 million, which is more than 40% of the total rural population of Somalia.

The most important towns found in or near the area, and their estimated population are: Baardheere (25544), Jilib (29951), Jamaame (22415) and Kismaayo (89333), in the Juba valley, and Belet Weyne (30869), Jowhar (36844), Balcad (28106), Mogadishu (pop. unknown), Afgooye (21602), Marka (63900), in the Shabelle valley.

Table 3: Regions, districts, and their populations (Somalia UNDP 2007, draft)

Zone	Region	District	Estimated population 2005 (mid-year)		
			Total	**Urban**	***Non-urban***
Central	Hiraan	Belet Weyne	144345	30869	113476
		Buko Burto	89120	17824	71296
		Jalalaqsi	46724	10279	36445
	Shabelle Dhexe	Jowhar	218027	36844	181183
		Balcad	120434	28106	92328
South	Shabelle Hoose	Marka	192939	63900	129039
		Afgooye	135012	21602	113410
		Baraawa	57652	15413	42239
		Kurtunwaarey	55445	7426	48019
		Qoryooley	134205	22841	111364
		Sablaale	43055	8011	35044
		Wanla Weyn	155643	22016	133627
	Bay	Baydhaba	227761	59107	168654
		Dinsoor	75769	12154	63615
		Qansax Dheere	98714	16743	81971
	Bakool	Xudur	93049	19110	73939
		(Ceel Barde)	(29179)	(5335)	(23844)
		Waajid	69694	14439	55255
	Gedo	Garbahaarey	38017	11650	26367
		Baardheere	106172	25544	80628
		(Doolow)	(26495)	(5674)	(20821)
		Luuq	62703	14676	48027
	Juba Dhexe	Bu’aale	59489	13588	45901
		Jilib	113415	29951	83464
		Saakow	65973	11200	54773
	Juba Hoose	(Kismaayo)	(166667)	(89333)	(77334)
		(Afmadow)	(51334)	(7122)	(44212)
		Jamaame	129149	22415	106734
		Total	**2532506**	**535708**	**1996798**
Total (including districts only partially inside study area)			(2806181)	(643172)	(2163009)

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) and land cover.

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-08. For the purpose of land evaluation the numerous soil groups identified have been grouped into a limited number of classes (see Table 4 below).

In addition to Soil Groups, individual soil characteristics are also used in land evaluation. Relevant soil characteristics and their classification are given in Table 5.

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 11 zones (i.e. zones 2, 4 – 10 and 13 - -15) are relevant for the study area (see also Figure 3). Detailed information can be found in FAO-SWALIM Technical Report No. L-13. 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 6) takes into account the longest LGP only, which is most significant for rainfed production of annual crops. The second calculation (Table 7) 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.

3.1.3 Temperature classes

Six temperature classes have been defined (Table 8). There is a close relationship between Altitude and Mean Annual Temperature (van Velthuizen and Verelst, 1995). For the study area, the mean temperature for the growing season (April-November) is not much different from the mean annual temperature.

Table 4: Simplified soil classes for land evaluation

Class	Soil Group (WRB, 2006)		Main limitations for plant growth
	Group	**Prefix**	
1	Calcisols	Haplic Vertic	low moisture availability; low nutrient availability
2	Cambisols	Fluvic	flooding; water erosion
	Fluvisols	Haplic Calcic Stagnic Salic	
3	Leptosols	Nudilithic Lithic Hyperskeletic	stoniness; limited rooting depth; low moisture availability
	Regosols	Haplic (Skeletic) Epileptic	
	Calcisols	Epileptic	
4	Solonchak	Haplic Vertic Stagnic	high excess salts; low nutrient availability; poor drainage
5a	Vertisols	Haplic Grumic Calcic Mazic	low nutrient availability; poor workability; imperfect drainage
	Cambisols	Vertic	
5b	Vertisols	Salic	moderate excess salts; low nutrient availability; poor workability
5c	Vertisols	Stagnic	poor drainage
	Stagnosols	Calcic	
6	Arenosols	Haplic, etc	low moisture availability; low nutrient retention capacity; wind erosion
7	Cambisols	Haplic	

Table 5: 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 6: Length of longest LGP and rainfall variability during that Growing Period

Length of longest Growing Period**		Description of LGP Zone	Variability of rainfall in main Growing Period	
days	**Zone**		**%**	**class**
0	1	No LGP; mean annual rainfall < 100 mm ***	200-400	Very High
< 30	2	Insignificant LGP; mean annual rainfall 100-250 mm ***	100-300	Very High
	3	Insignificant LGP; mean annual rainfall 250-500 mm ***	70-100	High
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)	50-100	High
	12	double, with short dry interval, total LGP 90-119 days		
	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

** the length (in days) of the longest growing period, in case of a bi-modal pattern with a long dry interval of 3 months or more, or the length of the total growing period in case of a uni-modal or weak 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 throughout the year)

Table 7: Total LGP and annual rainfall variability of the 15 LGP Zones of Somalia

LGP total		Description of LGP	Variability annual rainfall	
(days) **	**Zone**		**%**	**class**
0	1	No LGP; mean annual rainfall < 100 mm ***	80-160	High
< 30	2	Insignificant LGP; mean annual rainfall 100-250 mm ***	50-70	High
	3	Insignificant LGP; mean annual rainfall 250-500 mm ***	30-40	Low-Medium
30-59	4	single, Gu 30-59	40-50	Medium
	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)	30-50	Medium
	10	single, Gu 90-119 days		
	11	single, Gu + Deyr (merging, total 90-119 days)	20	Low
	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	20-40	Low
	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 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

FAO-SWALIM Technical Report no L-08 gives detailed information on landform. Most relevant for the present land evaluation exercise are the relief types, and in particular their drainage characteristics, 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 6 classes (Table 9).

Table 9: Simplified relief classes for land evaluation

1	**2**	**3**	**4**
Water shedding	**Water receiving**	**Neutral**	**Active erosion**
S08 Escarpment S24 Inselberg S25 Cuesta S26 Mesa S29 Hill S30 Hill complex S31 Ridge G08 Talus slope	**2a Closed** C02 Coastal Plain E05 Playa E06 Pan F11 Paleoriver F13 Depression F16 Delta L02 Lake basin S15 Depression (structural) **2b Drained** F03 Anastomizing river plain F04 Braided river plain F05 Meandering river plain F12 Alluvial plain F18 River plain F19 Floodplain F23 Old meandering river plain F25 River incision F01 Alluvial fan	C05 Stabilized dune F14 Pediment F15 Dissected pediment F20 Terraced surface F21 Upper pediment F22 Lower pediment S32 Planation surface S33 Denudational slope S34 Slope S36 Plain	**4a Water erosion** F09 Gully/rill erosion surface F10 Sheet erosion surface S35 Denudational surface **4b Wind erosion** C03 Sandy coast C04 Foredune C06 Mobile dune

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
1a	0-1	Level
1b	1-2	Almost level
1c	2-4	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. FAO-SWALIM Technical Report no L-03 gives the main 19 aggregations of landcover types. For the purpose of land evaluation these have been further aggregated into 10 classes (Table 11).

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

Class	Land Cover
1-5	Predominantly agricultural land
6	Herbaceous
7	Savanna (Sparse shrubs and other spaced Woody Vegetation)
8	Closed Shrubs (crown cover > 65%) - Thicket
9	General Open Shrubs (crown cover 65-15%)
10	General Open Trees; Open Woody (crown cover 65-40%)
11	Closed Trees (> 65%)
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). A revision of the Framework is underway (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 allows 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[2]) 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

[2] Sometimes called "land units" or "land mapping units"

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[3].
- 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.

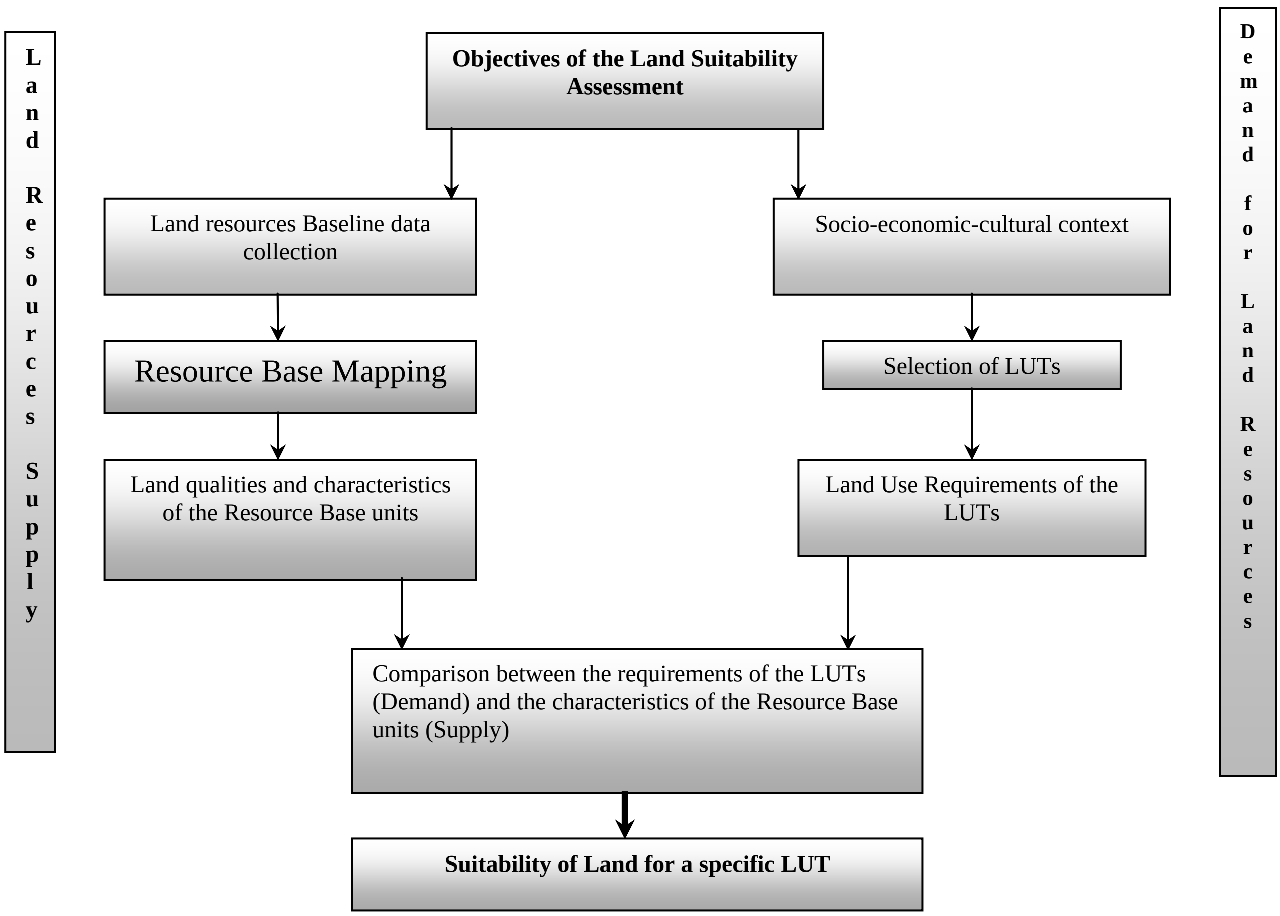


Figure 4: Methodological framework

[3] The revised framework for land evaluation (FAO, 2007) suggests a two-stage procedure, in which a physical evaluation is carried out first (as in the present study), followed by a stage of economic evaluation.

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 units 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. The RBUs are generated by combining different baseline data layers, including Length of Growing Period (LGP), relief type, slope, soil group and land cover type.

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

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: description of the kind of land use, and 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 given in Table 13 and described below.

Map 2: Resource Base Units

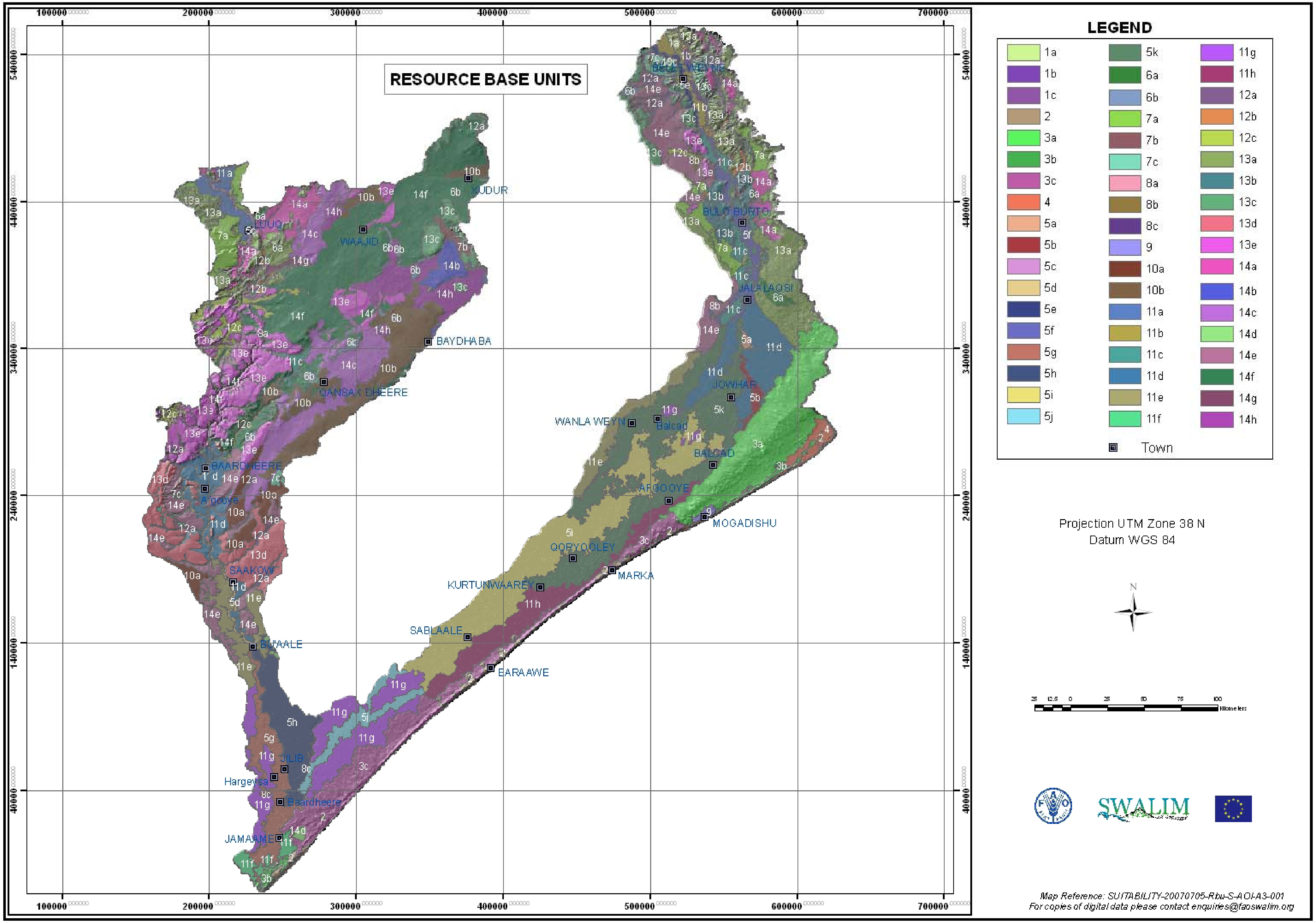


Table 12: Diagnostic Land Qualities for various major types of land use

Land Qualities (LQ)		Major Types of Land Use			
		Rainfed Agriculture	**Irrigated Agriculture**	**Extensive Grazing or Pastoralism**	**Forestry**
a	accessibility (for animals)			√	
c	temperature regime			√	√
d	erosion hazard (wind)	√		√	
e	erosion hazard (water)	√		√	
f	flood hazard (flashfloods)	√	√		
i	inundation hazard (flooding)	√	√		√
m	moisture availability	√		√	√
n	nutrient availability	√	√	√	
p	pests and diseases (tsetse)			√	
q	water availability for irrigation (surface water for gravity irr.)		√		
r	rooting conditions (soil depth)	√	√	√	√
t	topographic conditions for irrigation		√		
u	excess of salts (sodicity)	√	√	√	
v	vegetation (genetic potential)			√	
w	oxygen availability (internal and external drainage)	√	√		
z	excess of salts (salinity)	√	√	√	

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. Cotton is already grown in the area and could possibly be a viable cashcrop.

Rc: Cowpea, short Growing Period (80-90 days), e.g. variety "Katumani 80" from Kenya, low-medium input

Rk: Cotton, total Growing Period 180 days, medium input

Rm1: Maize, short Growing Period, sometimes harvested "green" (*Badhayse*) after 80 days, but usually harvested as grain after 100-105 days

Rs1: Sorghum, short Growing Period 85-100 days, e.g. KAR1 from Kenya or Gadam, medium input

Inputs levels assumed are medium for all LUTs and mainly consist of improved seed and use of modest quantities of manure and/or inorganic fertilizer.

I - Irrigated Agriculture

Somalia has a long history of Irrigated Agriculture on alluvial plains of the Juba and Shabelle rivers. Large commercial schemes of irrigated sugarcane, rice, banana and other fruit crops used to operate until the early 1990s. Since then much of the irrigation infrastructure has deteriorated. Opportunities exist to revive old schemes or to grow the same crops in smaller schemes. Three LUTs were defined and selected for the suitability assessment:

Ir: Rice, flood irrigation of paddy rice, small-scale, low-medium input (NPK fertilizer)

Ic: Citrus (and other fruits), controlled gravity irrigation, medium-high input (seedlings, fertilizer, pesticides, irrigation management and infrastructure)

Is: Sugarcane, controlled gravity irrigation, medium-high input (fertilizer, pesticides, irrigation management and infrastructure)

P - Extensive Grazing (Pastoralism)

Four LUTs were evaluated, which are:

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

Extensive Grazing in Somalia often takes the form of Transhumance Pastoralism. 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 the present study is to show overall and average availability of grazing resources throughout the study area. Inputs are low and mainly consist of labour (herding, watering) and the maintenance of waterpoints.

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. Main inputs into these LUTs are planting material (seedlings), watering in initial stages (first year), and continuous protection against livestock and fire (either by fencing or guarding).

Table 13: Land Use Types

Major Kind of Land Use		**Land Use Type (LUT)**	
R	Rainfed Agriculture	Rc	Rainfed cowpea; short GP (80 days); low-medium input
		Rk	Rainfed cotton; GP 160-180 days; medium input
		Rm1	Rainfed maize; short GP (80-90 days); medium input
		Rs1	Rainfed sorghum; short GP (90-100 days); medium input
I	Irrigated Agriculture	Ir	Flood irrigation of paddy ice; medium input
		Ic	Gravity irrigation of citrus and other fruits, medium input
		Is	Gravity irrigation of sugarcane, medium to high 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)
		Fce	Casuariana equisetifolia (shawri)
		Fcl	Conocarpus lancifolius (damas, ghalab)
		Fdg	Dobera glabra (garas)
		Fti	Tamarindus inidica (raqai)

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 Annexes 2 to 6.

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 LUT/RBU combination.

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[4]:

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

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

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 to 10. 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.

4.1.6 Land suitability classification

SOMALES has four Suitability Classes:

S1 = highly suitable (no limitations, level 1)

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 14 and 15 below show the physical land suitability of the study area for four LUTs, characterized by the production of individual crop varieties. Maps 3 and 4 show the land suitability for maize and sorghum respectively. Because of the semi-arid conditions in the area, most attention has been paid to crops with a short Growing Period. The four LUTs are defined as follows:

Rc: Cowpea, short Growing Period (80-90 days), e.g. variety "Katumani 80" from Kenya, low-medium input

Rk: Cotton, total Growing Period 180 days, medium input

Rm1: Maize, short Growing Period, sometimes harvested "green" (*Badhayse*) after 80 days, but usually harvested as grain after 100-105 days and used for *ugali*, *enjera*, popcorn, or cooked with peas, medium input

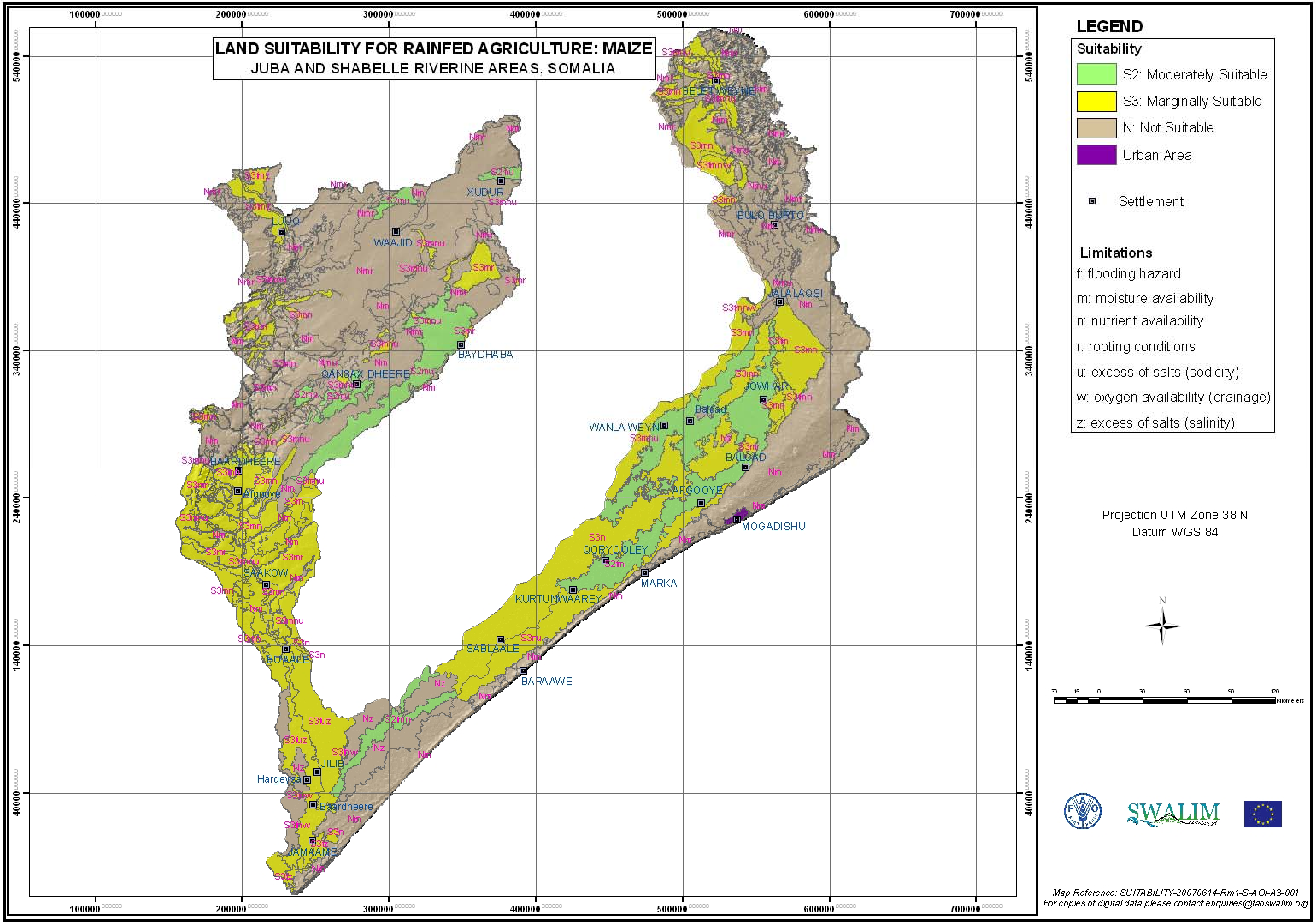
Rs1: Sorghum, short Growing Period 85-100 days, e.g. KAR1 from Kenya or Gadam, medium input

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 (lower Shabelle and coastal zone), long-term average crop yields will remain below their biological potential mainly because of rainfall variability (both seasonal and annual), flooding hazard, low soil fertility (alkaline soils) and/or high soil sodicity. Although some of these limitations can be overcome by improved management and increased inputs, this would mean increased costs which are unlikely to be off-set by increased production.

Roughly 10 to 25 of the study area is moderately suitable (class S2) for one or all of the four crops analyzed. Most of the moderately suitable land is made up of the floodplains of the middle Shabelle south of Jowhar (RBUs 5i, 5j, 5k). Another area moderately suitable for rainfed cropping is made up of the upland plateaus in the Juba catchment around Baydhaba, Qansax Dheere and Xudur (RBU 10b). One of the main limitations for cowpea and maize in the alluvial plains of both the Juba and Shabelle is the alkalinity (high pH) of the soil. Locally high sodicity and salinity also form a limitation. Where such conditions exist, tolerant crops such as cotton, and to a lesser extent sorghum, are expected to do better. It is for this reason that some of the alluvial plains of the lower Juba and Shabelle (RBUs 11g and 11h) are classified as moderately suitable for cotton, and marginally suitable or unsuitable for cowpea, maize and sorghum.

Around 35% of the study area is unsuitable (class N) for all four LUTs, and almost 55% is unsuitable for maize (Rm1), which is the most demanding crop. Severe limitations to rainfed cropping exist in the coastal dunes and plains (RBUs 2, 3, 4) because of the low moisture holding capacity of the soil. Short and unreliable growing periods, often in combination with shallow stony soils, pose a severe limitation in the hills and pediments in the northern parts of both the Juba and Shabelle catchments (RBUs 13a,b,c,e and 14c,g,h). High salinity makes some of the alluvial plains unsuitable for cowpea and maize (RBU 11g).

Map 3: Land suitability for Rainfed Agriculture: Maize (short GP)



Map 4: Land suitability for Rainfed Agriculture: Sorghum (short GP)

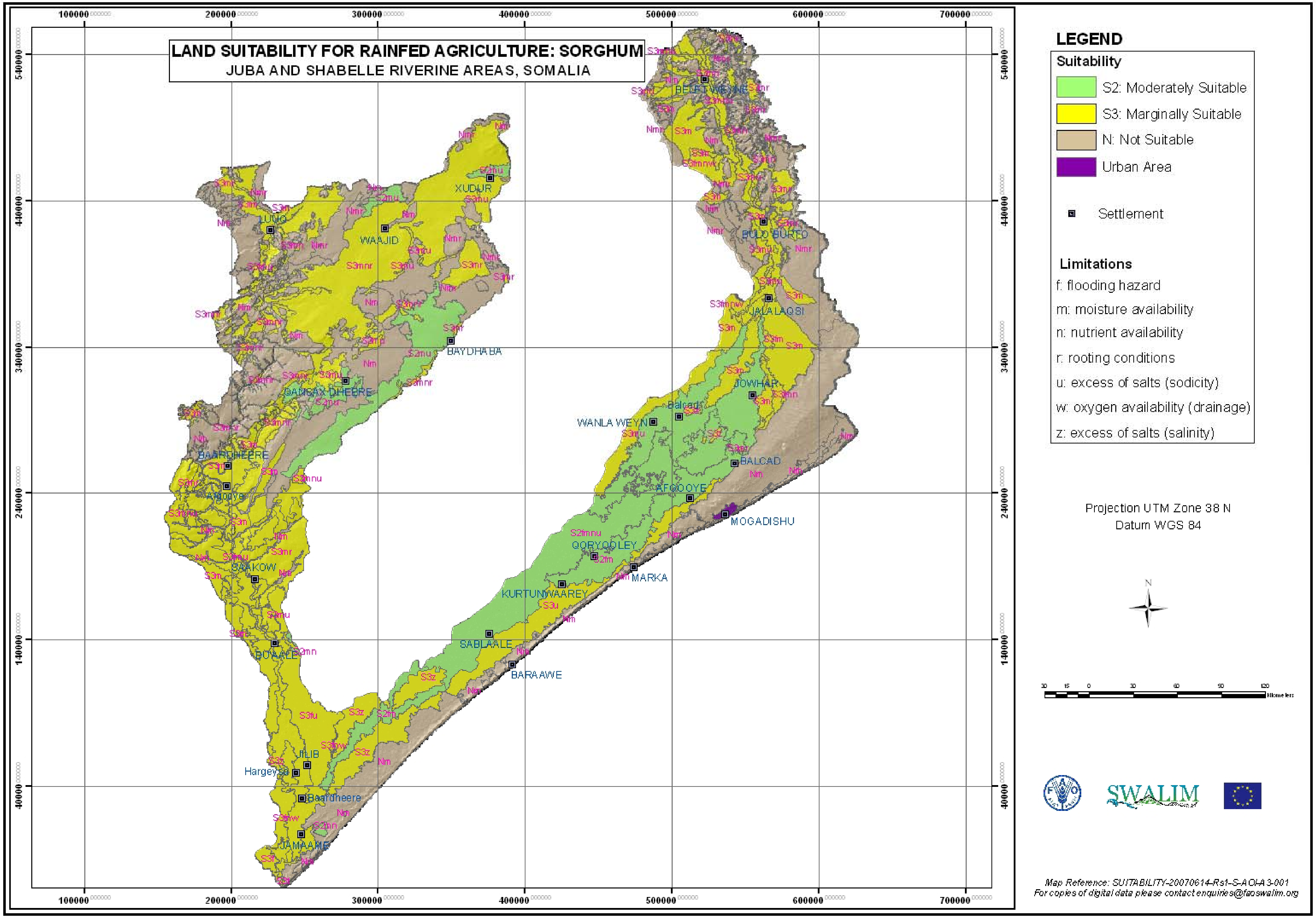


Table 14: Land suitability for Rainfed Agriculture

RBU	Area		Rc	Rk	Rm1	Rs1
	ha	%	cowpea 80 days	cotton 180 days	maize 80-90 days	sorghum 90-100 days
1a	8936	0.10	Nmr	Nmr	Nmr	Nmr
1b	8773	0.10	S3mnu	S3mn	S3mnu	S3mnu
1c	432	0.00	Nr	Nmr	Nmr	Nr
2	45031	0.51	Nm	Nm	Nm	Nm
3a	454503	5.17	Nm	Nm	Nm	Nm
3b	32788	0.37	Nm	Nm	Nm	Nm
3c	337576	3.84	Nm	Nm	Nm	Nm
4	50478	0.57	Nm	Nm	Nm	Nm
5a	6257	0.07	S3fm	S3f	S3fm	S3fm
5b	25225	0.29	S3fmn	S3fn	S3fmn	S3fmn
5c	23511	0.27	S3fmu	S3fm	S3fmnu	S3fmu
5d	24776	0.28	S3fmu	S3f	S3fmnu	S3fmu
5e	20714	0.24	S3fmu	S3f	S3fmnu	S3fmu
5f	85813	0.98	S3m	Nm	Nm	S3m
5g	160870	1.83	S3fuz	S3f	S3fuz	S3fu
5h	185594	2.11	S3fuz	S3f	S3fuz	S3fu
5i	585599	6.66	S2fmnu	S2fmn	S3n	S2fmnu
5j	91876	1.04	S2fm	S2fm	S2fmn	S2fm
5k	588025	6.69	S2fm	S2fm	S2fm	S2fm
6a	25546	0.29	S3m	Nm	Nm	S3m
6b	44809	0.51	S3mu	S3m	S3mnu	S3mu
7a	203662	2.32	Nmr	Nmr	Nmr	Nmr
7b	18764	0.21	Nmr	Nmr	Nmr	Nmr
7c	34763	0.40	S3mnu	S3mn	S3mnu	S3mnu
8a	981	0.01	S3fmn	S3fmn	S3fmn	S3fmn
8b	4943	0.06	S3fmnw	S3fnw	S3fmnw	S3fmnw
8c	3095	0.04	S3fnw	S3fnw	S3fnw	S3fnw
9	9251	0.11	Settlement (Mogadishu)			
10a	111229	1.27	S3m	S3m	S3m	S3m
10b	339521	3.86	S2mu	S2m	S2mu	S2mu
11a	57314	0.65	S3fmz	S3fm	S3fmz	S3fm
11b	52500	0.60	S3mn	S3mn	S3mn	S3mn
11c	101882	1.16	S3mu	Nm	Nm	S3mu
11d	369219	4.20	S3m	S3m	S3mn	S3m
11e	203932	2.32	S3mu	S3m	S3mnu	S3mu
11f	41402	0.47	S3fz	S3f	S3fz	S3f
11g	308284	3.51	Nz	S2fmz	Nz	S3z
11h	205921	2.34	S3u	S2fmuw	S3nu	S3u
12a	115429	1.31	Nm	Nm	Nm	Nm
12b	50487	0.57	S3mn	Nm	Nm	S3mn
12c	112775	1.28	S3mn	S3m	S3mn	S3m
13a	496151	5.64	Nmr	Nmr	Nmr	Nmr
13b	72120	0.82	Nmr	Nmr	Nmr	Nmr
13c	179449	2.04	Nmr	Nr	Nmr	Nmr
13d	266434	3.03	S3mr	S3mr	S3mr	S3mr
13e	515908	5.87	Nm	Nm	Nm	Nm
14a	192001	2.18	S3mr	Nm	Nm	S3mr
14b	55308	0.63	S3mr	S3mr	S3mr	S3mr
14c	363797	4.14	Nm	Nm	Nm	Nm
14d	10190	0.12	S2mn	S2mn	S3n	S2mn
14e	396880	4.51	S3m	S3m	S3mn	S3m
14f	885305	10.07	S3mnr	S3mnr	Nm	S3mnr
14g	19526	0.22	Nm	Nm	Nm	Nm
14h	186750	2.12	Nmr	Nmr	Nmr	Nmr
total	8792305	100				
Suitability Classes:			Limitations:			
S1 Highly Suitable S2 Moderately Suitable S3 Marginally Suitable N Not Suitable			f flooding hazard m moisture availability n nutrient availability r rooting conditions		u excess of salts (sodicity) w oxygen availability (drainage) z excess of salts (salinity)	

Table 15: Land suitability for Rainfed Agriculture (summary)

	Rc		Rk		Rm1		Rs1	
	area (ha)	**%**	**area (ha)**	**%**	**area (ha)**	**%**	**area (ha)**	**%**
S1	0	0	0	0	0	0	0	0
S2	1615211	18.4	2129416	24.2	1019422	11.6	1615211	18.4
S3	3758259	42.7	3096609	35.2	3013014	34.3	4066543	46.3
N	3418835	38.9	3566280	40.6	4759869	54.1	3110551	35.4
total	8792305	100	8792305	100	8792305	100	8792305	100

5.2 Land suitability for irrigated agriculture

Somalia has a long history of irrigated agriculture on the alluvial plains of the Juba and Shabelle rivers. In 1980 about 50000 ha was under controlled irrigation and 110000 ha under flood irrigation (Alim, 1987). Large commercial schemes of irrigated sugarcane, rice, banana, citrus and other fruit crops used to operate in the Shabelle below Jowhar and in the Juba near Jilib. Since the early 1990s much of the irrigation infrastructure has deteriorated. Opportunities exist to revive old schemes or to grow the same crops in smaller schemes. Three LUTs were defined and selected for the suitability assessment:

- **Ir**: **Rice.** Flood irrigation of paddy rice, small-scale, low-medium input (NPK fertilizer, irrigation management and infrastructure)
- **Ic**: **Citrus** (and other fruits[5]). Controlled irrigation, medium-high input (seedlings, fertilizer, pesticides, irrigation management and infrastructure)
- **Is**: **Sugarcane.** Controlled irrigation, medium-high input (fertilizer, pesticides, irrigation management and infrastructure)

Tables 16 and 17 and Maps 5, 6 and 7 show the physical land suitability of the study area for the three LUTs.

The land suitability evaluation carried out mainly concentrates on the suitability of the land (notable soils and topography) and less on the availability and quality of water for irrigation. The availability of water has only been determined in a general way through the land quality "q" ("availability of water for irrigation") and the assumption has been made that water is available in low-lying areas on the banks of the Juba and Shabelle[6]

There is very little land which has been classified as highly suitable (class S1) for any of the three LUTs. The only exception is a relatively small area (86000 ha) of narrow floodplains in the upper Shabelle (RBU 5f), which is highly suitable for sugarcane.

Also moderately suitable land (class S2) is rather less than may be expected, particularly for citrus and paddy rice. The area of moderately suitable land is less than 180000 ha for citrus (2% of total), 92000 ha for paddy rice (1%) and 667000 ha for sugarcane (nearly 8%). The main reason why most of the floodplains and alluvial plains of the Shabelle and Juba have been classified as only marginally suitable (class S3) for irrigation is because the soils are very alkaline (pH >8.5), are

[5] Within the context of the present study it can be assumed that the (physical) land suitability for citrus is the same as that for crops like banana, papaya and mango

[6] The Water Resources of the Juba and Shabelle riverine areas and of Somalia in general are the subject of additional specialized SWALIM studies.

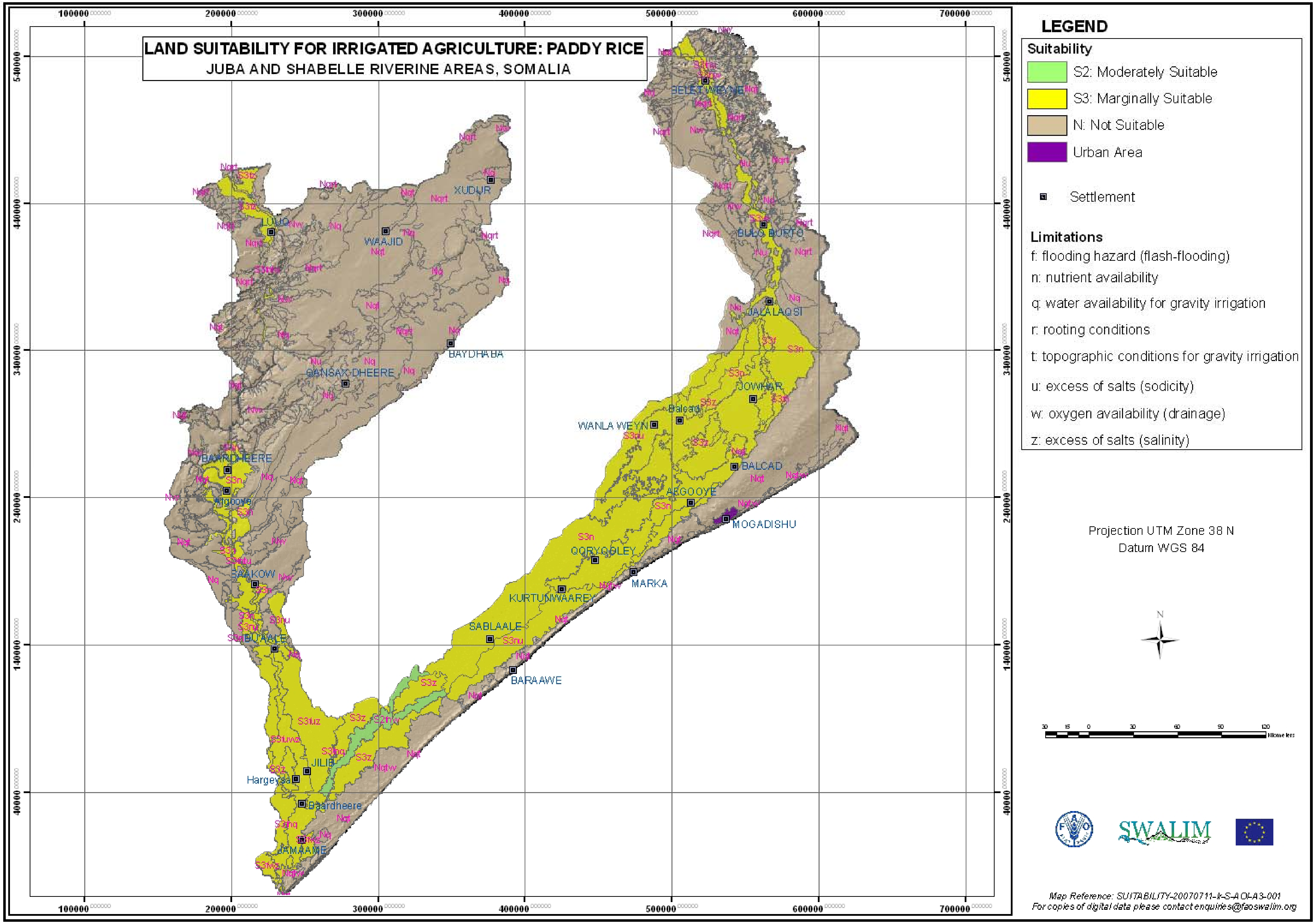
high in sodium (exchangeable sodium of > 40%) and/or are saline (electric conductivity of > 12 dS/m)[7].

In the case of high-input commercial schemes some soil improvement can be achieved and tolerant crop varieties can be introduced. Under such circumstances the land suitability would be rated differently. To demonstrate the land suitability for irrigated agriculture in case of ameliorated soils, an “alternative” suitability evaluation has been carried out excluding crop requirements and land qualities related to soil chemical properties, i.e. nutrient availability, sodicity and salinity. The results of this evaluation, carried out for the floodplains and alluvial plains of Juba and Shabelle only, are shown in Table 18. Under conditions of improved soil fertility, the area of land classified as highly suitable (S1) and moderately suitable (S2) increases considerably. In case of citrus the area classified as S1 or S2 increases from less than 180000 ha to more than 2 million ha.

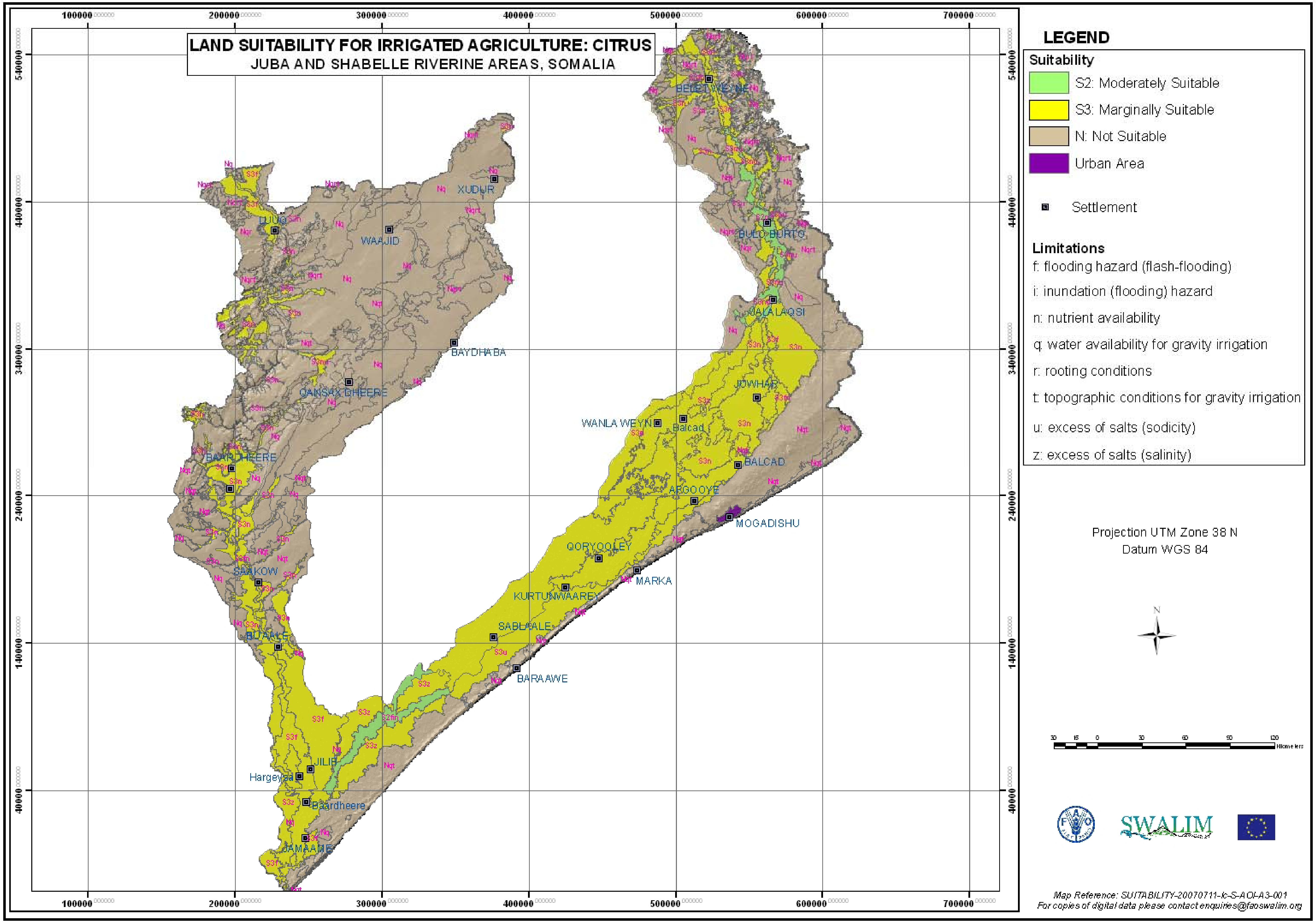
From existing soil reports and from SWALIM soil analysis it appears that the soils of the Juba and Shabelle alluvial plains and floodplain are mostly alkaline, and locally have high sodicity and salinity. However, considerable variability in soil properties exist which, because of its generalized scale, can not be captured in the present study. Also, as mentioned earlier, certain soil properties can be ameliorated if necessary. For these reasons, the suitability assessment for irrigated agriculture given in the present study should be considered as very general and not conclusive.

[7] Soil data for the floodplains and alluvial plains were mainly derived from Feasibility Studies carried out in 1970s and 1980s, supplemented by recent data from SWALIM (see FAO-SWALIM Technical Report No L-08). Not all reports confirm limitations due to high alkalinity, high sodicity and/or high salinity.

Map 5: Land suitability for Irrigated Agriculture: Paddy Rice



Map 6: Land suitability for Irrigated Agriculture: Citrus (and banana, papaya, mango)



Map 7: Land suitability for Irrigated Agriculture: Sugarcane

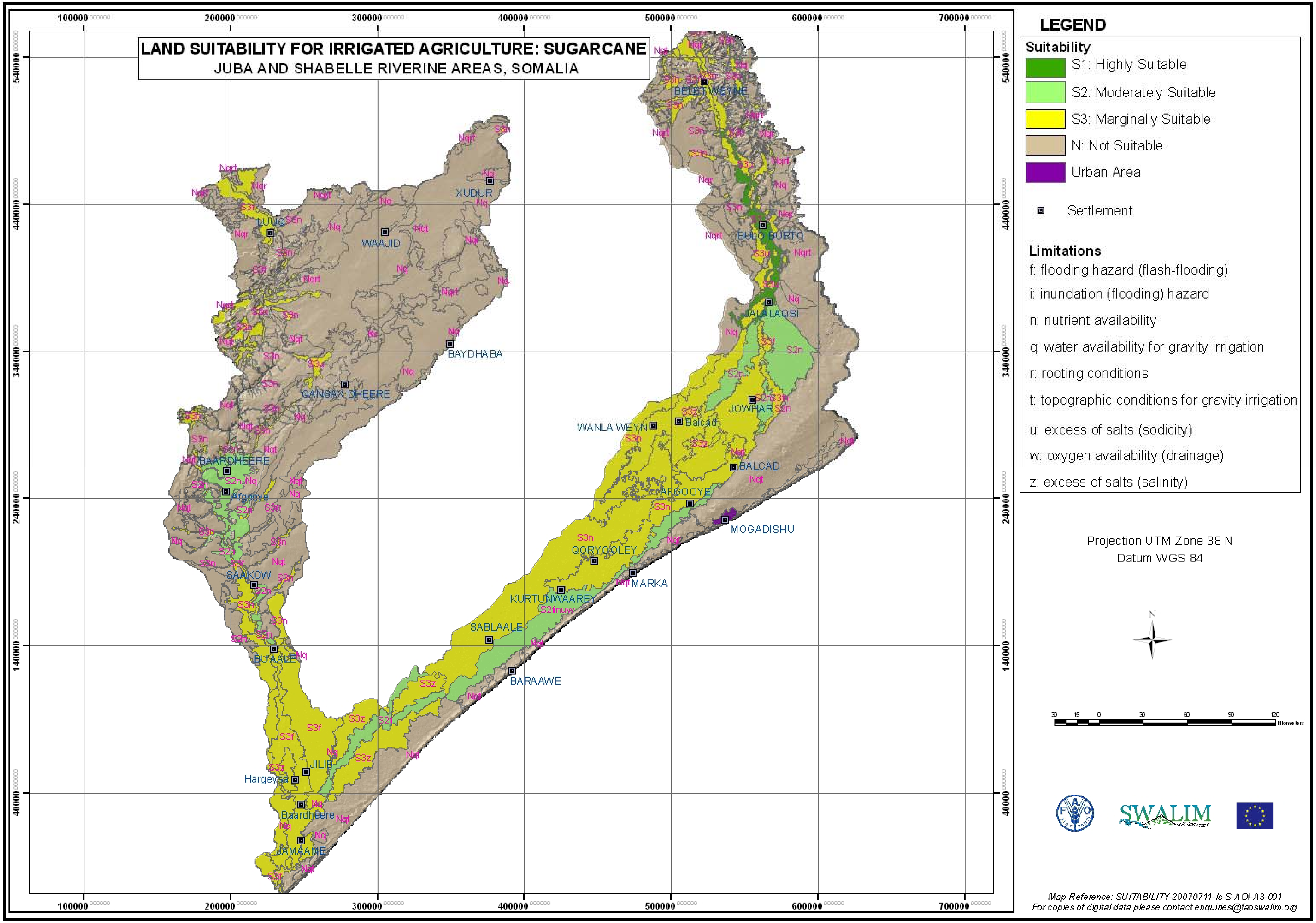


Table 16: Land suitability for Irrigated Agriculture

RBU	ha	%	Land Use Type		
			Ic (citrus)	Is (sugarcane)	Ir (paddy rice)
1a	8936	0.10	Nqr	Nr	Nqrt
1b	8773	0.10	Nq	Nq	Nqt
1c	432	0.00	Nqr	Nqr	Nqrt
2	45031	0.51	Nqt	Nqt	Nqt
3a	454503	5.17	Nqt	Nqt	Nqt
3b	32788	0.37	Nqt	Nqt	Nqtw
3c	337576	3.84	Nqt	Nqt	Nqtw
4	50478	0.57	Nqt	Nqt	Nqt
5a	6257	0.07	S3f	S3f	S3f
5b	25225	0.29	S3fn	S3fn	S3fn
5c	23511	0.27	S3fn	S3f	S3fntu
5d	24776	0.28	S3fn	S3f	S3fntu
5e	20714	0.24	S3fn	S3f	S3fnu
5f	85813	0.98	S2n	S1	S3w
5g	160870	1.83	S3f	S3f	S3fuwz
5h	185594	2.11	S3f	S3f	S3fuz
5i	585599	6.66	S3n	S3n	S3n
5j	91876	1.04	S2fin	S2fi	S2fnw
5k	588025	6.69	S3n	S3n	S3n
6a	25546	0.29	Nq	Nq	Nq
6b	44809	0.51	Nq	Nq	Nq
7a	203662	2.32	Nqr	Nqr	Nqrt
7b	18764	0.21	Nqr	Nqr	Nqr
7c	34763	0.40	Nqt	Nqt	Nqt
8a	981	0.01	Nq	Nq	Nq
8b	4943	0.06	Nq	Nq	Nq
8c	3095	0.04	Nq	Nq	S3fnq
9	9251	0.11	Settlement (Mogadishu)		
10a	111229	1.27	Nq	Nq	Nq
10b	339521	3.86	Nq	Nq	Nq
11a	57314	0.65	S3f	S3f	S3fz
11b	52500	0.60	S3n	S3n	S3nw
11c	101882	1.16	S3nu	S3u	Nu
11d	369219	4.20	S3n	S2n	S3n
11e	203932	2.32	S3n	S3n	S3nu
11f	41402	0.47	S3f	S3f	S3fwz
11g	308284	3.51	S3z	S3z	S3z
11h	205921	2.34	S3u	S2finuw	S3nu
12a	115429	1.31	S3n	S3n	Nw
12b	50487	0.57	S3n	S3n	Nw
12c	112775	1.28	S3n	S3n	Nw
13a	496151	5.64	Nqrt	Nrt	Nqrt
13b	72120	0.82	Nqrt	Nqrt	Nqrt
13c	179449	2.04	Nqrt	Nqrt	Nqrt
13d	266434	3.03	Nqt	Nqt	Nqt
13e	515908	5.87	Nqt	Nqt	Nqt
14a	192001	2.18	Nq	Nq	Nqt
14b	55308	0.63	Nq	Nq	Nq
14c	363797	4.14	Nq	Nq	Nq
14d	10190	0.12	Nq	Nq	Nq
14e	396880	4.51	Nq	Nq	Nqt
14f	885305	10.07	Nq	Nq	Nqt
14g	19526	0.22	Nq	Nq	Nqt
14h	186750	2.12	Nqr	Nqr	Nqrt

Suitability Classes:	Limitations:	
S1 Highly Suitable S2 Moderately Suitable S3 Marginally Suitable N Not Suitable	f flooding hazard (flash flooding) i inundation (flooding) hazard n nutrient availability q water availability for irrigation r rooting conditions	t topographic conditions for irr. u excess of salts (sodicity) w oxygen availability (drainage) z excess of salts (salinity)

Table 17: Land suitability for Irrigated Agriculture (summary)

	Ic (citrus)		Is (sugarcane)		Ir (rice)	
	area (ha)	%	area (ha)	%	area (ha)	%
S1	0	0	85813	1.0	0	0
S2	177689	2.0	667016	7.6	91876	1.0
S3	3239716	36.9	2664576	30.3	2948051	33.5
N	5374900	61.1	5374900	61.1	5752378	65.4
total	8792305	100	8792305	100	8792305	100

Table 18: Land suitability for Irrigated Agriculture: with & without soil fertility improvement

RBU	ha	% of total study area	Land Use Type					
			Ic (citrus)		Is (sugarcane)		Ir (paddy rice)	
			Present, low soil fertility	Improved high soil fertility	Present, low soil fertility	Improved, high soil fertility	Present, low soil fertility	Improved, high soil fertility
5a	6257	0.07	S3f	S3f	S3f	S3f	S3f	S3f
5b	25225	0.29	S3fn	S3f	S3fn	S3f	S3fn	S3f
5c	23511	0.27	S3fn	S3f	S3f	S3f	S3fntu	S3ft
5d	24776	0.28	S3fn	S3f	S3f	S3f	S3fntu	S3ft
5e	20714	0.24	S3fn	S3f	S3f	S3f	S3fnu	S3f
5f	85813	0.98	S2n	S1	S1	S1	S3w	S3w
5g	160870	1.83	S3f	S3f	S3f	S3f	S3fuwz	S3fw
5h	185594	2.11	S3f	S3f	S3f	S3f	S3fuz	S3f
5i	585599	6.66	S3n	S2fi	S3n	S2fi	S3n	S2fw
5j	91876	1.04	S2fin	S2fi	S2fi	S2fi	S2fnw	S2fw
5k	588025	6.69	S3n	S2fir	S3n	S2fir	S3n	S2frw
11a	57314	0.65	S3f	S3f	S3f	S3f	S3fz	S3f
11b	52500	0.60	S3n	S2fi	S3n	S2fi	S3nw	S3w
11c	101882	1.16	S3nu	S2irw	S3u	S2irw	Nu	S2r
11d	369219	4.20	S3n	S1	S2n	S1	S3n	S2tw
11e	203932	2.32	S3n	S1	S3n	S1	S3nu	S2rtw
11f	41402	0.47	S3f	S3f	S3f	S3f	S3fwz	S3fw
11g	308284	3.51	S3z	S2fi	S3z	S2fi	S3z	S2fw
11h	205921	2.34	S3u	S2fiw	S2finuw	S2fiw	S3nu	S2f
12a	115429	1.31	S3n	S2r	S3n	S2r	Nw	Nw
12b	50487	0.57	S3n	S2r	S3n	S2r	Nw	Nw
12c	112775	1.28	S3n	S1	S3n	S1	Nw	Nw
Suitability Classes:			Limitations:					
S1 Highly Suitable S2 Moderately Suitable S3 Marginally Suitable N Not Suitable			f flooding hazard (flash flooding) i inundation (flooding) hazard n nutrient availability q water availability for irrigation r rooting conditions			t topographic conditions for irr. u excess of salts (sodicity) w oxygen availability (drainage) z excess of salts (salinity)		

5.3 Land suitability for extensive grazing (pastoralism)

Tables 19 and 20 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 the various LUTs is also presented on Maps 8 and 9 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, 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 19 and 20 show that the suitability results are the same for camels, goats, and sheep respectively. The results for cattle are somewhat different.

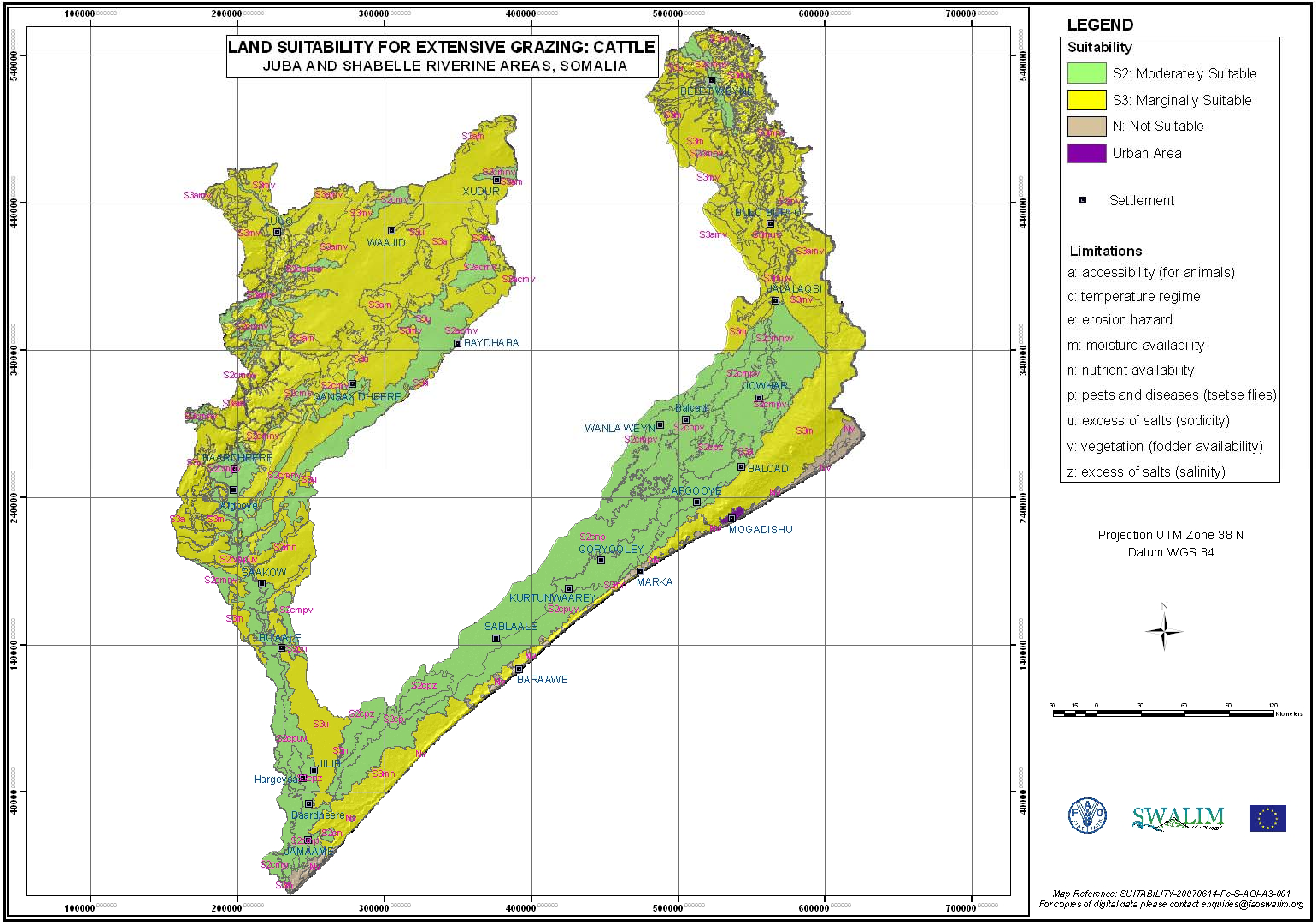
No land was identified that is highly suitable (class S1) for any of the LUTs. The reason for that varies from place to place. In the low lying alluvial plains it may be the presence of tsetse fly, the lack of abundant grazing because of cropping activities, or limited potential biomass because of high soil sodicity or salinity. Most of the northern areas have limited rainfall and can therefore only provide limited and seasonal grazing.

Equally, also very little land was identified that is completely unsuitable (class N) for grazing. Most environments support some type of vegetation which seasonally provides at least a minimum of grazing. Less than 2% of the study area was classified as unsuitable and mainly comprise coastal plains which are devoid of vegetation.

For camels, goats and sheep slightly over 50% of the area is moderately suitable (class S2) and most of the remaining part marginally suitable (class S2). The main limitations in marginally suitable land are low rainfall (short growing period), particularly in the northern part of the Shabelle catchment and the northwestern part of the Juba catchment.

For cattle, more land is marginally suitable (60% classified as S3) than moderately suitable (38% classified as S2). As compared to camels, goats and sheep, bovines are more sensitive to rough terrain and do not easily access steep slopes and/or stony and rocky areas. The areas most suitable for cattle (class S2) are the extensive alluvial plains of the Shabelle and lower Juba, as well as the gently sloping upland plains of the northeastern Juba catchment (see Map 8).

Map 8: Land suitability for Extensive Grazing (Pastoralism): Cattle



Map 9: Land suitability for Extensive Grazing (Pastoralism): Camels, Goats, Sheep

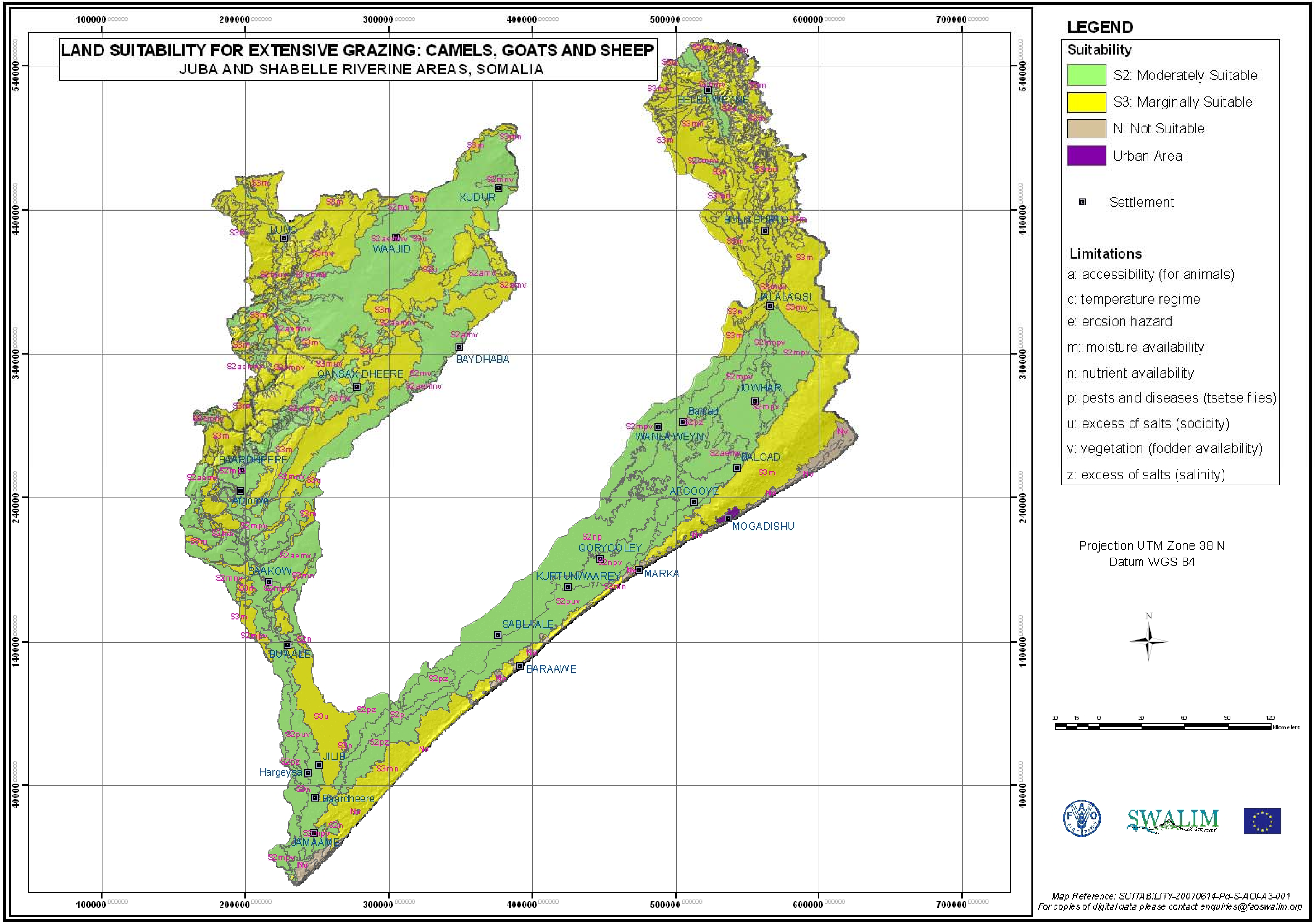


Table 19: Land suitability for Extensive Grazing

RBU	ha	%	Pc Cattle	Pd,Pg,Ps Camels Goats Sheep	RBU	ha	%	Pc Cattle	Pd,Pg,Ps Camels Goats Sheep
1a	8936	0.10	S3mn	S3mnv	**10a**	111229	1.27	S2cmnv	S2mnv
1b	8773	0.10	S3u	S3u	**10b**	339521	3.86	S2cmv	S2mv
1c	432	0.00	S3mn	S3mnv	**11a**	57314	0.65	S3mv	S3m
2	45031	0.51	Nv	Nv	**11b**	52500	0.60	S2cmnv	S2mnv
3a	454503	5.17	S3m	S3m	**11c**	101882	1.16	S3muv	S3muv
3b	32788	0.37	Nv	Nv	**11d**	369219	4.20	S2cmpv	S2mpv
3c	337576	3.84	S3mn	S3mn	**11e**	203932	2.32	S2cmpv	S2mpv
4	50478	0.57	Nv	Nv	**11f**	41402	0.47	S2cmp	S2mpv
5a	6257	0.07	S2cmnpv	S2mnpv	**11g**	308284	3.51	S2cpz	S2pz
5b	25225	0.29	S2cmnpv	S2mnpv	**11h**	205921	2.34	S2cpuv	S2puv
5c	23511	0.27	S2cmuv	S2muv	**12a**	115429	1.31	S3mn	S3mn
5d	24776	0.28	S2cmpuv	S2mpuv	**12b**	50487	0.57	S3mnv	S3mn
5e	20714	0.24	S2cmuv	S2muv	**12c**	112775	1.28	S2cmnv	S2cmnv
5f	85813	0.98	S3mv	S3m	**13a**	496151	5.64	S3amv	S3m
5g	160870	1.83	S2cpuv	S2puv	**13b**	72120	0.82	S3amv	S3m
5h	185594	2.11	S3u	S3u	**13c**	179449	2.04	S3am	S3m
5i	585599	6.66	S2cnp	S2np	**13d**	266434	3.03	S3a	S2aemv
5j	91876	1.04	S2cp	S2p	**13e**	515908	5.87	S3am	S3m
5k	588025	6.69	S2cnpv	S2npv	**14a**	192001	2.18	S3amv	S3m
6a	25546	0.29	S3mv	S3mv	**14b**	55308	0.63	S2acmv	S2amv
6b	44809	0.51	S3u	S3u	**14c**	363797	4.14	S3mv	S3m
7a	203662	2.32	S3mv	S3m	**14d**	10190	0.12	S2cn	S2n
7b	18764	0.21	S3mv	S3m	**14e**	396880	4.51	S3m	S3m
7c	34763	0.40	S3u	S3u	**14f**	885305	10.07	S3a	S2aemnv
8a	981	0.01	Nv	Nv	**14g**	19526	0.22	S2cemnv	S2emnv
8b	4943	0.06	S3n	S3n	**14h**	186750	2.12	S3mv	S3m
8c	3095	0.04	S3n	S3n					
9	9251	0.11	Settlement		**total**	8792305	100		

Suitability Classes:	Limitations:	
S1 Highly Suitable S2 Moderately Suitable S3 Marginally Suitable N Not Suitable	a accessibility (for animals) c temperature regime (for animals) d erosion hazard (wind) e erosion hazard (water) m moisture availability (for plant growth) n nutrient availability (for plant growth)	p pests and diseases (tsetse fly) u excess of salts (sodicity; for plants) w oxygen availability (drainage; for plant growth) v vegetation (present fodder availability) z excess of salts (salinity; for plants)

Table 20: Land suitability for Extensive Grazing (summary)

	Pc (cattle)		Rd, Pg, Ps (camels, goats, sheep)	
	area (ha)	%	area (ha)	%
S1	0	0	0	0
S2	3356660	38.2	4508399	51.3
S3	5297116	60.2	4145377	47.1
N	138529	1.6	138529	1.6
total	8792305	100	8792305	100

5.4 Land suitability for forestry

Tables 21 and 22 below show the physical land suitability of the study area for seven forestry species. Three of the seven species evaluated are indigenous in the area, namely "Qurac" (*Acacia tortilis*), "Damas" or "Ghalab" (*Conocarpus lancifolius*) and "Garas" (*Dobera glabra*). 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 their possible uses is given in Annexes 4, 5 and 6. The suitability for *Azadirachta indica*, *Acacia nilotica*, *Conocarpus lancifolius* and *Acacia tortillis* is also presented on Maps 10, 11 and 12 respectively.

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/or 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[8].

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.

More than 20% of the study area was found to be highly suitable (class S1) for five of the seven species. The major floodplains and alluvial plains of the Shabelle River have no major limitation for the productive growth of *Acacia nilotica*, *A. tortilis*, *Conocarpus lancifolius*, *Dobera glabra and Tamarindus indica*.

More than 55% of the study area is highly to moderately suitable (classes S1 and S2) for four of the species, namely *Acacia. tortilis*, *Conocarpus lancifolius*, *Dobera glabra* and *Tamarindus indica*.

Unsuitable (class N) to marginally suitable (class S3) land for forestry is found in the hilly areas in the north of the study area, where relatively low rainfall and shallow soils form the main constraints.

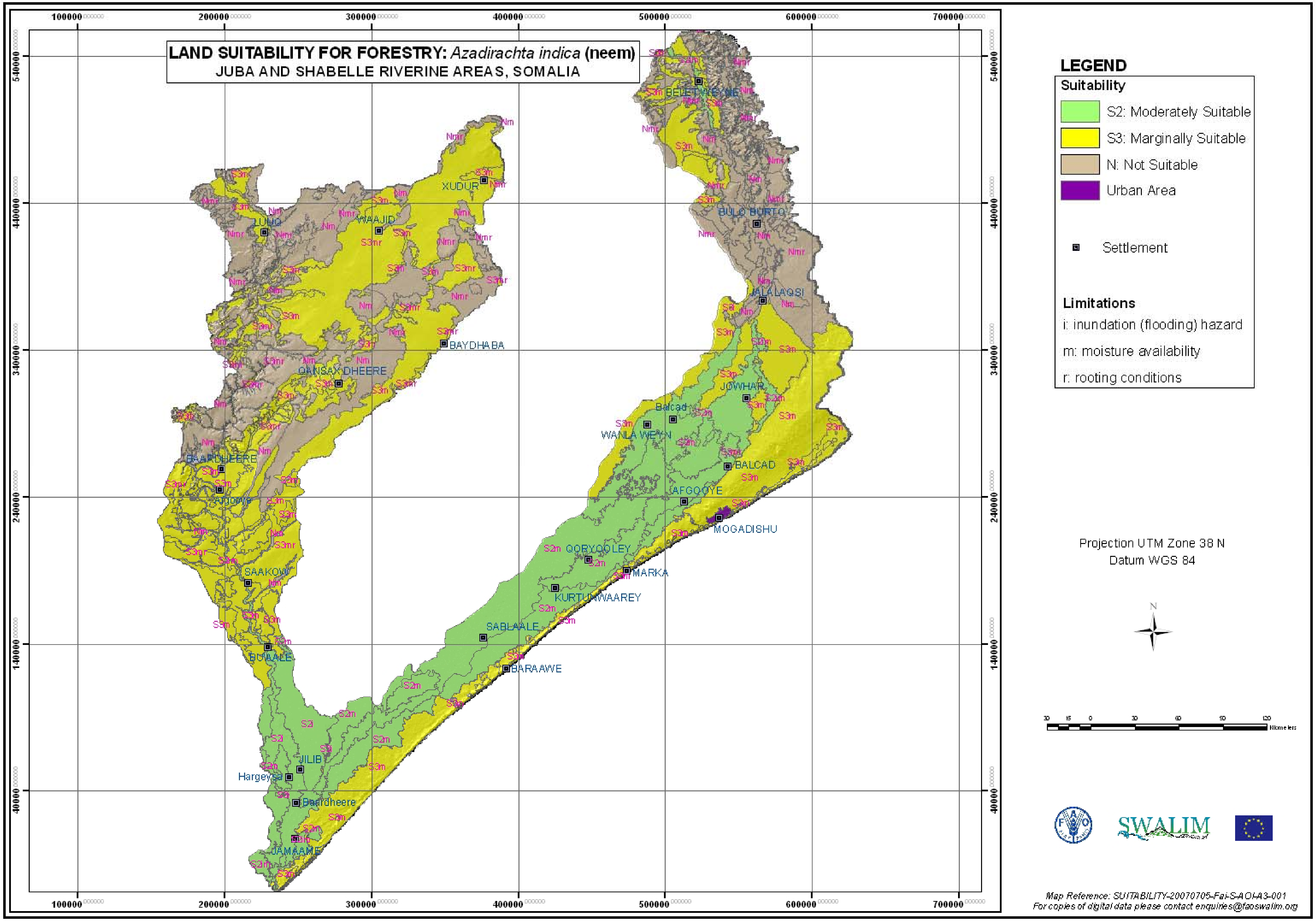
Of the species analysed, *Acacia tortilis* and *Conocarpus lancifolius* seem the most adapted to the prevailing conditions in the study area (Map 12), followed by *Dobera glabra* and *Tamarindus indica*. Two other species, which have similar requirements (see Annex 5) and which can be expected to do equally well are *Prosopis cineraria* and *Ziziphus mauritiana* ("gob").

The selection of a tree species for plantation depends not only on its adaptability to the prevailing environmental conditions, but also on its potential use and acceptance by land users involved. Some trees may even do too well and become invasive and/or annoy people who not directly benefit from them. Cultural and seemingly irrational beliefs should also be considered when promoting tree plantation.

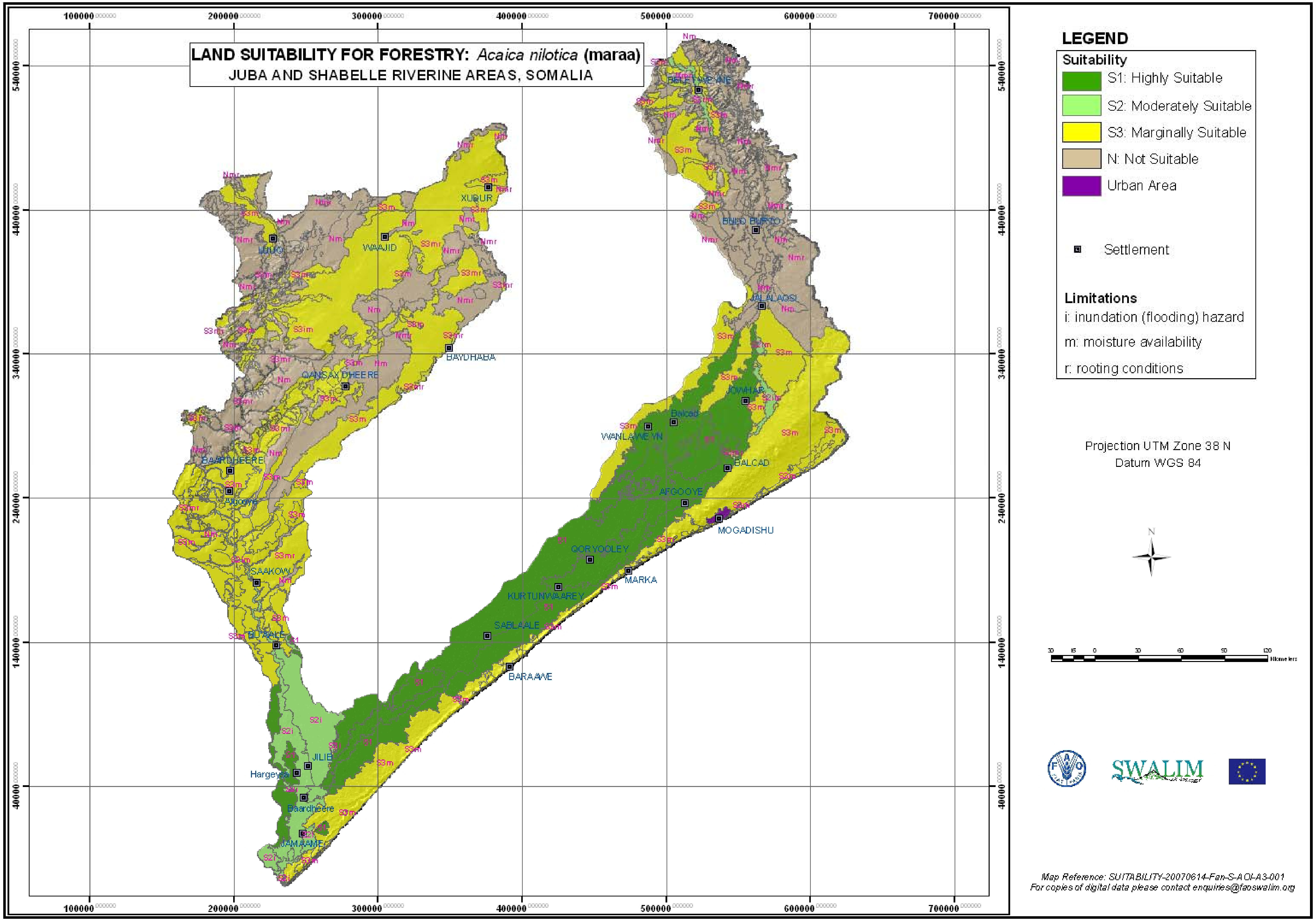
Table 23 below gives an indication of recommended species for the study area. This Table is by no means exhaustive, as there are many other suitable species and many other functions of trees and uses of forestry products.

[8] When an area is found to be highly suitable for a certain indigenous species, it does not necessarily mean that this species is part of the present vegetation. It only means that this species could be successfully planted in that particular area.

Map 10: Land suitability for Forestry: *Azadirachta indica*



Map 11: Land suitability for Forestry: *Acacia nilotica*



Map 12: Land suitability for Forestry: *Conocarpus lancifolius, Acacia tortilis*

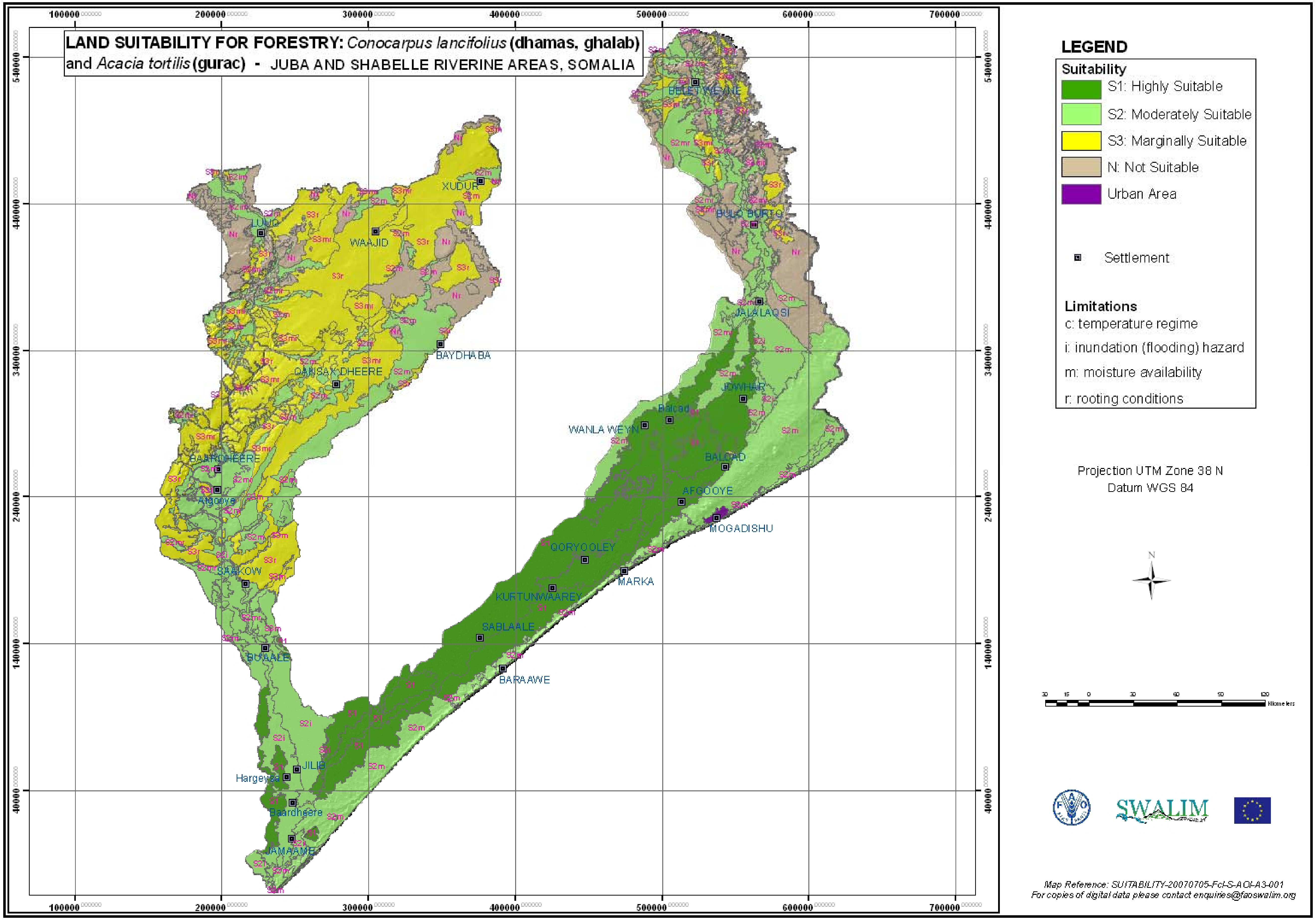


Table 21: Land suitability for Forestry

RBU	ha	%	Land Utilization Type (LUT)				
			Fai	Fan	Fat, Fcl	Fce	Fdg, Fti
1a	8936	0.10	Nmr	Nmr	Nr	Nr	Nmr
1b	8773	0.10	S3m	S3m	S2m	S3m	S2m
1c	432	0.00	Nmr	Nmr	Nr	Nmr	Nr
2	45031	0.51	S3m	S3m	S2m	S2m	S2m
3a	454503	5.17	S3m	S3m	S2m	S2m	S2m
3b	32788	0.37	S3m	S3m	S2m	S2m	S2m
3c	337576	3.84	S3m	S3m	S2m	S2m	S2m
4	50478	0.57	S3m	S3m	S2m	S2m	S3m
5a	6257	0.07	S2im	S2im	S2i	S2im	S2im
5b	25225	0.29	S2im	S2im	S2i	S2im	S2im
5c	23511	0.27	S3m	S3m	S2im	S2im	S2im
5d	24776	0.28	S2im	S2im	S2i	S2im	S2im
5e	20714	0.24	S2im	S2im	S2i	S2im	S2im
5f	85813	0.98	Nm	Nm	S2m	Nm	S3m
5g	160870	1.83	S2i	S2i	S2i	S2im	S2i
5h	185594	2.11	S2i	S2i	S2i	S2im	S2i
5i	585599	6.66	S2m	S1	S1	S2m	S1
5j	91876	1.04	S2m	S1	S1	S2m	S1
5k	588025	6.69	S2m	S1	S1	S2m	S1
6a	25546	0.29	Nm	Nm	S2m	Nm	S3m
6b	44809	0.51	S3m	S3m	S2m	S3m	S2m
7a	203662	2.32	Nmr	Nmr	Nr	Nmr	Nmr
7b	18764	0.21	Nmr	Nmr	Nr	Nmr	Nr
7c	34763	0.40	S3m	S3m	S2m	S3m	S2m
8a	981	0.01	S3im	S3im	S3i	S3i	S3i
8b	4943	0.06	S3i	S3i	S3i	S3i	S3i
8c	3095	0.04	S3i	S3i	S3i	S3i	S3i
9	9251	0.11	Settlement				
10a	111229	1.27	S3m	S3m	S2m	S3m	S2m
10b	339521	3.86	S3m	S3m	S2m	S3m	S2m
11a	57314	0.65	S3m	S3m	S2im	S3m	S3m
11b	52500	0.60	S3m	S3m	S2m	S3m	S2m
11c	101882	1.16	Nm	Nm	S2m	Nm	S3m
11d	369219	4.20	S3m	S3m	S2m	S3m	S2m
11e	203932	2.32	S3m	S3m	S2m	S3m	S2m
11f	41402	0.47	S2im	2i	S2i	S2im	S2i
11g	308284	3.51	S2m	1	S1	S2m	S1
11h	205921	2.34	S2m	1	S1	S2m	S1
12a	115429	1.31	Nm	Nm	S3m	Nm	Nm
12b	50487	0.57	Nm	Nm	S2mr	Nm	S3m
12c	112775	1.28	S3m	S3m	S2m	S3m	S2m
13a	496151	5.64	Nmr	Nmr	Nr	Nmr	Nmr
13b	72120	0.82	Nmr	Nmr	Nr	Nmr	Nmr
13c	179449	2.04	Nmr	Nmr	Nr	Nr	Nmr
13d	266434	3.03	S3mr	S3mr	S3r	S3mr	S3r
13e	515908	5.87	Nm	Nm	S3mr	Nm	S3mr
14a	192001	2.18	Nm	Nm	S3r	Nm	S3mr
14b	55308	0.63	S3mr	S3mr	S3r	S3mr	S3r
14c	363797	4.14	Nm	Nm	S3mr	Nm	S3mr
14d	10190	0.12	2m	1	S1	S2m	S1
14e	396880	4.51	S3m	S3m	S2mr	S3m	S2mr
14f	885305	10.07	S3mr	S3mr	S3r	S3mr	S3r
14g	19526	0.22	S3m	S3m	S2mr	S3m	S2mr
14h	186750	2.12	Nmr	Nmr	Nr	Nmr	Nr
total	8792305	100					

Suitability Classes:	Limitations:
S1 Highly Suitable	c temperature conditions
S2 Moderately Suitable	i inundation (flooding) hazard
S3 Marginally Suitable	m moisture availability
N Not Suitable	r rooting conditions

Table 22: Land suitability for Forestry (Summary)

	Fai		**Fan**		**Fat, Fcl**		**Fce**		**Fdg, Fti**	
	area (ha)	**%**	**area (ha)**	**%**	**area (ha)**	**%**	**area (ha)**	**%**	**area (ha)**	**%**
S1	0	0	1789895	20.4	1789895	20.4	0	0	1789895	20.4
S2	2254733	25.6	464838	5.3	3423694	38.9	3198620	36.4	3052174	34.7
S3	3911194	44.5	3911194	44.5	2403201	27.3	2967307	33.7	2659292	30.2
N	2626378	29.9	2626378	29.9	1175515	13.4	2626378	29.9	1290944	14.7
total	8792305	100	8792305	100	8792305	100	8792305	100	8792305	100

Table 23: Summary of tree species suitable for various environments and uses

Species	**Fodder**		**Timber, poles**		**Fuel**		**Soil Cons**	
	Lowland Plains	Upland	Lowland Plains	Upland	Lowland Plains	Upland	Dunes	Upland
Acacia nilotica tugaar, maraa	yes		yes		yes			
Acacia tortilis qurac	yes	yes			yes	yes		yes
Conocarpus lancifolius dhamas, ghalab	yes	yes	yes	yes	yes	yes		yes
Dobera glabra garas	yes	yes	yes	yes	yes	yes		
Prosopis cineraria	yes	yes	yes	yes	yes	yes	yes	
Tamarindus indica raqai	yes	yes	yes	yes	yes	yes		yes
Ziziphus mauritiana gob	yes	yes	yes	yes	yes	yes		yes

5.5 Comparison of suitability for the major types of land use

Table 24 lists the suitability classification for selected LUTs within each of the four major land use types, i.e. Forestry, Extensive Grazing, Rainfed Agriculture and Irrigated Agriculture (both for present "low" fertility levels and for "improved" fertility levels).

Since the present land suitability evaluation is only of a physical nature, it is not possible to directly compare the results for each of the major land use types. For example, there are no objective criteria to compare an S3 for Forestry with an S2 for Grazing. However, the overview shows which RBUs represent the most valuable land in the study area and also identifies land which has very limited agricultural potential.

If an RBU is suitable for more than one major type of land use, it makes it particularly valuable since most farmers are involved in more than one type of land use.

Large areas with relatively high suitability for three or all four major types of land use are:

- The floodplains of both the lower Shabelle and the lower Juba (RBUs 5a – 5k)
- The plateau areas within the Juba catchment (RBUs 10a, 10b)
- Alluvial plains throughout both the Shabelle and Juba valleys (RBUs 11a – 11h)

Large areas with limited potential include the following:

- The coastal dune complex and coastal plain (RBUs 2, 3a – 3c)
- Depressions, scattered through both the Shabelle and Juba valleys (RBUs 6a, 6b)
- Erosion surfaces in the northern part of the study area (RBUs 7a – 7c)
- Most of the hilland in the northern part of the study area (RBUs 13a, 13b, 13c, 13e)

Large areas which are not suitable for irrigation but have a marginal to moderate potential for all three other major types of land use:

- The gently sloping pediments occurring throughout the Juba catchment (RBUs 14a, 14b, 14c, 14e, 14f, and to a lesser extent in the upper Shabelle catchment (RBUs 14a, 14f)

Table 24: Overview of land suitability for major types of land use

RBU	Area		Forestry	Grazing	Rainfed	Irrigated	
						Is (sugarcane)	
	ha	%	Fat, Fcl	Pd,Pg,Ps (camels, shoats)	Rs1 (sorghum)	Present, low soil fertility	Improved, high soil fertility
1a	8936	0.10	Nr	S3mnv	Nmr	Nr	Nr
1b	8773	0.10	S2m	S3u	S3mnu	Nq	Nq
1c	432	0.00	Nr	S3mnv	Nr	Nqr	Nqr
2	45031	0.51	S2m	Nv	Nm	Nqt	Nqt
3a	454503	5.17	S2m	S3m	Nm	Nqt	Nqt
3b	32788	0.37	S2m	Nv	Nm	Nqt	Nqt
3c	337576	3.84	S2m	S3mn	Nm	Nqt	Nqt
4	50478	0.57	S2m	Nv	Nm	Nqt	Nqt
5a	6257	0.07	S2i	S2mnpv	S3fm	S3f	S3f
5b	25225	0.29	S2i	S2mnpv	S3fmn	S3fn	S3f
5c	23511	0.27	S2im	S2muv	S3fmu	S3f	S3f
5d	24776	0.28	S2i	S2mpuv	S3fmu	S3f	S3f
5e	20714	0.24	S2i	S2muv	S3fmu	S3f	S3f
5f	85813	0.98	S2m	S3m	S3m	S1	S1
5g	160870	1.83	S2i	S2puv	S3fu	S3f	S3f
5h	185594	2.11	S2i	S3u	S3fu	S3f	S3f
5i	585599	6.66	S1	S2np	S2fmnu	S3n	S2fi
5j	91876	1.04	S1	S2p	S2fm	S2fi	S2fi
5k	588025	6.69	S1	S2npv	S2fm	S3n	S2fir
6a	25546	0.29	S2m	S3mv	S3m	Nq	Nq
6b	44809	0.51	S2m	S3u	S3mu	Nq	Nq
7a	203662	2.32	Nr	S3m	Nmr	Nqr	Nqr
7b	18764	0.21	Nr	S3m	Nmr	Nqr	Nqr
7c	34763	0.40	S2m	S3u	S3mnu	Nqt	Nqt
8a	981	0.01	S3i	Nv	S3fmn	Nq	Nq
8b	4943	0.06	S3i	S3n	S3fmnw	Nq	Nq
8c	3095	0.04	S3i	S3n	S3fnw	Nq	Nq
10a	111229	1.27	S2m	S2mnv	S3m	Nq	Nq
10b	339521	3.86	S2m	S2mv	S2mu	Nq	Nq
11a	57314	0.65	S2im	S3m	S3fm	S3f	S3f
11b	52500	0.60	S2m	S2mnv	S3mn	S3n	S2fi
11c	101882	1.16	S2m	S3muv	S3mu	S3u	S2irw
11d	369219	4.20	S2m	S2mpv	S3m	S2n	S1
11e	203932	2.32	S2m	S2mpv	S3mu	S3n	S1
11f	41402	0.47	S2i	S2mpv	S3f	S3f	S3f
11g	308284	3.51	S1	S2pz	S3z	S3z	S2fi
11h	205921	2.34	S1	S2puv	S3u	S2finuw	S2fiw
12a	115429	1.31	S3m	S3mn	Nm	S3n	S2r
12b	50487	0.57	S2mr	S3mn	S3mn	S3n	S2r
12c	112775	1.28	S2m	S2cmnv	S3m	S3n	S1
13a	496151	5.64	Nr	S3m	Nmr	Nrt	Nrt
13b	72120	0.82	Nr	S3m	Nmr	Nqrt	Nqrt
13c	179449	2.04	Nr	S3m	Nmr	Nqrt	Nqrt
13d	266434	3.03	S3r	S2aemv	S3mr	Nqt	Nqt
13e	515908	5.87	S3mr	S3m	Nm	Nqt	Nqt
14a	192001	2.18	S3r	S3m	S3mr	Nq	Nq
14b	55308	0.63	S3r	S2amv	S3mr	Nq	Nq
14c	363797	4.14	S3mr	S3m	Nm	Nq	Nq
14d	10190	0.12	S1	S2n	S2mn	Nq	Nq
14e	396880	4.51	S2mr	S3m	S3m	Nq	Nq
14f	885305	10.07	S3r	S2aemnv	S3mnr	Nq	Nq
14g	19526	0.22	S2mr	S2emnv	Nm	Nq	Nq
14h	186750	2.12	Nr	S3m	Nmr	Nqr	Nqr

6 FURTHER DEVELOPMENT OF LAND EVALUATION PROCEDURE

The physical land suitability evaluation applied and explained in this report (SOMALES) is based on internationally accepted methods and easily allows for expansion and refinement. Some limitations of the present assessment and suggestions for further development are mentioned below.

Limitations:

- The land resource inventory, on which the land resources assessment is based, is general and does not allow for detailed land evaluation. For example, from soil data it appears that soil fertility problems related to irrigated agriculture exist in the floodplains and alluvial plains of the Juba and Shabelle rivers. However, considerable variability in soil properties occurs which, because of its generalized scale, can not be captured in the present study. So, even though Resource Base Units as large as several hundred thousand hectares may have been classified as "marginally suitable for irrigated agriculture", it is quite possible that within this RBU there are pockets of land which are "highly suitable" and can accommodate schemes of a few thousand hectares.
- 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. For example, out of necessity rainfall data for the period 1961-1990 were used to calculate LGP, whereas a longer period of up to 2006 would have given better results.
- The evaluation does not cover the dynamics of pastoralism. The suitability of individual RBUs was established, whereas pastoralists move their livestock from one RBU to another and rarely confine themselves to one RBU. For example, an RBU may have plenty of grazing in the wet season and nothing in the dry season. If taken in isolation this RBU cannot sustain livestock. However, in combination with dry-season grazing somewhere else, this RBU will be very valuable for pastoralists.

Development:

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, Land Use Type requirements
- Validation of results and fine-tuning of SOMALES decision trees
- More detailed studies of specific areas of interest
- Further integration of water and land resource inventories, particularly with respect to irrigated agriculture.

Second stage:

As mentioned in the Introduction (Chapter 1), the present first phase of physical land evaluation should ideally be followed by a second stage of economic evaluation. However, such an economic evaluation does not fall within 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.S. 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	Landscape	Altitude	Ac1	Ca1	Cf1	Cf2	Dr	EC1	ES1	Ex	LCs	LGP	Mg	OC	Pv	Rs	Soils	Sd	Ss	Ta	Text	Ca/Mg	SOIL GROUP (WRB 2006)
		m	top	top	top	sub		top	top	top			top	top									
1a	Piedmont	180-200	AL	V	F	D	4	-	-	L	7-14	2	L	VL	H	3	1	VS	2	VH	L	VH	Haplic Calcisol (Chromic)
1b	Piedmont	180-200	VA	L	F	F	4	MS	ES	L	9	8, 9	M	HI	M	3	1	VD	2	VH	L	L	Haplic Calcisol (Chromic)
1c	Piedmont	180-200	AL	V	F	D	4	-	-	L	6-9	4, 5	L	VL	M	3	1	VS	2	VH	L	VH	Epileptic Calcisol (Chromic)
2	Mobile dune	<150	AL	L	F	F	4	NS	NS	L	14	10	L	VL	M	4b	6	VD	1a-5	VH	S	M	Haplic Arenosol (Calcaric)
3a	Coastal dune	<150	AL	V	F	F	3	NS	NS	H	9, 5	10	H	LO	M	3	6	VD	1a-6	VH	C	H	Ferralic Arenosol (Aridic)
3b	Coastal dune	<150	AL	L	F	F	5	NS	NS	L	14	10	L	VL	M	3	6	VD	1a-6	VH	S	M	Ferralic Arenosol (Aridic)
3c	Coastal dune	<150	AL	L	F	F	5	NS	NS	L	9	10	L	VL	M	3	6	VD	1a-6	VH	S	M	Ferralic Arenosol (Aridic)
4	Coastal plain	<30	AL	L	F	F	4	NS	NS	L	14	10	L	VL	M	3	6	VD	1a-5	VH	S	M	Protic Arenosol (Aridic)
5a	Flood plain	120	AL	V	F	F	3	NS	NS	M	10	8, 9	H	LO	M	2b	5c	VD	1a	VH	C	H	Salic Fluvisol (Calcaric, Clayic)
5b	Flood plain	100-110	VA	M	F	F	3	NS	NS	L	5, 9	8, 9	M	LO	M	2b	2-5a	DD	1a	VH	L	M	Haplic Regosol (Calcaric, Hyposalic)
5c	Flood plain	<155	VA	H	F	F	3	NS	VS	H	5, 6, 13	5	H	LO	M	2b	2-5a	MD	1a-2	VH	C	M	Haplic Fluvisol (Calcaric, Clayic)
5d	Flood plain	40-100	VA	H	F	F	3	NS	VS	H	5, 13, 10	9	H	LO	M	2b	2-5a	MD	1a-2	VH	C	M	Haplic Fluvisol (Calcaric, Clayic)
5e	Flood plain	170-200	VA	H	F	F	3	NS	VS	H	5, 6	8	H	LO	M	2b	2-5a	MD	1a-1c	VH	C	M	Haplic Fluvisol (Calcaric, Clayic)
5f	Flood plain	120-170	AL	M	F	F	4	NS	NS	M	9-5	5	M	LO	M	2b	1, 2	DD	1a-1c	VH	L	M	Calcic Fluvisol (Aridic, Clayic)/Vertic Hypocalcic Calcisol (Aridic, Clayic)
5g	Flood plain	0-50	AL	H	F	F	4	SA	VS	H	5-10	14	H	HI	L	2b	2-5c	DD	1a-1b	VH	C	M	Haplic Fluvisol (Calcaric, Clayic)/Stagnic Fluvisol (Clayic)
5h	Flood plain	15-35	AL	M	F	F	3	SA	ES	H	11	14	V	LO	L	2b	5c	DD	1a-1b	VH	C	L	Stagnic Vertisol (Calcaric)/Salic Solonetz (Clayic)
5i	Flood plain	100-110	AL	M	F	F	3	NS	SO	L	9-5	14	M	ME	L	2b	5b-5c	VD	1a-1b	VH	C	M	Calcic Vertisol (Calcaric)
5j	Flood plain	0-40	AL	L	F	F	4	NS	MS	H	10-9-5	14	M	LO	L	2b	5a-5c	VD	1a-1b	VH	C	L	Gleyic Vertisol (Calcaric, Hyposalic)/Fluvic Vertic Cambisol (Calcaric, Clayic)
5k	Flood plain	55-120	VA	M	M	M	3	NS	NS	L	5	14	M	LO	L	2b	5a-5b-2	DD	1a-1b	VH	L	M	Calcic Mazic Vertisol (Chromic)/Vertic Cambisol (Calcaric, Chromic)
6a	Depression	140-195	VA	H	F	F	3	NS	NS	H	5-7	4, 5	H	HI	M	2a	5a	DD	1a-1c	VH	C	M	Grumic Vertisol (Calcaric, Hyposalic)
6b	Depression	230-530	VA	H	F	F	3	NS	ES	H	6, 5, 9	6	H	LO	M	2a	5a, 2	MD	1a-1c	HH	C	M	Calcic Fluvisol (Arenic)
7a	Erosion surface	170-340	VA	M	F	D	3	NS	NS	L	9, 7	4, 5	M	HI	M	4a	3	VS	1a-3	VH	L	M	Calcic Petric Gypsisol (Siltic)
7b	Erosion surface	400-630	VA	M	F	D	3	NS	NS	L	8, 9	6	M	HI	M	4a	3	VS	1a, 1b	HH	L	M	Epileptic Calcisol (Arenic)
7c	Erosion surface	80-310	VA	M	M	F	3	NS	ES	L	9, 14	8, 9	M	HI	M	4a	3, 1	VD	1a-4	VH	C	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
8a	Lake basin	115-335	VA	M	M	M	2	NS	NS	L	14, 7	6	M	VL	M	2a	2	DD	1a, 1b	VH	L	M	Grumic Vertisol (Calcaric)
8b	Lake basin	40-170	VA	M	M	M	1	NS	NS	L	9, 13	8, 9	M	VL	M	2a	2	DD	1a-1c	VH	L	M	Grumic Vertisol (Calcaric, Hyposalic)
8c	Lake basin	<25	VA	M	M	M	1	NS	NS	L	5, 13	14	M	VL	M	2a	2, 5a	DD	1a-1c	VH	L	M	Protic Arenosol (Aridic)
9	Settlement	<80	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	Technosols
10a	Plain	110-185	AL	H	F	A	4	NS	NS	M	5, 10	9	H	LO	M	3	5a	DD	1a-1c	VH	C	M	Endoleptic Grumic Vertisol (Chromic)
10b	Plain	280-550	VA	H	F	F	3	NS	VS	H	5, 9	6	V	LO	M	3	5a	DD	1a-1b	HH	C	L	Calcic Endoleptic Vertisol (Calcaric, Chromic)
11a	Alluvial plain	160-180	AL	M	F	F	3	SA	MS	M	9, 6	4	M	LO	M	2b	2, 5a	VD	1a-1b	VH	C	M	Calcic Petric Gypsisol (Clayic)/Haplic Vertisol (Hyposalic, Calcaric))
11b	Alluvial plain	180-500	AL	H	F	F	4	NS	NS	L	5, 9, 7	8	M	HI	M	2b	5a, 2	VD	1a-1c	HH	C	H	Calcic Fluvisol (SIltic)/Calcic Mazic Vertisol (Calcaric)
11c	Alluvial plain	130-270	VA	M	M	M	2	NS	ES	H	5, 9, 7	5	H	ME	M	2b	7, 5a	DD	1a, 1b	VH	C	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
11d	Alluvial plain	45-150	VA	H	F	F	3	SS	SO	H	5, 10, 7	8, 9	H	HI	M	2b	1, 5a, 2	DD	1a-1c	VH	C	M	Calcic Endoleptic Vertisol (Humic, Chromic)
11e	Alluvial plain	45-150	AL	H	F	F	3	NS	NS	H	10, 9, 5	8, 9	M	HI	M	2b	1, 5a, 2	VD	1a-1c	VH	C	H	Haplic Solonchak (Sodic, Arenic)
11f	Alluvial plain	<20	AL	H	F	F	4	SA	NS	H	7, 5	10	H	HI	M	2b	2	MD	1a	VH	L	M	Haplic Cambisol (Calcaric)
11g	Alluvial plain	15-90	AL	H	F	F	3	VS	SO	H	10, 9, 7	14	V	LO	L	2b	5b, 5c	DD	1a	VH	C	L	Salic Fluvisol (Calcaric, Clayic)
11h	Alluvial plain	40-90	VA	M	F	F	2	NS	VS	H	5, 9	14	M	LO	M	2b	5a, 2	DD	1a	VH	C	M	Calcic Grumic Vertisol (Calcaric, Pellic)/Haplic Fluvisol (Calcaric)
12a	Lateral valley	70-320	VA	M	F	M	2	NS	NS	L	9, 6, 5	8, 9	M	VL	M	2b	3, 2	MD	1a-1c	VH	L	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
12b	Lateral valley	130-330	VA	M	F	M	2	NS	NS	L	9, 7, 5	4, 5	M	VL	M	2b	7, 2	MD	1a-3	VH	L	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
12c	Lateral valley	100-380	VA	L	F	F	5	NS	MS	M	9, 7	6	L	VL	M	2b	7, 2	DD	1a-1c	VH	L	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
13a	Hilland	140-550	AL	-	D	D	5	-	-	-	9, 7	4, 5	-	-	M	1	3	VS	2-5	HH	S	-	Hyperskeletic Leptosol (Aridic)
13b	Hilland	150-300	AL	-	D	D	5	-	-	-	10	4, 5	-	-	M	1	3	VS	2-5	VH	S	-	Hyperskeletic Leptosol (Aridic)
13c	Hilland	250-720	AL	-	D	D	5	-	-	-	9-7	8, 9	-	-	M	1	3	VS	2-5	HH	S	-	Endopetric Calcisol (Arenic, Aridic)
13d	Hilland	150-315	AL	-	D	D	5	-	-	-	9, 5	8, 9	-	-	M	1	3, 7	VS	2-4	VH	S	-	Hyperskeletic Leptosol (Aridic)
13e	Hilland	130-450	AL	H	M	A	4	NS	NS	M	9, 7, 5	6	M	LO	M	1	3	SS	2-5	HH	C/L	H	Epileptic Calcisol (Siltic, Chromic)
14a	Pediment	115-320	VA	-	D	D	4	-	-	-	9, 7, 5	4, 5	-	-	M	3	3, 1	VS	2-4	VH	S	-	Calcic Petric Gypsisol (Siltic)
14b	Pediment	450-620	AL	-	D	D	5	-	-	-	10, 5	8, 9	-	-	M	3	3, 1	VS	1a-1c	HH	S	-	Grumic Vertisol (Calcaric, Hyposalic)
14c	Pediment	220-500	AL	M	A	D	4	-	-	L	8, 5	6	M	LO	M	3	3	SS	1a-1c	HH	L	M	Epileptic Regosol (Aridic, Calcaric)/Lithic Leptosol (Calcaric)
14d	Pediment	5-75	AL	M	F	F	3	NS	MS	L	10, 7	14	M	LO	M	3	7	VD	1a, 1b	VH	L	M	Haplic Solonchak (Sodic, Arenic)
14e	Pediment	60-330	VA	M	F	M	3	NS	NS	H	10, 5, 7	8, 9	M	ME	M	3	3, 7	SS	1a-3	VH	I	M	Haplic Regosol (Skeletic, Calcaric)/Calcic Endoleptic Vertisol (Chromic)
14f	Pediment	150-650	VA	M	A	D	4	-	-	L	9, 7, 5	6	M	LO	M	3	3, 1	VS	1a-3	HH	L	M	Calcic Fluvisol (Arenic)/Lithic Leptosol (Aridic)
14g	Pediment	170-290	AL	L	F	D	2	NS	NS	L	6	6	M	HI	M	3	3, 1	SS	1a-3	VH	L	L	Epileptic Calcisol (Arenic)
14h	Pediment	220-500	VA	M	M	D	4	-	-	L	8, 9	6	M	ME	M	3	3	VS	1a-3	HH	L	M	Epileptic Calcisol (Siltic, Chromic)

RBU = Resource Base Unit Dr = Drainage Ta = Mean annual temperature	LC = Land Cover Pv = Rainfall variability Text = Texture Rs = Relief	Ac = Acidity (pH) EC = Electric Conductivity LGP = Length of Growing Period Ca/Mg = Calcium/Magnesium ratio	Ca = Exchangeable Calcium ESP = Exchangeable Sodium Perc. Mg = Exchangeable Magnesium Sd = Soil depth	Cf = Coarse fragments Ex = Cation Exchange Cap (CEC) OC = Organic Carbon Ss = Slope	For meaning of class symbols see Table 5 in main text

ANNEX 2: 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 3: Crop requirements (irrigated crops)

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 (t/ha) *
Banana		Musa acuminate	Food (fresh), animal feed	> 20 °C	1200-2200 high	mod	> 240	mod-high	mod	very low 0-3	mod tolerant	3.5-5.0 irrigated
Citrus		Citrus spp	Food (fresh fruit)	22-30 °C	900-1200 high	low	> 240	mod-high	deep	very low 0-3	tolerant	2.0-3.0 irrigated
Paddy rice		Oriza sativa	Food (grain), fodder	av. 21 °C	high	low	105-150	high	mod	low 0-5	not tolerant	6.0-10.0
Tomato		Solanum lycopersicum	Food (fresh)	20-30 °C	400-600	low	90-100	high	mod	low 0-5	mod. tolerant	2.0-4.5 irrigated
Sugarcane		Saccharum officinarum	Food (sugar), fuel	30-34 °C	high	low	> 360	mod	deep	very low 0-3	not tolerant	4.5-6.0 irrigated

* Attainable yield under irrigation or flooding with medium input (fertilizer mostly). 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 18-35°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: Requirements forestry species (species presently not included in SOMALES)

LUT	Species	Ecology						
		Moisture req.	**Altitude**	**Soils**	**Landform**	**pH**	**CaCO3**	**General**
Fab	*Acacia bussei* **galool**	130-500mm	300-1800m	deep, sandy	plateau & plains			
Fec	*Eucalyptus camaldulensis* **baxrasaaf**	250-1250mm	< 1500m < 1000m 19-26°C	prefers light soils; rocky soils tolerated		alkaline; tolerates salinity		kills other plants around it; high water demand
Fks	*Khaya senegalensis* **moogano**	400-1530mm	< 1800m 19-40°C	medium-heavy textured, deep fertile soils		neutral to acid		
Fll	*Leucaena leucocephala*	600-1000mm	< 800m 16-32 °C	tolerant of wide variety of soils		alkaline-neutral		suited to irrigated sites
Fpa	*Parkinsonia aculeate* **geed, walaayo**	250-800mm	< 1400m 20-32°C					
Fpc	*Prosopis cineraria*	400-800mm drought resist.	< 600m 21-28 °C	dry stony & Vertisols tolerated	alluvial plain	alkaline; tolerates salinity		seasonal water logging tolerated
Ftc	*Terminalia catappa* **beydaan**	> 1000mm drought tolerant	< 300m	tolerant of wide variety of soils		tolerates salinity		tolerated salt spray
Fzm	*Ziziphus mauritiana* **gob**	150-500mm	< 600m 24-45°C	wide range	riverine and rocky	tolerates salinity		deciduous in drought

Info:www.worldagroforestrycentre.org/SEA/Products/AFDbases; www.nps.gov/plants/alien; www.newforestsproject.com; Edible plants of Tanzania (RELMA, 2002); Trees of Somalia (Oxfam, 1990)

ANNEX 6: 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)

Species	**Uses**						**INFO**
	Fodder	**Food**	**Timber, poles**	**Fuel**	**Soil conservation**	**Other**	
Acacia bussei **galool**	leaves, pods		hardwood, difficult to work	firewood, charcoal	reforestation	tannin, gums, beekeeping, fibre	Trees of Somalia
Eucalyptus camaldulensis **baxrasaaf**			poles, timber	firewood, charcoal	windbreak, shelterbelt	tannins (bark), medicine, shade, beekeeping	Trees of Somalia; Arid zone forestry (FAO)
Khaya senegalensis **moogano mahogany**			timber, carvings	firewood		shade, beekeeping, medicine	Trees of Somalia
Leucaena leucocephala	leaves		poles, timber	firwood, charcoal	soil improvement, hedge, shelterbelt	shade, medicine, dyes, gums	Trees of Somalia; Arid zone forestry (FAO)
Parkinsonia aculeate **geed, walaayo**							
Prosopis cineraria	leaves, pods	dried pods	poles, posts, carvings	firewood	sand dune fixation, soil improvement	shade, fencing	www.en.wikipedia.org
Schinus molle							
Terminalia catappa **beydaan**		fruits	carvings, timber	firewood	sand dune fixation, soil improvement	tannins, dyes, medicine, shade	Trees of Somalia
Ziziphus mauritiana **gob**	leaves	fruits	carving, tool handles, poles	firewood	shelterbelt	live fencing, tannins, dyes, medicine	Trees of Somalia

ANNEX 7: SOMALES: Severity level decision trees for Rainfed Agriculture

Land Use Types (LUT):

- Rc: Rainfed cowpea, short GP, 80 days, low-medium input
- Rk: Rainfed cotton, total GP 180 days, medium input
- Rm1: Rainfed maize, short GP, 80-90 days, medium input
- Rs1: Rainfed sorghum, short GP, 90-100 days, medium input

Decision tree Rainfed 1: (d) Erosion hazard - wind **(Rc, Rk, Rm1, Rs1)**

Land Characteristic	Severity level
Relief class	
1, 2a, 2b, 3, 4a	**1**
4b	**3**

Decision tree Rainfed 2: (e) Erosion hazard - water **(Rk, Rm1, Rs1)**

Land characteristics							Severity level
Slope class		Soil Group (class)		LGP Zone			
class	score	class	score	class	score	total score	
1a (0-1%)		all		all			**1**
1b,1c (1-4%)	1	1,2,6,7	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	2	1,2,2a	1	4	**2**
	1		2	3,4,5	1.5	4.5	**2**
	1		2	6-15	2	5	**2**
2,3 (4-16%)	2	1,2,6,7	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	2	1,2,2a	1	5	**2**
	2		2	3,4,5	1.5	5.5	**3**
	2		2	6-15	2	6	**3**
4,5 (> 16%)	3	1,2,6,7	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	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), Fluvisols (class 2), and Cambisols (class 7) - erosion hazard is relatively low in arid zones (LGP zones 1 - 5)							
						3-3.5	1
						4-5.0	2
						5.5-6	3
						6.5-7	4

Decision tree Rainfed 3: (e) Erosion hazard - water **(Rc)**

Land characteristics							Severity level
Slope class		Soil Group (class)		LGP Zone			
class	score	class	score	class	score	total score	
1a (0-1%)		all		all			**1**
1b,1c (0-4%)	1	1,2,6,7	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	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**
2,3 (4-16%)	2	1,2,6,7	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	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**
4,5 (> 16%)	3	1,2,6,7	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	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), Fluvisols (class 2), and Cambisols (class 7) - erosion hazard is relatively low in arid zones (LGP zones 1 - 5)							
						3-3.5	1
						4-5.0	2
						5.5-6	3
						6.5-7	4

Decision tree Rainfed 4: (f) Flooding hazard (flash-flooding) **(Rc, Rk, Rm1, Rs1)**

Land characteristics					Severity level
Relief (classes)		Soil Group			
class	score	class	score	total score	
1, 3, 4a, 4b	1	1,3,6,7	1	2	**1**
	1	4,5a,5b	2	3	**1**
	1	2,5c	4	5	**2**
2a	2	1,3,6,7	1	3	**1**
	2	4,5a,5b	2	4	**1**
	2	2,5c	4	6	**3**
2b	3	1,3,6,7	1	4	**1**
	3	4,5a,5b	2	5	**2**
	3	2,5c	4	7	**3**
Assumptions: - Flooding most likely in water receiving sites (relief classes 2a, 2b) - Fluvisols (Soil Group 2) are indicative of (flash) flooding					
				2-4	1
				5	2
				6-7	3

Decision tree Rainfed 5: (i) Inundation (flooding) hazard **(Rc, Rk, Rm1, Rs1)**

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

Decision tree Rainfed 6: (m) Moisture availability **(Rc, Rs1)**

Land characteristics							Severity level
LGP Zone		Rainfall variability		Soil Group			
class	score	class	score	class	score	total score	
1	10	H	5	3, 6	5	20	**4**
	10	H	5	1,4,5a,5b,7	2	17	**4**
	10	H	5	2,5c	1	16	**4**
2	5	H	5	3, 6	5	15	**4**
	5	H	5	1,4,5a,5b,7	2	12	**4**
	5	H	5	2,5c	1	11	**4**
3	4	L	2	3,6	5	11	**4**
	4	L	2	1,4,5a,5b,7	2	8	**3**
	4	L	2	2,5c	1	7	**3**
4, 5, 6	4	M	3	3, 6	5	12	**4**
	4	M	3	1,4,5a,5b,7	2	9	**3**
	4	M	3	2,5c	1	8	**3**
7, 8, 9	3	M	3	3, 6	5	11	**4**
	3	M	3	1,4,5a,5b,7	2	8	**3**
	3	M	3	2,5c	1	7	**3**
10	2	M	3	3, 6	5	10	**4**
	2	M	3	1,4,5a,5b,7	2	7	**3**
	2	M	3	2,5c	1	6	**2**
11, 12, 13	2	L	2	3, 6	5	9	**3**
	2	L	2	1,4,5a,5b,7	2	6	**2**
	2	L	2	2,5c	1	5	**2**
14, 15	1	L	2	3, 6	5	8	**3**
	1	L	2	1,4,5a,5b,7	2	5	**2**
	1	L	2	2,5c	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	2
						7-9	3
						10-19	4

Decision tree Rainfed 7: (m) Moisture availability **(Rm1)**

Land characteristics							Severity level
LGP Zone		Rainfall variability		Soil Group			
class	score	class	score	class	score	total score	
1	10	H	5	3, 6	5	20	**4**
	10	H	5	1,4,5a,5b,7	2	17	**4**
	10	H	5	2,5c	1	16	**4**
2	8	H	5	3, 6	5	18	**4**
	8	H	5	1,4,5a,5b,7	2	15	**4**
	8	H	5	2,5c	1	14	**4**
3	6	L	2	3,6	5	13	**4**
	6	L	2	1,4,5a,5b,7	2	10	**3**
	6	L	2	2,5c	1	9	**3**
4	6	M	3	3, 6	5	14	**4**
	6	M	3	1,4,5a,5b,7	2	11	**4**
	6	M	3	2,5c	1	9	**3**
5	6	M	3	3, 6	5	14	**4**
	6	M	3	1,4,5a,5b,7	2	11	**4**
	6	M	3	2,5c	1	10	**3**
6	5	M	3	3, 6	5	13	**4**
	5	M	3	1,4,5a,5b,7	2	10	**3**
	5	M	3	2,5c	1	9	**3**
7, 8, 9	4	M	3	3, 6	5	12	**4**
	4	M	3	1,4,5a,5b,7	2	9	**3**
	4	M	3	2,5c	1	8	**3**
10	2	M	3	3, 6	5	10	**4**
	2	M	3	1,4,5a,5b,7	2	7	**3**
	2	M	3	2,5c	1	6	**2**
11	2	L	2	3, 6	5	9	**3**
	2	L	2	1,4,5a,5b,7	2	6	**2**
	2	L	2	2,5c	1	5	**2**
12	2	L	2	3, 6	5	9	**3**
	2	L	2	1,4,5a,5b,7	2	6	**2**
	2	L	2	2,5c	1	5	**2**
13	2	L	2	3, 6	5	9	**3**
	2	L	2	1,4,5a,5b,7	2	6	**2**
	2	L	2	2,5c	1	5	**2**
14	1	L	2	3, 6	5	8	**3**
	1	L	2	1,4,5a,5b,7	2	5	**2**
	1	L	2	2,5c	1	4	**2**
15	1	L	2	3, 6	5	8	**3**
	1	L	2	1,4,5a,5b,7	2	5	**2**
	1	L	2	2,5c	1	4	**2**
Assumptions: - 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	2
						7-10	3
						10-19	4

Decision tree Rainfed 8: (m) Moisture availability **(Rk)**

Land characteristics							Severity level
LGP Zone		Rainfall variability		Soil Group			
class	score	class	score	class	score	total score	
1	10	H	5	3, 6	5	20	**4**
	10	H	5	1,4,5a,5b,7	2	17	**4**
	10	H	5	2,5c	1	16	**4**
2	8	H	4	3, 6	5	17	**4**
	8	H	4	1,4,5a,5b,7	2	13	**4**
	8	H	4	2,5c	1	12	**4**
3	6	L	1	3,6	5	12	**4**
	6	L	1	1,4,5a,5b,7	2	9	**3**
	6	L	1	2,5c	1	8	**3**
4	6	M	2	3, 6	5	13	**4**
	6	M	2	1,4,5a,5b,7	2	10	**4**
	6	M	2	2,5c	1	9	**3**
5	6	M	2	3, 6	5	13	**4**
	6	M	2	1,4,5a,5b,7	2	10	**4**
	6	M	2	2,5c	1	9	**3**
6, 7	4	M	2	3, 6	5	11	**4**
	4	M	2	1,4,5a,5b,7	2	8	**3**
	4	M	2	2,5c	1	7	**3**
8, 9, 10	3	M	2	3, 6	5	10	**4**
	3	M	2	1,4,5a,5b,7	2	7	**3**
	3	M	2	2,5c	1	6	**2**
11	3	L	1	3, 6	5	9	**3**
	3	L	1	1,4,5a,5b,7	2	6	**2**
	3	L	1	2,5c	1	5	**2**
12	2	L	1	3, 6	5	8	**3**
	2	L	1	1,4,5a,5b,7	2	5	**2**
	2	L	1	2,5c	1	4	**2**
13	1	L	1	3, 6	5	7	**2**
	1	L	1	1,4,5a,5b,7	2	4	**2**
	1	L	1	2,5c	1	3	**1**
14	1	L	1	3, 6	5	7	**2**
	1	L	1	1,4,5a,5b,7	2	4	**2**
	1	L	1	2,5c	1	3	**1**
15	2	L	1	3, 6	5	8	**3**
	2	L	1	1,4,5a,5b,7	2	5	**2**
	2	L	1	2,5c	1	4	**2**

Assumptions:
- Cotton with long GP (180 days) grown over both rainy seasons (Gu and 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 (Soil Groups 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position. Cotton is able to extract moisture from Vertisols
- Rainfall pattern LGP Zone 15 not ideal, as cotton requires dry conditions during ripening (5th month)

3	1
4-6	2
7-9	3
10-19	4

Decision tree Rainfed 9: (n) Nutrient availability **(Rk, Rs1)**

Land characteristics							Severity level
pH(H2O)		CEC (25-75cm)		Ca/Mg *(see tree 12)* topsoil			
class	score	class	score	class	score	total score	
NE 6.6-7.5	1	L <16	3	VL, VH	3	7	**3**
	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 7.5-8.5	2	L	3	VL, VH	3	8	**3**
	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 >8.5	3	L	3	VL, VH	3	9	**3**
	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) - 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
						7-9	3

Decision tree Rainfed 10: (n) <u>Nutrient availability</u> **(Rm1)**

Land characteristics							Severity level
pH(H2O) (topsoil)		CEC (25-75cm) (topsoil)		Ca/Mg *(see tree 12)* (topsoil)			
class	score	class	score	class	score	total score	
NE 6.6-7.5	1	L <16	4	VL, VH	3	8	**3**
	1		4	L, H	2	7	**3**
	1		4	M	1	6	**2**
	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 7.5-8.5	3	L	4	VL, VH	3	10	**3**
	3		4	L, H	2	9	**3**
	3		4	M	1	8	**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**
VA >8.5	5	L	4	VL, VH	3	12	**3**
	5		4	L, H	2	11	**3**
	5		4	M	1	10	**3**
	5	M	2	VL, VH	3	10	**3**
	5		2	L, H	2	9	**3**
	5		2	M	1	8	**3**
	5	H	1	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							
						3-5	1
						6	2
						7-12	3

Decision tree Rainfed 11: (n) Nutrient availability **(Rc)**

Land characteristics							Severity level
pH(H2O)		CEC (25-75cm)		Ca/Mg *(see tree 12)* (topsoil)			
class	score	class	score	class	score	total score	
NE 6.6-7.5	1	L <16	3	VL, VH	3	7	**3**
	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 7.5-8.5	2	L	3	VL, VH	3	8	**3**
	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 >8.5	4	L	3	VL, VH	3	10	**3**
	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 6 7-10	1 2 3

Decision tree Rainfed 12: Ca/Mg ratio

Land characteristics				Ca/Mg ratio	
Ca++		Mg++		ranges	classes
code	me/100g	code	me/100g		
L	< 10	L	< 1	10	**M**
		M	1-5	0.2-10	**L**
		H	5-10	<1	**VL**
		V	>10	0.05-1	**VL**
M	10-25	L	<1	>10	**H**
		M	1-5	2-25	**M**
		H	5-10	1-5	**M**
		V	>10	<2.5	**L**
H	25-50	L	<1	>50	**VH**
		M	1-5	5-50	**H**
		H	5-10	2.5-10	**M**
		V	>10	<5	**L**
V	> 50	L	<1	>50	**VH**
		M	1-5	>10	**H**
		H	5-10	5-20	**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 13: (r) Rooting conditions **(Rk, Rm1, Rs1)**

Land characteristics							Severity level
Soil depth		Coarse fragments (topsoil)		Coarse fragments (subsoil)			
class	score	class	score	class	score	total score	
VS < 25cm	10	F	1	n/a	3	14	**4**
	10	M	2	n/a	3	15	**4**
	10	A	3	n/a	3	16	**4**
SS 25-50cm	4	F < 5%	1	F	1	6	**1**
	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 50-100	3	F <5%	1	F	1	5	**1**
	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 100-150	2	F <5%	1	F	1	4	**1**
	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 > 150	1	F <5	1	F	1	3	**1**
	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**
						3-6	1
						7-9	2
						10-13	3
						14-16	4

Decision tree Rainfed 14: (r) Rooting conditions **(Rc)**

Land characteristics							Severity level
Soil depth		Coarse fragments topsoil		Coarse fragments subsoil			
class	score	class	score	class	score	total score	
VS < 25cm	5	F	1	n/a	3	9	**4**
	5	M	2	n/a	3	10	**4**
	5	A	3	n/a	3	11	**4**
SS 25-50cm	2	F < 5%	1	F	1	4	**1**
	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 50-100	1	F <5%	1	F	1	3	**1**
	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 100-150	1	F <5%	1	F	1	3	**1**
	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 > 150	1	F <5	1	F	1	3	**1**
	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 15: (u) Excess of salts (sodicity) **(Rc, Rk, Rm1, Rs1)**

Land Characteristic		Severity level	
		LUT	
Sodicity (topsoil)		**Rc, Rm1, Rs1**	**Rk**
code	ESP		
NS	< 6	**1**	**1**
MS	6-15	**1**	**1**
SO	15-25	**2**	**1**
VS	25-40	**3**	**2**
ES	> 40	**4**	**3**

Decision tree Rainfed 16: (w) Oxygen availability (drainage) **(Rc, Rk, Rm1, Rs1)**

Land Characteristic	Severity level
Drainage class	
6,5,4,3	**1**
2	**2**
1, 0	**3**

Decision tree Rainfed 17: (z) Excess of salts (salinity) **(Rc, Rk, Rm1, Rs1)**

Land Characteristic		Severity level		
		LUT		
Salinity (topsoil)		**Rk,**	**Rs1**	**Rc, Rm1**
code	EC (dS/m)			
NS	> 2	**1**	**1**	**1**
SS	2-3	**1**	**1**	**1**
MS	3-5	**1**	**1**	**2**
SA	5-8	**1**	**2**	**3**
VS	8-12	**2**	**3**	**4**
ES	> 12	**3**	**4**	**4**

ANNEX 8: SOMALES: Severity level decision trees for Irrigated Agriculture

Land Use Types (LUT):

- Ir: Flood irrigation of paddy **rice**, small-scale, low-medium input (NPK fertilizer)
- Ic: Gravity irrigation of **citrus** and other fruits, medium-high input (seedlings, fertilizer, pesticides)
- Is: Gravity irrigation of **sugarcane**, medium-high input (fertilizer, pesticides)

Decision tree Irrigated 1: (f) Flooding hazard (flash-flooding) **(Ic, Ir, Is)**

Land characteristics					Severity level
Relief		Soil Group			
class	score	class	score	total score	
1, 3, 4a, 4b	1	1,3,6,7	1	2	**1**
	1	4,5a,5b	2	3	**1**
	1	2,5c	4	5	**2**
2a	2	1,3,6,7	1	3	**1**
	2	4,5a,5b	2	4	**1**
	2	2,5c	4	6	**3**
2b	3	1,3,6,7	1	4	**1**
	3	4,5a,5b	2	5	**2**
	3	2,5c	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 (Soil Group 4) are likely to have periodically high groundwater table				2-4 5 6-7	1 2 3

Decision tree Irrigated 2: (i) Inundation (flooding) hazard **(Ic, Is, Ir)**

Land characteristics						Severity level	
Relief	Slope		Soil Group			LUT	
						Ic, Is	**Ir**
class	class	score	class	score	total score		
1,3,4a,4b	all	1	all	1	2	**1**	**1**
2b	1c,2,3,4,5 (> 2%)	1	all	2	3	**1**	**1**
	1b (1-2%)	2	1,3,6,7	1	3	**1**	**1**
		2	4,5a,5b	2	4	**2**	**1**
		2	2,5c	3	5	**2**	**1**
	1a (< 1%)	3	1,3,6,7	1	4	**2**	**1**
		3	4,5a,5b	2	5	**2**	**1**
		3	2,5c	3	6	**2**	**1**
2a	1a,1b,1c,2,3,4,5	5	1,3,6,7	1	6	**2**	**1**
		5	4,5a,5b	2	7	**3**	**1**
		5	2,5c	3	8	**3**	**2**
Assumptions: - Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b) - Fluvisols (Soil Group 2) are indicative for flooding - No inundation on sloping land - Only severe and prolonged inundation is a limitation for paddy rice (Ir)					2-3 4-6 7-8	1 2 3	1 1 1-2

Decision tree Irrigated 3: (n) <u>Nutrient availability</u> **(Ic, Ir)**

Land characteristics							Severity level
pH(H2O) (topsoil)		CEC (25-75cm) (topsoil)		Ca/Mg *(see tree 5)* (topsoil)			
class	score	class	score	class	score	total score	
NE 6.6-7.5	1	L <16	4	VL, VH	3	8	**3**
	1		4	L, H	2	7	**3**
	1		4	M	1	6	**2**
	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 7.5-8.5	3	L	4	VL, VH	3	10	**3**
	3		4	L, H	2	9	**3**
	3		4	M	1	8	**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**
VA >8.5	5	L	4	VL, VH	3	12	**3**
	5		4	L, H	2	11	**3**
	5		4	M	1	10	**3**
	5	M	2	VL, VH	3	10	**3**
	5		2	L, H	2	9	**3**
	5		2	M	1	8	**3**
	5	H	1	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						3-5 6 7-12	1 2 3

Decision tree Irrigated 4: (n) <u>Nutrient availability</u> **(Is)**

Land characteristics							Severity level
pH(H2O) (topsoil)		CEC (25-75cm) (topsoil)		Ca/Mg *(see tree 5)* (topsoil)			
class	score	class	score	class	score	total score	
NE 6.6-7.5	1	L <16	4	VL, VH	3	8	**3**
	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 7.5-8.5	2	L	4	VL, VH	3	9	**3**
	2		4	L, H	2	8	**3**
	2		4	M	1	7	**3**
	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 >8.5	4	L	4	VL, VH	3	11	**3**
	4		4	L, H	2	10	**3**
	4		4	M	1	9	**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 6 7-11	1 2 3

Decision tree Irrigated 5: Ca/Mg ratio

Land characteristics				Ca/Mg ratio	
Ca++		Mg++		ranges	classes
code	me/100g	code	me/100g		
L	< 10	L	< 1	10	**M**
		M	1-5	0.2-10	**L**
		H	5-10	<1	**VL**
		V	>10	0.05-1	**VL**
M	10-25	L	<1	>10	**H**
		M	1-5	2-25	**M**
		H	5-10	1-5	**M**
		V	>10	<2.5	**L**
H	25-50	L	<1	>50	**VH**
		M	1-5	5-50	**H**
		H	5-10	2.5-10	**M**
		V	>10	<5	**L**
V	> 50	L	<1	>50	**VH**
		M	1-5	>10	**H**
		H	5-10	5-20	**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 Irrigated 6: (q) Water availability for gravity irrigation **(Ic, Ir, Is)**

Land Characteristics		Severity level	
		LUT	
		Ic, Is	**Ir**
Relief class	LGP class		
1, 3, 4a, 4b	all	**4**	**4**
2a	1-9	**4**	**4**
	10-15	**4**	**3**
2b	all	**1**	**1**
Assumptions: - Floodplains and alluvial plains close to running water - Small-scale paddy rice may also be possible in shallow depressions away from running water in areas with relatively long Growing Period			

Decision tree Irrigated 7: (r) Rooting conditions **(Ic, Is)**

Land characteristics							Severity level
Soil depth		Coarse fragments (topsoil)		Coarse fragments (subsoil)			
class	score	class	score	class	score	total score	
VS < 25cm	10	F	1	n/a	3	14	**4**
	10	M	2	n/a	3	15	**4**
	10	A	3	n/a	3	16	**4**
SS 25-50cm	7	F < 5%	1	F	1	9	**3**
	7		1	M	2	10	**3**
	7		1	A	3	11	**3**
	7	M 5-40	2	F	1	10	**3**
	7		2	M	2	11	**3**
	7		2	A	3	12	**3**
	7	A >40%	3	F	1	11	**3**
	7		3	M	2	12	**3**
	7		3	A	3	13	**3**
MD 50-100	4	F <5%	1	F	1	6	**2**
	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	**3**
	4	A >40%	3	F	1	8	**2**
	4		3	M	2	9	**3**
	4		3	A	3	10	**3**
DD 100-150	2	F <5%	1	F	1	4	**1**
	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	**2**
	2		2	A	3	7	**2**
	2	A >40	3	F	1	6	**2**
	2		3	M	2	7	**2**
	2		3	A	3	8	**2**
VD > 150	1	F <5	1	F	1	3	**1**
	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	**2**
	1		3	A	3	7	**2**
						3-5	1
						6-8	2
						9-13	3
						14-16	4

Decision tree Irrigated 8: (r) <u>Rooting conditions</u> **(Ir)**

Land characteristics							Severity level
Soil depth		Coarse fragments (topsoil)		Coarse fragments (subsoil)			
class	score	class	score	class	score	total score	
VS < 25cm	13	F	1	n/a	n/a	14+	**4**
	13	M	3	n/a	n/a	16+	**4**
	13	A	6	n/a	n/a	19+	**4**
SS 25-50cm	4	F < 5%	1	F	1	6	**2**
	4		1	M	2	7	**2**
	4		1	A	3	8	**2**
	4	M 5-40	3	F	1	8	**2**
	4		3	M	2	9	**3**
	4		3	A	3	10	**3**
	4	A >40%	6	F	1	11	**3**
	4		6	M	2	12	**3**
	4		6	A	3	13	**3**
MD 50-1003	2	F <5%	1	F	1	4	**1**
	2		1	M	2	5	**1**
	2		1	A	3	6	**2**
	2	M 5-40	3	F	1	6	**2**
	2		3	M	2	7	**2**
	2		3	A	3	8	**2**
	2	A >40%	6	F	1	9	**3**
	2		6	M	2	10	**3**
	2		6	A	3	11	**3**
DD, VD > 100	1	F <5%	1	F	1	3	**1**
	1		1	M	2	4	**1**
	1		1	A	3	5	**1**
	1	M 5-40	3	F	1	5	**1**
	1		3	M	2	6	**2**
	1		3	A	3	7	**2**
	1	A >40%	6	F	1	8	**2**
	1		6	M	2	9	**3**
	1		6	A	3	10	**3**
						3-5	1
						6-8	2
						9-13	3
						14-16	4

Decision tree Irrigated 9: (t) topographic conditions for gravity irrigation **(Ic, Is)**

Land characteristics						Severity level
Relief		Slope				
class	score	class	%	score	total score	
1,4a, 4b	8	1a	0-1	2	10	**3**
	8	1b	1-2	1	9	**3**
	8	1c	2-4	2	10	**3**
	8	2	4-10	4	12	**4**
	8	3,4,5	> 10%	8	16	**4**
3	5	1a	0-1	2	7	**2**
	5	1b	1-2	1	6	**2**
	5	1c	2-4	2	7	**2**
	5	2	4-10	4	9	**3**
	5	3,4,5	> 10%	8	13	**4**
2a	3	1a	0-1	2	5	**2**
	3	1b	1-2	1	4	**2**
	3	1c	2-4	2	5	**2**
	3	2	4-10	4	7	**3**
	3	3,4,5	> 10%	8	11	**4**
2b	1	1a	0-1	2	3	**1**
	1	1b	1-2	1	2	**1**
	1	1c	2-4	2	3	**1**
	1	2	4-10	4	5	**2**
	1	3,4,5	> 10%	8	9	**4**
Note: this decision tree refers to gravity irrigation only - ideal slope assumed to be 1-2%						
					2-3	1
					4-5	2
					6-8	3
					9-16	4

Decision tree Irrigated 10: (t) topographic conditions for gravity irrigation **(Ir)**

Land characteristics						Severity level
Relief		Slope				
class	score	class	%	score	total score	
1,4a, 4b	8	1a	0-1	1	9	**3**
	8	1b	1-2	2	10	**3**
	8	1c	2-4	5	13	**4**
	8	2,3,4,5	> 4	8	16	**4**
3	5	1a	0-1	1	12	**3**
	5	1b	1-2	2	7	**3**
	5	1c	2-4	5	10	**4**
	5	2,3,4,5	> 4	8	13	**4**
2a	1	1a	0-1	1	2	**1**
	1	1b	1-2	2	3	**1**
	1	1c	2-4	5	6	**3**
	1	2,3,4,5	> 4	8	9	**3**
2b	2	1a	0-1	1	3	**1**
	2	1b	1-2	2	4	**2**
	2	1c	2-4	5	7	**3**
	2	2,3,4,5	> 4	8	10	**4**
Note: this decision tree refers to irrigation by flooding and ponding for paddy rice only - ideal slope assumed to be < 1%						
					2-3	1
					4-5	2
					6-8	3
					9-16	4

Decision tree Irrigated 11: (u) Excess of salts (sodicity) **(Ic, Ir, Is)**

Land Characteristic		Severity level	
		LUT	
Sodicity (topsoil)		**Ic, Is**	**Ir**
code	ESP		
NS	< 6	**1**	**1**
MS	6-15	**1**	**1**
SO	15-25	**1**	**2**
VS	25-40	**2**	**3**
ES	> 40	**3**	**4**
Assumptions: - Sodicity levels can be manipulated to some extent under good management (LUTs Ic, Is) in well drained soils - Sodicity levels not easily lowered in depressions with poorly drained soils (LUT Ir)			

Decision tree Irrigated 12: (w) Oxygen availability (drainage) and permeability **(Ic, Ir, Is)**

Land Characteristic	Severity level	
	LUT	
Drainage class	**Ic, Is**	**Ir**
6,5	**1**	**4**
4	**1**	**3**
3	**1**	**2**
2	**2**	**1**
1	**3**	**1**
0	**4**	**1**
This decision tree relates to Oxygen availability for citrus and sugarcane (favouring well drained soils) and to Permeability for paddy rice (requiring low permeability, usually associated with poor drainage)		

Decision tree Irrigated 13: (z) Excess of salts (salinity) **(Ic, Ir, Is)**

Land Characteristic		Severity level	
		LUT	
Salinity (topsoil)		**Ic, Is**	**Ir**
code	EC (dS/m)		
NS	< 2	**1**	**1**
SS	2-3	**1**	**1**
MS	3-5	**2**	**2**
SA	5-8	**2**	**3**
VS	8-12	**3**	**3**
ES	> 12	**3**	**4**
Assumptions: - Salinity levels can be manipulated to some extent under good management (LUTs Ic, Is) in well drained soils - Salinity levels not easily lowered in depressions with poorly drained soils (LUT Ir)			

ANNEX 9: 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			
		Land Use Type			
Slope class	Coarse fragments (topsoil)	**Pg** Goats	**Ps** Sheep	**Pd** Camels	**Pc** Cattle
1a,1b,1c (0-4%)	F	**1**	**1**	**1**	**1**
	M	**1**	**1**	**1**	**1**
	D	**1**	**2**	**2**	**2**
2 (4-10%)	F	**1**	**1**	**1**	**1**
	M	**1**	**1**	**2**	**2**
	D	**1**	**2**	**2**	**3**
3,4 (10-25%)	F	**1**	**1**	**2**	**2**
	M	**1**	**1**	**2**	**3**
	D	**2**	**2**	**2**	**3**
5 (> 25%)	F	**1**	**3**	**4**	**4**
	M	**2**	**3**	**4**	**4**
	D	**2**	**4**	**4**	**4**

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

Land Characteristic		Severity level		
		Land Use Type		
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) REF !!				

Decision tree pastoralism 3: (d) Erosion hazard - wind **(Pc, Pd, Pg, Ps)**

Land Characteristic	Severity level
Relief class	
1, 2a, 2b, 3, 4a	**1**
4b	**3**

Decision tree pastoralism 4: (e) Erosion hazard **(Pc, Pd, Pg, Ps)**

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

Decision tree pastoralism 5: (m) Moisture availability **(Pc, Pd, Pg, Ps)**

(this tree relates to herbaceous plant growth and potential biomass production)

Land characteristics							Severity level
LGP Zone		Rainfall variability		Soil Group			
class	score	class	score	class	score	total score	
1	10	H	5	3	4	19	**4**
	10	H	5	1,4,7	2	17	**4**
	10	H	5	2,5abc	1	16	**4**
	10	H	5	6	0	15	**3**
2	8	H	4	3, 6	4	16	**4**
	8	H	4	1,4,7	2	13	**3**
	8	H	4	2,5abc	1	12	**3**
3	6	L	1	3,6	4	11	**3**
	6	L	1	1,4,7	2	9	**3**
	6	L	1	2,5abc	1	8	**2**
4	6	M	2	3, 6	4	12	**3**
	6	M	2	1,4,7	2	10	**3**
	6	M	2	2,5abc	1	9	**3**
5	6	M	2	3, 6	4	12	**3**
	6	M	2	1,4,7	2	10	**3**
	6	M	2	2,5abc	1	9	**3**
6, 7	4	M	2	3, 6	4	10	**3**
	4	M	2	1,4,7	2	8	**2**
	4	M	2	2,5abc	1	7	**2**
8, 9, 10	3	M	2	3, 6	4	9	**3**
	3	M	2	1,4,7	2	7	**2**
	3	M	2	2,5abc	1	6	**2**
11	3	L	1	3, 6	4	8	**2**
	3	L	1	1,4,7	2	6	**2**
	3	L	1	2, 5abc	1	5	**2**
12	2	L	1	3, 6	4	7	**2**
	2	L	1	1,4,7	2	5	**2**
	2	L	1	2,5abc	1	4	**1**
13	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,7	2	4	**1**
	1	L	1	2,5abc	1	3	**1**
14	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,7	2	4	**1**
	1	L	1	2,5abc	1	3	**1**
15	1	L	1	3, 6	4	6	**2**
	1	L	1	1,4,7	2	4	**1**
	1	L	1	2,5abc	1	3	**1**
Assumptions: - Shallow and sandy soils have low waterholding capacity (Soil Groups 3 & 6); Fluvisols, or soils with fluvic properties imply water-receiving topographic position)							
						3-4	1
						5-8	2
						9-15	3
						16-19	4

Decision tree pastoralism 6: (n) <u>Nutrient availability</u> **(Pc, Pd, Pg, Ps)**

(this tree relates to herbaceous plant growth and potential biomass production)

Land characteristics					Severity level
Organic Carbon (topsoil)		CEC (topsoil)			
class	score	class	score	total score	
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, HI	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 7: (p) <u>Pests and diseases (tsetse)</u> **(Pc, Pd, Pg, Ps)**

Land characteristics			Severity level
LGP	Mean annual temp (Ta)	Relief	
class	class	class	
1-7	all	all	**1**
8-15	CC-HH (< 26 °C)	all	**1**
	VH, EH (26-30 °C)	1, 2a, 3, 4a, 4b	**1**
		2b	**2**
- Tsetse fly most prominent in riverine areas (floodplains, alluvial plains) occurs in areas with relatively long growing period and high temperatures - Under good management, tsetse infested areas can still be productive and the maximum severity level has been set at "2" (slight limitation).			

Decision tree pastoralism 8: (r) <u>Rooting conditions</u> **(Pc, Pd, Pg, Ps)**

(this tree relates to herbaceous plant growth and potential biomass production)

Land characteristics							Severity level
Soil depth		Coarse fragments (topsoil)		Coarse fragments (subsoil)			
class	score	class	score	class	score	total score	
VS < 25cm	10	F	1	n/a	3	14	**3**
	10	M	2	n/a	3	15	**3**
	10	D	3	n/a	3	16	**3**
SS 25-50cm	4	F < 5%	1	F	1	6	**1**
	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 50-100	3	F <5%	1	F	1	5	**1**
	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 100-150	2	F <5%	1	F	1	4	**1**
	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 > 150	1	F <5	1	F	1	3	**1**
	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 9: (u) Excess of salts (sodicity) **(Pc, Pd, Pg, Ps)**

(this tree relates to herbaceous plant growth and potential biomass production)

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

Decision tree pastoralism 10: (v) Vegetation / Land cover (fodder availability) **(Pd, Pg)**

Land characteristics					Severity level
Land Cover (simplified classes)		LGP Zone			
class	score	LGP Zone	score	total score	
12,13,14 (no cover)	15	all		15+	**4**
1-5 (agriculture)	5	2	7	12	**3**
	5	4,5	6	11	**3**
	5	6,7	5	10	**2**
	5	8,9	4	9	**2**
	5	10	3	8	**2**
	5	13	2	7	**2**
	5	14,15	1	6	**2**
6,7 (herbaceous)	4	2	7	11	**3**
	4	4,5	6	10	**3**
	4	6,7	5	9	**2**
	4	8,9	4	8	**2**
	4	10	3	7	**2**
	4	13	2	6	**2**
	4	14,15	1	5	**1**
9,10 (open shrub, open trees)	2	2	7	9	**2**
	2	4,5	6	8	**2**
	2	6,7	5	7	**2**
	2	8,9	4	6	**2**
	2	10	3	5	**1**
	2	13	2	4	**1**
	2	14,15	1	3	**1**
8,11 (closed shrub, closed trees)	2	2	7	9	**2**
	2	4,5	6	8	**2**
	2	6,7	5	7	**2**
	2	8,9	4	6	**2**
	2	10	3	5	**1**
	2	13	2	4	**1**
	2	14,15	1	3	**1**
Notes: • 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 LGP zone do not occur in reality				3-5 6-10 10-12 13-15	1 2 3 4

Decision tree pastoralism 11: (v) Vegetation / Land cover (fodder availability) **(Pc, Ps)**

Land characteristics					Severity level
Land Cover (simplified classes)		LGP Zone			
class	score	LGP Zone	score	total score	
12,13,14 (no cover)	15	all		15+	**4**
1-5 (agriculture)	5	2	7	12	**3**
	5	4,5	6	11	**3**
	5	6,7	5	10	**2**
	5	8,9	4	9	**2**
	5	10	3	8	**2**
	5	13	2	7	**2**
	5	14,15	1	6	**2**
6,7 (herbaceous)	2	2	7	9	**2**
	2	4,5	6	8	**2**
	2	6,7	5	7	**2**
	2	8,9	4	6	**2**
	2	10	3	5	**1**
	2	13	2	4	**1**
	2	14,15	1	3	**1**
9,10 (open shrub, open trees)	4	2	7	11	**3**
	4	4,5	6	10	**3**
	4	6,7	5	9	**2**
	4	8,9	4	8	**2**
	4	10	3	7	**2**
	4	13	2	6	**2**
	4	14,15	1	5	**1**
8,11 (closed shrub, closed trees)	5	2	7	12	**3**
	5	4,5	6	11	**3**
	5	6,7	5	10	**3**
	5	8,9	4	9	**2**
	5	10	3	8	**2**
	5	13	2	7	**2**
	5	14,15	1	6	**2**
Notes:					
• Seasonal movement of livestock between various zones assumed				3-5	1
• In agricultural land some grazing available between fields and also crop residues and weeds (cut & carry in orchards)				6-10	2
				10-12	3
• Some combinations of land cover and LGP zone do not occur in reality				13-15	4

Decision tree pastoralism 12: (y) Water availability (for animals) **(Pd, Pc, Pg, Ps)**

(not presently applied in SOMALES)

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

Decision tree pastoralism 13: (z) Excess of salts (salinity) **(Pc, Pd, Pg, Ps)**

(this tree relates to herbaceous plant growth and potential biomass production)

Land Characteristic		Severity level
Salinity (topsoil)		
class	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 10: 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)
- Fce: *Casuarina equisetifolia* (timber, fuel, soil conservation)
- Fcl: *Conocarpus lancifolius* (fodder, timber, fuel, soil cons.)
- Fdg: *Dobera glabra* (fodder, fuel)
- Fti: *Tamarindus indica* (fodder, timber, fuel)

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

Land characteristics		Severity level (1-4)	
Altitude (masl)	Ta (°C)	Land Use Type	
		Fan, Fat, Fcl, Fti	**Fai, Fce, Fdg**
1550-1875	WA (18-20)	**3**	**2**
900-1550	VW (20-24)	**2**	**1**
300-900	HO (24-28)	**1**	**1**
0-300	VH (28-30)	**1**	**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
Relief (classes)		Soil Group			
	score		score	total score	
1, 3, 4a, 4b	1	1,3,6,7	1	2	**1**
	1	5a, 5b	2	3	**1**
	1	4	3	4	**2**
	1	2, 5c	4	5	**2**
2b	2	1,3,6,7	1	3	**1**
	2	5a, 5b	2	4	**2**
	2	4	3	5	**2**
	2	2, 5c	3.5	5.5	**2**
2a	3	1,3,6,7	1	4	**2**
	3	5a, 5b	2	5	**2**
	3	4	3	6	**3**
	3	2, 5c	3.5	6.5	**4**
Assumptions: - Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b) - Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (Soil Group 4) and Stagnosols (Soil Group 5c) are likely to have seasonally high groundwater table					
				2-3	1
				4-5.5	2
				6	3
				6.5	4

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

Land characteristics					Severity level
Relief (classes)		Soil Group			
class	score	class	score	total score	
1, 3, 4a, 4b	1	1,3,6,7	1	2	**1**
	1	5a,5b	2	3	**1**
	1	4	3	4	**1**
	1	2,5c	4	5	**1**
2b	2	1,3,6,7	1	3	**1**
	2	5a,5b	2	4	**1**
	2	4	3	5	**1**
	2	2,5c	3.5	5.5	**2**
2a	3	1,3,6,7	1	4	**1**
	3	5a,5b	2	5	**1**
	3	4	3	6	**2**
	3	2,5c	3.5	6.5	**3**
Assumptions: - Flooding (inundation) most likely in water receiving sites (relief classes 2a, 2b) - Fluvisols (Soil Group 2) are indicative for flooding and Solonchaks (Soil Group 4) and Stagnosols (SG 5c) are likely to have periodically high groundwater table				2-3 4-6 6.5	1 2 3

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

Land characteristics		Severity level
Relief (classes)	Soil Group	
class	class	
1, 2b, 3, 4a, 4b	1,3,4,5a,5b,6,7	**1**
2a	2, 5c	**2**
Note: Acacia nilotica thrives well under periodic inundation		

Decision tree forestry 5: (m) <u>Moisture availability</u> **(Fai, Fan, Fat, Fcl, Fdg, Fti)**

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

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

Fat, Fcl score	rating	Fdg, Fti score	rating	Fan score	rating	Fai score	rating
2-5	1	2-4	1	2-4	1	2-3	1
6-8	2	5-6	2	5	2	4-5	2
9-11	3	7-8	3	6-7	3	6-7	3
12-14	4	9-14	4	8-14	4	8-14	4

Decision tree forestry 6: (m) <u>Moisture availability</u> **(Fce)**

Land characteristics					Severity level
LGP Zone		Soil Group			
class	score	class	score	total score	
1	10	2,5c	2	12	**4**
	10	6	1	11	**4**
	10	1,4,5ab,7	5	15	**4**
	10	3	6	16	**4**
2	8	2,5c	2	10	**3**
	8	6	1	9	**3**
	8	1,4,5ab,7	5	13	**4**
	8	3	6	14	**4**
3	7	2,5c	2	9	**3**
	7	6	1	8	**3**
	7	1,4,5ab,7	5	12	**4**
	7	3	6	13	**4**
4, 5	6	2,5c	2	8	**3**
	6	6	1	7	**2**
	6	1,4,5ab,7	5	11	**4**
	6	3	6	12	**4**
6, 7	5	2,5c	2	7	**2**
	5	6	1	6	**2**
	5	1,4,5ab,7	5	10	**3**
	5	3	6	11	**4**
8, 9	4	2,5c	2	6	**2**
	4	6	1	5	**2**
	4	1,4,5ab,7	5	9	**3**
	4	3	6	10	**3**
10 – 12	3	2,5c	2	5	**2**
	3	6	1	4	**2**
	3	1,4,5ab,7	5	8	**3**
	3	3	6	9	**3**
13, 14	2	2,5c	2	4	**2**
	2	6	1	3	**1**
	2	1,4,5ab,7	5	7	**2**
	2	3	6	8	**3**
15	1	2,5c	2	3	**1**
	1	6	1	2	**1**
	1	1,4,5ab,7	5	6	**2**
	1	3	6	7	**2**
Casuarina equisetifolia considered drought tolerant and prefers coarse-textured soils.					
				2-3	1
				4-7	2
				8-10	3
				11-14	4

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

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

Fan, Fce: total score	Severity	Fat, Fai, Fcl, Fdg, Fti: total score	Severity
3-5	1	3-7	1
6-8	2	8-11	2
9-13	3	12-13	3
14-16	4	14-16	4