

## CHAPTER ONE

### 1.1 General

Eritrea is a country that emerged as a nation after a long fierce fighting for independence against Ethiopia. Its natural resources are not abundant and like all other sectors, including the infrastructure, have suffered serious damage during the long lasting war, thus negatively affecting its productive capacity. The territory used to be one of the most developed areas in terms of agriculture and light industry. But because of wrong policies of the Ethiopian government the capacity had been reduced to below subsistence i.e. most people depends on food aid for their survival (CIA, 1999).

The FAO (1994a) report on Eritrea suggested there is reason for optimism, however. In the first place the Eritrean people are a hard working and resourceful and secondly, it is the human factor that counts more than the abundance of resource endowment, as the history of many nations demonstrates. The later is true but it doesn't mean that natural resources are not important. In fact natural resources, like human resources, are very important to a country like Eritrea where more than 70% of the population is dependent on agriculture. So in order to use natural resources appropriately without degrading them, proper evaluation of natural resources is very important for planners and other policy makers to decide on proper land use.

### 1.2 Research initiatives

Natural resources are the basis for the existence of human beings. Their distribution differs from one region to the other and from one country to another. Eritrea, like most sub-Saharan African countries, has limited natural resources especially rainfall. Its erratic nature and uneven distribution seriously limits successful rain-fed agriculture. In addition soil erosion (water and wind) increases the danger of reducing the fertility and sustainability of these natural resources (especially soils).

People have every right to use the existing natural resources for their benefit, but only without jeopardising the ability of future generations to use these resources

(Norgaard, 1994). This is the essence of sustainable use of natural resources, but this is only possible when the nature and qualities of the existing natural resources are known and policies and strategies for their optimal use and conservation are in place. Land is the core of all natural resources whether it is used for agriculture or otherwise. The initiative for this project emerged from the fact that evaluating the land and utilising it to its maximum capacity without endangering the environment is the best way to ensure sustainable use of land. I believe there is a shortage in terms of a suitable strategy and system of land evaluation for the Eritrean situation. It is hoped that this dissertation will contribute to the sustainable use of the natural resources of Eritrea without negatively affecting the social and economic livelihood of the present communities. That is it aims to promote “inter-generation equity” in terms of land use by looking at **both** present and future generations, and **not only** at future generations, as is often implied (Laker, personal communication).

### 1.3 Objectives of the study

The general objective of the study was to develop an appropriate strategy and system of land suitability evaluation for Eritrean situation. The specific objectives are:

- I To examine the strategy and system of land evaluation currently used in Eritrea.
- II To compare major land capability and suitability schemes/systems available in different parts of the world.
- III To look at the advantages and disadvantages of these different land evaluation systems in relation to the Eritrean situation.
- IV To design a step by step strategy and system of land suitability evaluation for Eritrea.

## 1.4 Research methodology

The study consisted of three main parts viz.:

- A. Collection and analyses of data on the present situation regarding land evaluation in Eritrea. This was done by consulting bodies like NGOs, working with in the country, the FAO and the Eritrean ministries of Agriculture and Land, Water and Environment.
- B. In-depth studies of various land evaluation systems developed and used in different parts of the world. From these principles, concepts and approaches, which could be useful to incorporate in a land evaluation strategy and system for Eritrea, were identified.
- C. Synthesis of a proposed land evaluation strategy and system for Eritrea.

## 1.5 Information about Eritrea

### 1.5.1 History of Eritrea

On first January 1890, Italy set the boundaries of Eritrea and ruled it as a colony until 1941. After the British defeated the Italians in Africa, the British then took over the administration of Eritrea. Following a decision by the United Nations, Eritrea was federated to Ethiopia in 1952, with a certain amount of autonomy.

However, during the federation with Ethiopia, Emperor Haile Selassie's government systematically violated the rights granted by the UN. The oppression intensified with the dissolution of the Eritrean parliament and the annexation of Eritrea as Ethiopia's fourteenth province in 1962.

In 1961, an armed struggle for independence began. Thirty years of fighting ended in May 1991, when the Eritrean people's liberation front (EPLF) liberated Asmara and established the provincial government of Eritrea (PGE). In an internationally supervised referendum in April 1993, 99.8% of the Eritreans voted for independence, which was officially declared on 24<sup>th</sup> of May 1993 (Esterhuysen, 1998).

### 1.5.2 Location and size of Eritrea

Eritrea is located in the Northeast of Africa and its geographic co-ordinates are 1500N and 3900E (CIA, 1999) and it is located between 12 and 18 degrees N and between 36 and 44 degrees E. The total area of the country is 121,320 sq. km. It is bordering Sudan in the west and northwest, Red Sea in the north and northeast, Djibouti in the southeast and Ethiopia in the south (Esterhuysen, 1998) (Figure 1.1). Figure 1.2 shows the position of Eritrea in relation to some East and North African countries.

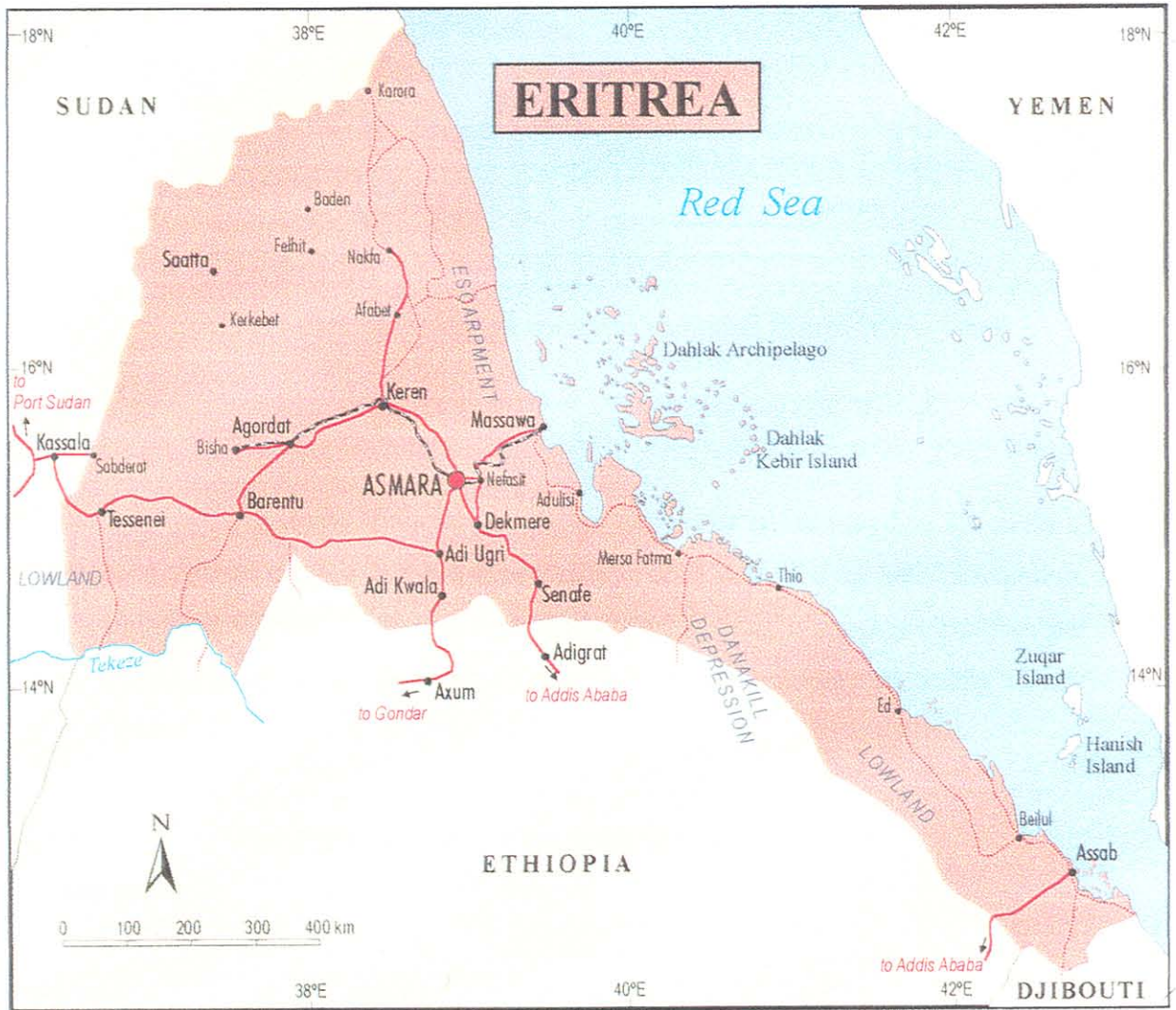


Fig. 1.1: Geographic location of Eritrea (From Esterhuysen, 1998)

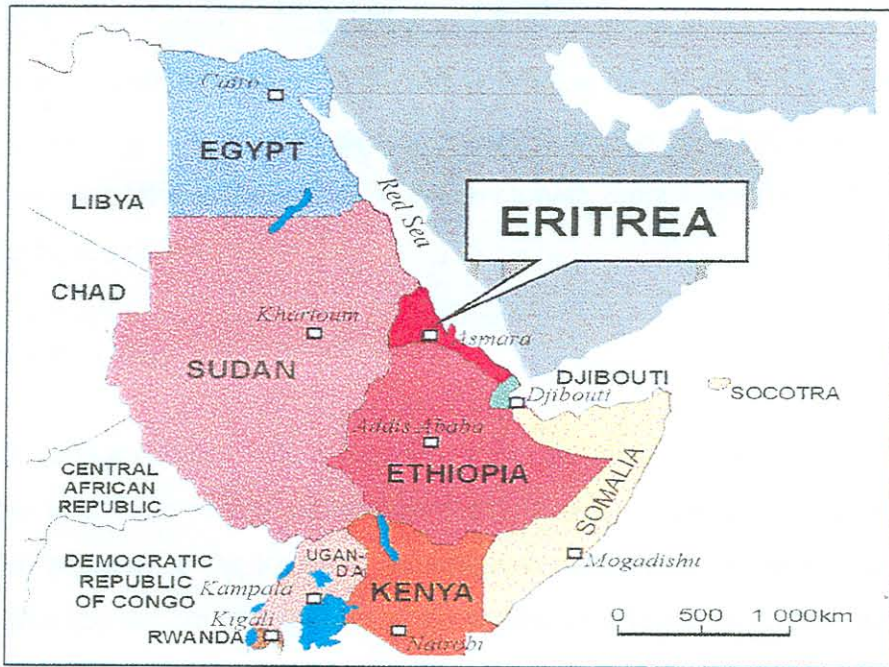


Fig. 2: Map of East and North African countries including Eritrea (CIA, 1999)

### 1.5.3 Population

According to CIA (1999), the total population of Eritrea is estimated to 3,9 million. Population growth is 3.9% and life expectancy is 55,7 years for the total population, 53,6 years for males and 57,9 years for women. Fertility rate is about six children per women. The age structure, percentage, male and female numbers according to age group are as follows:

Table 1.1: Number of people in relation to age groups (CIA, 1999)

Age group	%	Male	Female
0-14	43	859,899	852,329
15-65	54	1,061,921	1,078,102
>65	3	67,969	64,503

### 1.5.4 Natural resources

Natural resources are here discussed in relation to agricultural production capacity. It is impossible to try to discuss all the natural resources of Eritrea and it will be out of the scope of this project. In this section climate, soils, topography and water resources will be discussed.

#### 1.5.4.1 Climate

Eritrea is a country with a complex series of landscape and climatic features, which give to a wide variety of agro-ecological zones. Climate in Eritrea range from hot arid, adjacent to the Red Sea, to temperate sub-humid in isolated micro-catchments within the eastern escarpment of the highlands (Figure 3). According to temperature, around 72% of the country is classified as very hot or hot (with mean annual temperature exceeding 24°C) while not more than 14% is classified as mild or cool (with mean annual temperature below 21.5°C) (Table, 1.2).

Table 1.2 Temperature regimes of Eritrea (Source FAO, 1994a)

Temperature Regime	Mean annual Temperature (°C)	Elevation range (m)	Area	
			Sq.km.	% of country
Very hot	29-26,5	<0-500	40,705	33.4
Hot	26,5-24	500-1000	47,454	38.9
Warm	24-21,5	1000-1500	16,982	13.9
Mild	21,5-19	1500-2000	11,623	9.5
Cool	<19	>2000	5,073	4

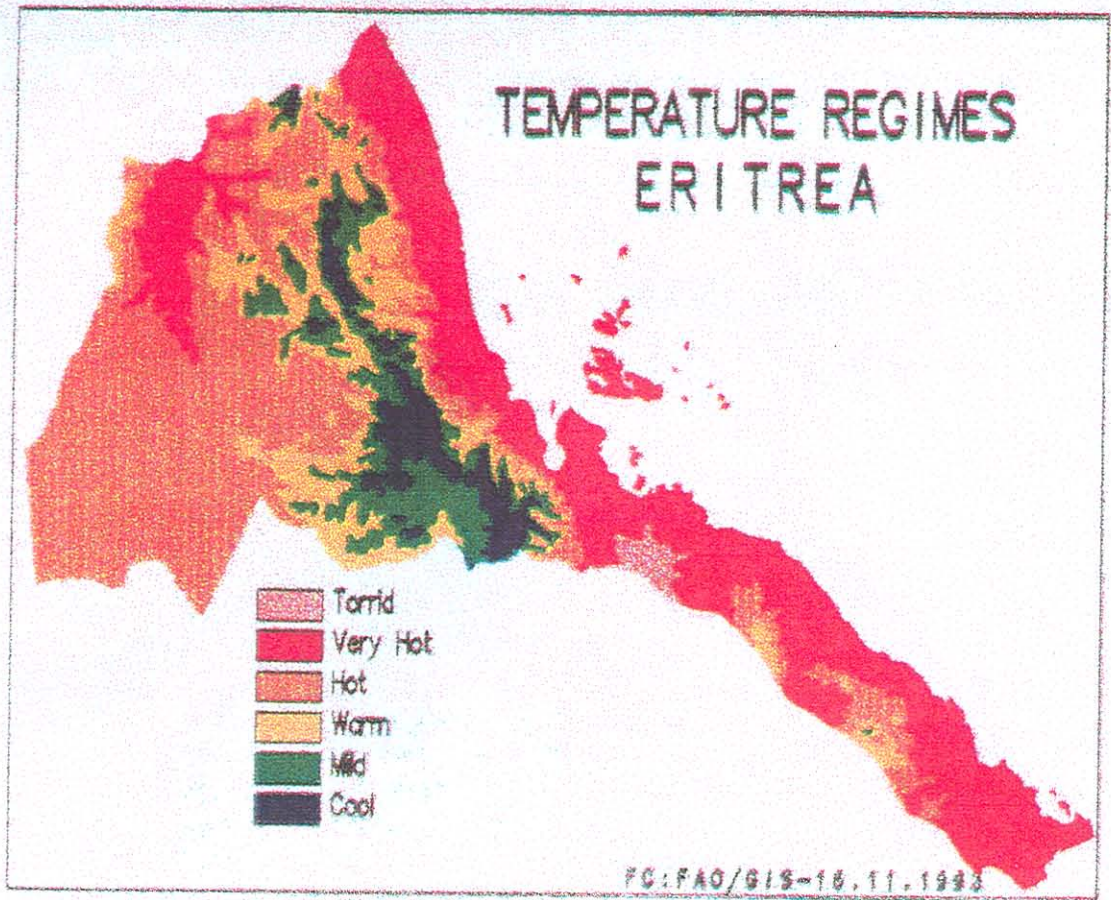


Fig. 1.3: Temperature regime of Eritrea (from FAO, 1994)

Like other Sahelian African countries, Eritrea receives its rainfall from the south-west monsoon in the summer months, from April to October. "Small rain" fall in April and May, and the "main rain" follow in July with the heaviest total precipitation in July and August. Only the coastal plains, and the southern part of the eastern escarpment of the central highlands, have a winter rainfall (November through March) that is borne by north and north-east continental air-streams that carry little moisture until affected by the Red sea where they pick up moisture (FAO, 1994a).

Generally, total annual rainfall tends to increase from north to south; from less than 200 mm at the northern border with Sudan to over 700 mm in a restricted area on the southern border with Ethiopia. A small region, known as the "green belt", on average receives over 900 mm (Figure 1.4).

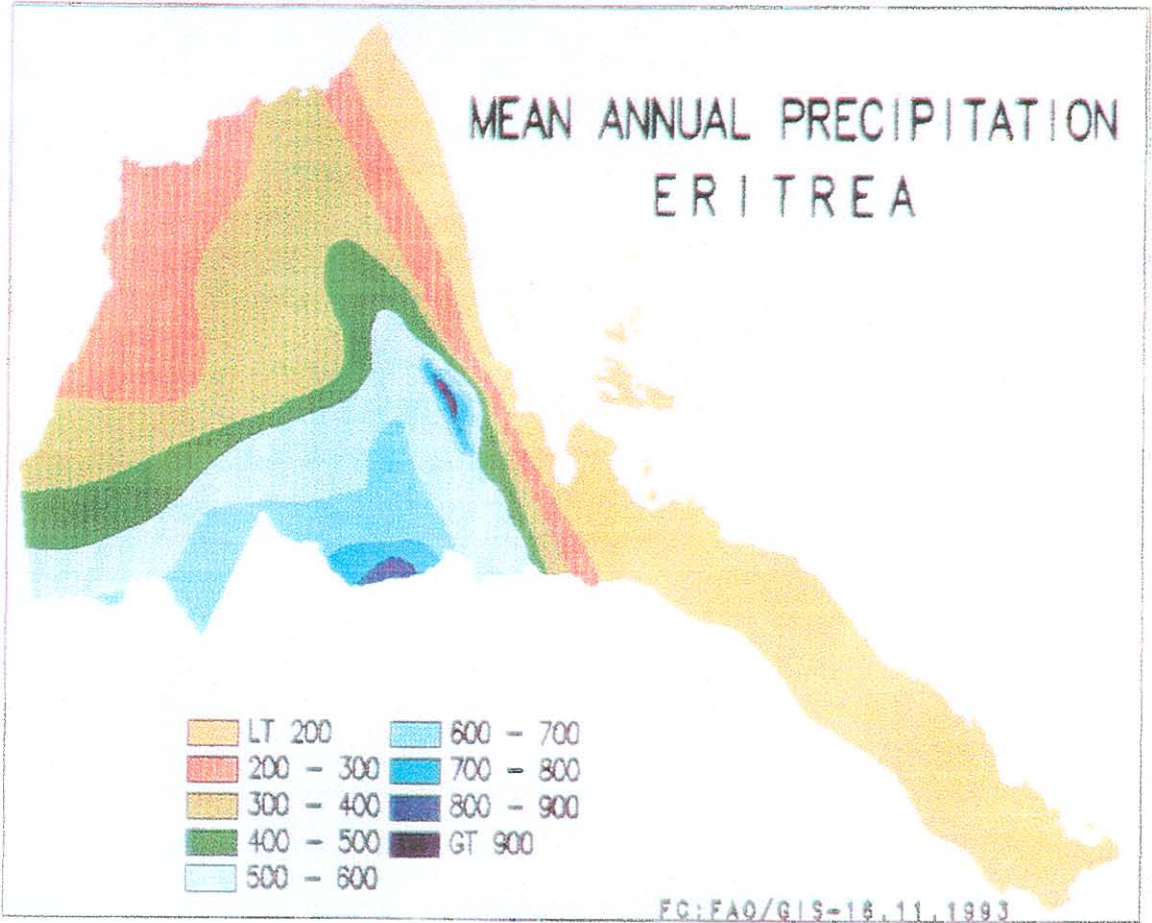


Fig. 1. 4: Map showing distribution of rainfall in Eritrea (FAO, 1994a)

The problem of inadequate total rainfall over much of the country is compounded by the high variability of both total annual rainfall and its intra-annual distribution. All existing and potentially important crop production areas are to varying degrees drought-prone by international standards, with the exception of the small "green belt" mentioned above.

Table 1.3 shows the distribution of rainfall in Eritrea for the past eight years for some representative stations. From this one can understand how skewed the distribution is and how small the total amount of rainfall is. This is to show the nature of rainfall but



data for thirty years should be analysed. The information in Table 1.3 was obtained from the ministry of Agriculture.

Table 1.3 Mean annual rainfall of representative stations of Eritrea (MOA, 2000)

Station	Asab	Massawa	Tessenei	Keren	Agordat	Ghinda	Barentu	Nakfa	Asmara	Adikeyih
Years	1992-1999	1995-1999	1993-1999	1992-1999	1992-1999	1992-1999	1992-1999	1992-1999	1992-1999	1992-1999
Jan.	15.5	22.2	0	0	0	60.7	0	5.5	4.7	1.3
Feb.	8.2	6.8	0	0	0	24.6	0	0.8	0	2
Mar.	9.9	5.8	0	7.4	3.6	40.2	0.7	16.7	9.7	17.4
Apr.	4.5	11.1	2.9	16.3	8.3	53.3	4.1	48.2	17.8	37.4
May	0	5.6	20.6	29.6	26.9	19.5	34.5	48.9	61	41
June	2	0	32.8	61.9	20.9	7	40.9	27.6	13.8	24.3
July	1.1	1	105.9	123.7	117	73.8	151.4	91.8	158.8	135.5
Aug.	18.2	9.4	167.2	177.5	144.5	53.9	156.5	158.9	153.1	71.4
Sep.	1.1	0	65.7	39.7	44.7	16.6	47.8	47.9	23.6	3.8
Oct.	1	35.1	11.2	14.4	11.3	78.3	8.8	42	38.5	20.5
Nov.	1.3	52.4	3.4	2.1	0.8	93	5.6	26	9	10
Dec.	3	41.6	0	0	0	127.2	0	1.4	0	0
Total	113.5	191	409.7	472.6	378	648.1	457.5	515.7	577.3	364.6

#### 1.5.4.2 Soils

According to FAO (1994a), twelve major soil units were identified in Eritrea, these are Arenosols, Solonchaks, Leptosols, Calcisols, Lixisols, Luvisols, Gypsisols, Cambisols, Fluvisols, Nitisols, Vertisols and Regosols. Their distribution is shown on Figure 1.5, and it can be seen that, much of the area is dominated by Leptosols, which are weakly developed shallow soils (FAO-UNESCO, 1990). Some of the most important characteristics of each soil unit are explained as follows and the general description of the soil and the origins of the name are presented in Appendix 1.

**Arenosols:** Connotative of weakly developed coarse textured soils (FAO-UNESCO, 1990). These soils can be found in different environments and the possibilities to use them for agriculture vary accordingly. All Arenosols have certain features in common i.e. their texture is coarse, which is accountable for their high permeability and low water holding capacity (FAO-UNESCO, 1991). Arenosols of arid area, with annual rainfall of <300 mm, are mostly used for extensive (nomadic) grazing. If the rainfall is >300 mm, dry farming could be possible. Good yields of small grains, pulses, melons and fodder crops have been obtained on irrigated Arenosols but high percolation

Arenosols but high percolation losses often make surface irrigation impossible. The low coherence, low nutrient storage capacity and high sensitivity to erosion (especially wind erosion) are further limitations of Arenosols in the dry zone (Driessen and Dudal, 1991). Eritrea has <1% of the total area covered by Arenosols.

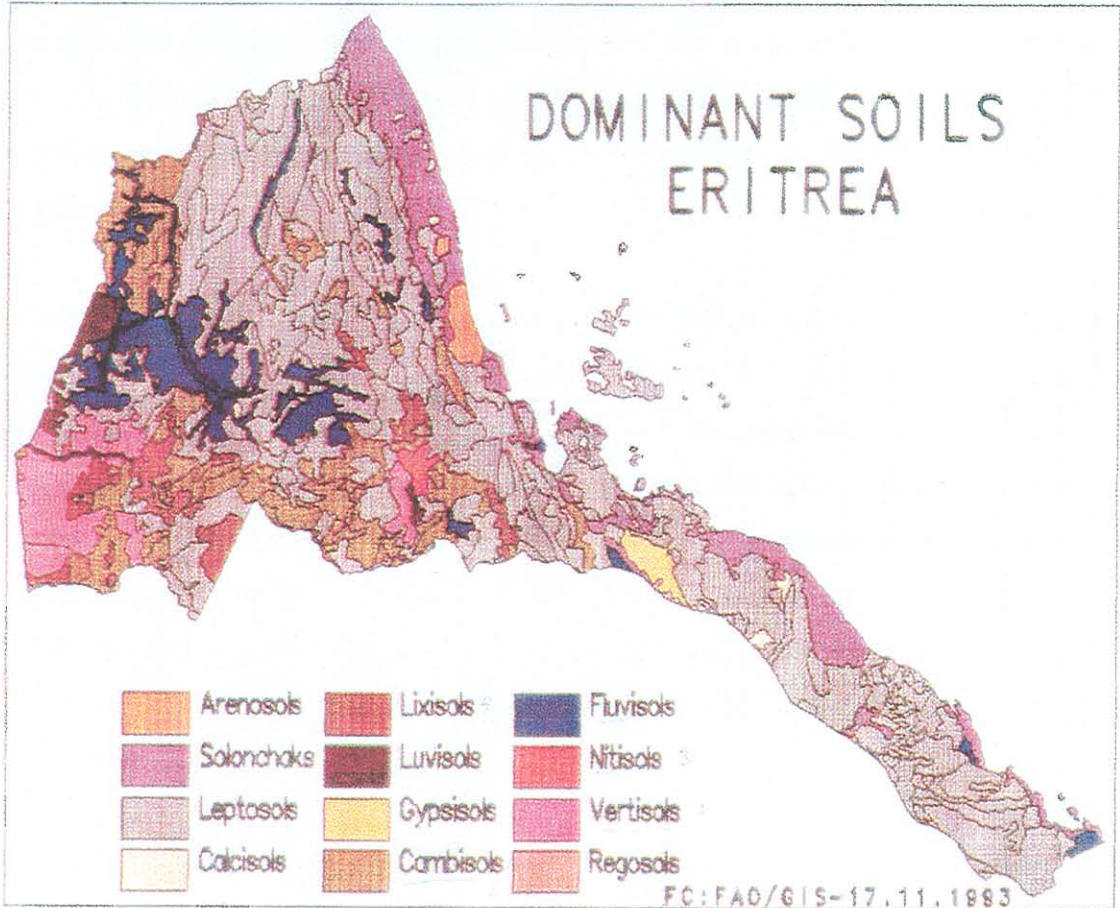


Fig. 1.5: Dominant soil units of Eritrea (FAO, 1994a)

**Solonchaks:** Saline soils (soils with high accumulation of salts) (Landon, 1991). According to Driessen and Dudal (1991) the accumulation of salts can affect plant growth in two ways. That is directly, by inducing physiological drought as a result of high osmotic pressure of the soil moisture and indirectly, by skewing the composition of the soil solution which disturb the availability of plant nutrients. These soils can not be used for normal cropping. It needs more water for leaching and normal irrigation is not adequate for desalinisation. Sometimes the opposite could happen, i.e. that salt contained in the irrigation water remains behind in the soil and the salt level builds up. In Eritrea Solonchaks are found in the coastal areas of the Red Sea.

**Leptosols:** these are very shallow, freely drained soils, with no gleyic or stagnic properties at shallow depth and they are free from high level of soluble salts. Their shallowness or stoniness affects their water holding capacity. The chemical soil fertility of Leptosols is often higher on hill than on level land. Crops can grow on these soils, but at the high risk of soil erosion. Terracing and removal of stones by hand could transform steep slope with shallow and stony soils into cultivable land (FAO-UNESCO 1990). Because of their extreme shallowness they are not recommended for cultivation. Almost 50% of Eritrean land is dominated by Leptosols.

**Calcisols:** soils with high amount of lime (FAO-UNESCO, 1990). They can be used for extensive grazing. Wheat or sunflower might do well under rainfed conditions, preferably after a few fallow years, but with well managed irrigation, they can give good result. Fodder crops such as Rhodes grass and alfalfa can tolerate high calcium level. Cotton can be grown with the addition of nitrogen, phosphorous fertilizers and trace elements (Fe, Zn). Furrow irrigation is better than basin irrigation because it reduces seedling mortality due to surface crusting; pulses are very vulnerable, especially during seedling stage (FAO-UNESCO, 1990). Calcisols occupy <1 % of Eritrea.

**Lixisols:** Soils with high accumulation of clay and strong weathering (Landon, 1991). The low aggregate stability in the surface horizon(s) of Lixisols is conducive to slaking and/or erosion if the topsoil is exposed to the direct impact of raindrops. Heavy machinery or tillage of wet soils can cause structure deterioration and compaction of the surface soil and interfere with the rooting of crops. Minimum tillage and erosion control measures such as terracing, contour ploughing, mulching and the use of cover crops help to conserve the soil. Perennial crops are better than annual crops especially on sloping land. Erosion and soil deterioration can be enhanced through cultivation of tuber crops (groundnut) so it must be avoided. Many Lixisols are best used for extensive grazing or forestry (FAO-UNESCO, 1990).

**Luvisols:** soils of high base status and accumulation of clay content in lower horizons (Landon, 1991 and FAO-UNESCO, 1990). Luvisols are fertile soils suitable for a

wide range of agricultural uses. Structure could be deteriorated with high silt content, if the soil is tilted in wet condition and/or with heavy machinery. Luvisols on steep slopes require erosion control measures (FAO-UNESCO, 1990). Around 3% of Eritrean soils are Luvisols.

**Gypsisols:** Soils with high accumulation of calcium sulphate (FAO-UNESCO, 1990). In the lower B-horizon or slightly deeper, it is possible to find from a soft, powdery and highly porous mixture of gypsum, lime and clay, to a hard and massive layer of almost pure, coarse gypsum crystals. Gypsisols with few percent of gypsum in the upper 30 cm layer (60 cm if irrigated) can be used for the production of small grains, cotton, alfalfa etc. Dry farming on Gypsisols needs fallow years and other water harvesting methods but it is not profitable. Generally, dry farming with more than 25% Gypsum cannot be recommended (Dreissen and Dudal, 1991). 2% of Eritrea is covered by Gypsisols.

**Cambisols:** A cambic B-horizon is the main feature of Cambisols. According to FAO-UNESCO (1990) most Cambisols can be categorised into four main criteria:

- I. Most Cambisols occur in areas with high precipitation but with good position of discharge of surplus water.
- II. Most Cambisols are medium textured and have a good structural stability, a high porosity, good internal drainage and a good water holding capacity.
- III. Most Cambisols contain, at least, some weatherable minerals in the silt and sand fractions.
- IV. Most Cambisols have a neutral to weakly acid soil reaction, a satisfactory chemical fertility and an active soil fauna.

These, therefore, makes them soils of good agricultural quality and are mostly intensively used. Such soil types contribute 15-20% of the total area of Eritrea.

**Fluvisols:** Soils of alluvial deposits (FAO-UNESCO, 1990) and they are depositional rather than pedogenetic profiles (Landon, 1991). These are young soils with weak horizon differentiation. Some show structural development but only in parts of the profile. It is evident that their recent sedimentation and wetness dominate the

characteristics of Fluvisols. The high natural fertility makes them favourable for the cultivation of a wide range of dry land crops on river levees and on higher parts in marine landscapes. For example, in tropical lowlands with a year round supply of fresh water, three crops per year are possible (FAO-UNESCO, 1990). 8-10% of Eritrean soils is Fluvisols.

**Nitisols:** Tropical soils with prominent shiny clay skin, which are usually formed on basic rocks (Landon, 1991). They are well-drained soils with deeply developed nitic horizon. Nitisols are one of the most productive soils of the humid tropics, their deep and porous solum permits deep rooting. They are, therefore, less susceptible to erosion than many other soils. They have good internal drainage, water holding capacity and workability. These make them suitable for most tropical crops (FAO-UNESCO, 1990). Unfortunately such soils are very scarce in Eritrea and their percentage is less than one.

**Vertisols:** According to FAO-UNESCO (1990) these are soils with swelling and cracking characteristics when they are wet and dry and they are suited to large-scale mechanized forms of agriculture but are less suited to low-technology farming on account of their poor workability. They are susceptible to erosion so cultivation should be discouraged on slopes more than 5 degrees. Some measures (contour cultivation and contour banding) can improve infiltration and helps to make better use of available water but care should be taken to protect water stagnating against bands and this can be done through graded bands. Vertisols make around 10% of Eritrean soil.

**Regosols:** Soils with low moisture holding capacity and susceptible to erosion problems. In tropical areas, they are mainly used for extensive grazing and many are not used at all (FAO-UNESCO, 1990). In Eritrea the area covered by these soils is very insignificant (<0.5%).

### 1.5.4.3 Topography

Eritrea has a wide range of altitudes; the lowest being 10m above sea level in the port of Massawa and the highest is 2490m above sea level in Adikeyih in the south of Eritrea near the border with Ethiopia (Figure 1.6). In addition to these there are two extremes of elevation, where the lowest point near Kulul within the Denakil depression which is -130m (one of the hottest places in the world) and the highest point, Soira 3018m above sea level (Esterhuysen, 1998). The wide variation in elevation has an effect on potential evapo-transpiration and temperature and their relation can be seen in Table 1.4 (Ministry of Land, Water and Environment, 1997).

Eritrea is divided into six major agro-ecological zones depending on climate, landform, soils, etc. The topography of Eritrea includes mountains, hills, rolling plains and flatland. Table 1.5 shows the type of the landform, percentage area covered, and dominant crops for each agro-ecological zone. Each zone will be discussed fully in Section 1.6.

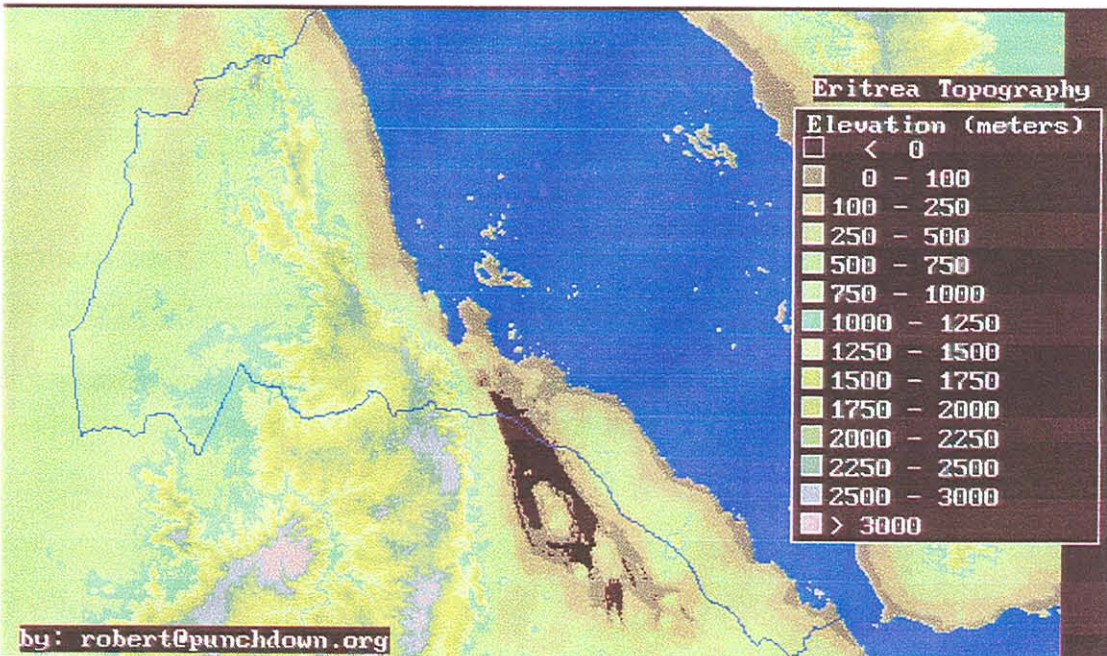


Fig. 1.6: Topographical map of Eritrea (from Van Buskirk, 1999)

Table 1.4: Altitude co-relations with PET and temperature (Ministry of Land Water and Environment, 1997)

Station	Altitude (m)	Annual PET (mm)	Average rainfall(mm)	Mean max.(°c)	Mean min.(°c)	Mean (°c)
Massawa	10	2033	191	32.9	26.8	29.8
Aseb	11	2341	113.5	35	25.3	30.15
Tesenay	585	1928	409.7	36.1	21.1	28.6
Agordat	626	2031	378	36.4	21.6	29
Ghinda	962	1655	648.1	29.1	20.1	24
Barentu	980	2044	457.5	33.5	16.9	25.1
Keren	1460	1808	472.6	30.8	15.3	23.05
Nakfa	1676	1595	515.7	25.2	12.7	18.95
Asmara	2325	1585	577.3	23.2	10.1	16.65
Adikeyih	2490	1624	364.6	24.7	10.9	17.8

Table 1.5 Agro-ecological zones and their landforms (adapted from Ministry of Land, Water and Environment, 1997)

Agr-ecological zone	Dominant crops	Land form	Area %
Moist highland	Barley, wheat, teff, sorghum, maize, finger millet, pulses	Undulating to rolling plateau, partly dissected, with hills, valleys, ridges and escarpments.	7,4
Arid highland	Sorghum, pearl millet, barley	Steep escarpments and mountains, with dissected plateau and rolling hills	2,5
Moist lowland	Sorghum, sesame, cotton, finger millet, pearl millet, maize	Undulating to rolling plains with outlying hills: lower part of western escarpment with ridges and valleys.	16,2
Arid lowland	Sorghum, pearl millet	Flat to rolling plains with outlying hills and mountains.	34,3
Sub-humid escarpment	Maize, sorghum, coffee, barley	Steep escarpment with mountains and valleys.	0,8
Semi-desert zone	Sorghum and maize under spate irrigation	Flat to rolling plains with outlying hills and mountains, islands, volcanic calderas, dunefields, and evaporite basin.	38,8

#### 1.5.4.4 Vegetation

Vegetation of Eritrea is very sparsely scattered. According to Van Buskirk (1999) Eritrean vegetation is divided into two major categories viz. highland and lowland vegetation, depending on the type and density. The soil types, land use, and the climate determine the vegetation of an area. In general, the dominant vegetation types includes Acacia bushland and shrubland, Savanna woodland, some disturbed forests with *Juniperus procera* and *Olea africana*, scattered woodland (*Hyphenae palm* along

major rivers), sparse scrub, grass and halophytic communities (*Acacia mellifera*), bare lava or sand (Ministry of Land, Water and Environment, 1997).

### 1.5.5 Surface water resources

According to FAO (1994a), Eritrea falls into three drainage basins. The Mereb-Gash and Tekeze-Setit rivers drain into Nile basin. The rivers of the eastern escarpment and the Barka-Anseba system form part of the Red Sea basin, while a narrow strip of land along the south-eastern border drains in to the closed Denkel basin.

The Tekeze-Setit river basin has a catchment area of 68,751 km<sup>2</sup>, of which the major part is in Ethiopia. The Eritrean portion of the catchment comprises the Right Bank of the river over a distance of some 60km upstream from the Sudanese border. The Setit is a major tributary of the Atbara river (Sudan), which itself joins the Nile below Khartoum.

The Mereb-Gash is a narrow, westward-oriented basin covering 24,000 km<sup>2</sup> of Eritrea from the southern part of the central highlands to the Sudanese border. Much of the upper basin has a high erosion hazard, which has resulted in the deposition of wide areas of colluvial sands and gravel along the main river valleys.

Both the Barka and Anseba rivers arise on the north-western slopes of the central highlands to the Sudan border in the extreme north-west of Eritrea. The area of the basin is 41,700 km<sup>2</sup> but annual rainfall is low, ranging from 500mm in highlands to less than 200mm in the northern lowlands. The Red Sea drainage basin also comprises numerous small rivers originating from the eastern escarpment. Only a very small area of the country lies in the Denkel basin which, due to its closed topography and arid climate, is characterised by highly saline soils and has little agricultural potential.

Some of the rivers could have some good potential for irrigation and at the same time could be a cause of major conflict between countries like the Sudan which depends on irrigation from water comes from Eritrea through some rivers like the Gash river.



Around ten countries of the region are discussing the fair use of some major rivers like Nile and this is a good hope, which can avoid unnecessary conflict in future.

## 1.6 Agro-ecological zones

Agro-ecological zone (AEZ) refers to any method for classifying the earth's surface into more-or-less homogeneous areas with respect to the physical factors that are most important to crop (or other plant) production (Rossiter, 1994). It provides the geographical basis for national agricultural planning, and a number of applications have been developed for research, extension, project identification, and regulation of land use (Ministry of Land, Water and Environment, 1997). FAO (1994a) and Ministry of Land, Water and Environment (1997) classified Eritrea into six major agro-ecological zones depending on agro-climate and soil parameters (Fig. 1.7). Each agro-ecological zone is divided into agro-ecological units and in Eritrea there are 55 agro-ecological units. The main six zones are summarized as follows:

### 1.6.1 *Arid highland zone*

It is found in the northern highlands of Eritrea. The climate of this zone is arid with annual precipitation of 200-500 mm. On the other hand, evapo-transpiration ranges from 1600-1800 mm. The topography of this zone includes steep escarpments and mountains with dissected plateau and rolling hills. The dominant crops include sorghum, pearl millet and barley. Livestock like cattle, sheep, goat and camel are common to the area. Vegetation is sparse shrubland with scattered bushland and woodland. Soils like Lithosols, Cambisols, Leptosols, and some bare rocks are dominant in this zone. The area covered by this zone is only 2,5 % of Eritrea (Ministry of Land, Water and Environment, 1997).

### 1.6.2 *Arid lowland zone*

This zone is found in northern Eritrea, excluding coastal strips, extreme northwest and lower part of eastern escarpment. It has flat to rolling plains with outlying hills and mountains with annual precipitation range of 200-500 mm and evapo-

Fig. 1.7 Agro-ecological map of Eritrea



transpiration of 1800-2000 mm. Natural vegetation are in the form of shrubland and bushland (scattered woodland). Cambisols, Leptosols and Fluvisols are the dominant soil units of the zone. The area has good potential for grazing or browsing and the dominant crops are sorghum and pearl millet. Camel, cattle goats and sheep are well adapted to the zone. This is the second largest zone with around 34,3% contribution to the total area (Ministry of Land, Water and Environment, 1997).

### **1.6.3 Moist highland zone**

This zone is found in central and southern highlands of Eritrea with warm to cool semi-arid climate (FAO, 1994a). The annual precipitation ranges from 500-700 mm with potential evapo-transpiration of 1600-1800mm. The landforms include undulating to rolling plateau, hills, valleys, ridges and escarpments with the highest altitude of 3018 meter above sea level. Dominant vegetation of the zone is in the form of derived bushland and shrubland with remnant *Juniperus procera* and *Olea africana* and the common soil unit includes Cambisols, Luvisols, Lithosols, Regosols and Vertisols. Barley, wheat, teff, sorghum, maize, finger millet and some pulses are the main crops with sheep, goat and cattle as the major livestock of the zone. This zone covers about 7,4% of the total area of Eritrea (Ministry of Land, Water and Environment, 1997).

### **1.6.4 Moist lowland zone**

This is known as the breadbasket of Eritrea (irrigation potential, important grazing area and wildlife). It is found in the southwest of the country and upper Mereb valley. The landforms include undulating to rolling plains with outlying hills and the annual precipitation ranges from 500-800 mm with potential evapo-transpiration of 1800-2000. The altitude range is 500-1600 meter with savanna woodland and derived bushland as natural vegetation of the zone. Cotton, sesame, sorghum, pearl millet and maize are dominant crops with cattle, sheep, goat and camel as important livestock. Soils like Cambisols, Vertisols, Fluvisols, Lithosols, Regosols are common and the area covered by this zone is about 16,2% (Ministry of Land, Water and Environment, 1997).

### 1.6.5 *Semi-desert*

This is the largest zone (38.8%) and includes coastal areas, islands and the area of northwest of Barka-Sawa river. Landforms include flat to rolling plains, with hills and mountains, volcanic calderas. The precipitation is usually less than 200 mm but the evapo-transpiration ranges from 1800-2100 mm. Sparse scrub, grass and halophytic communities' bare lava or sand dominate the vegetation of the area. Soils like Solonchaks, Lithosols, Cambisols are common. Sorghum and maize are grown only under spate irrigation. Generally, it can be said that the productivity of this zone is very low (Ministry of Land, Water and Environment, 1997).

### 1.6.6 *Sub-humid zone*

This is the smallest (0,8%) and unique zone and sometimes called the green belt zone (FAO, 1994a). It is found in the central escarpment with annual precipitation range from 700-1100 mm and evapo-transpiration of 1600-2000 mm. The landforms are steep escarpment with mountains and valleys. The vegetation is in the form of disturbed forest with *Juniperus procera* and *Olea africana*. Crops like maize, sorghum, coffee and livestock like cattle, sheep and goats are adapted to this zone. Lithosols, Cambisols, and Fluvisols are the major soil units of the zone (Ministry of Land Water and Environment, 1997).

## 1.7 Present land use

According to the FAO Production yearbook (FAO, 1997) the estimated present land uses of Eritrea are presented in Table 1.6. These data is subjected to some errors because they are estimated data not the exact count on the available land use. The possible meanings of the land use categories, which were used by FAO during the preparation of the book, are given below.

Table 1.6 Land use of Eritrea (FAO, 1997)

Land use	Area(1000ha)
Arable and permanent crop	520F
Arable land	440F
Permanent crop	80F
Non arable and permanent	9580F
Irrigation	28F
Land area	10100
Total area	11760

F= FAO estimate

*Arable land*- includes land under temporary crops (double-cropped areas are counted only once) temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (<5 years). The abandoned land resulting from shifting cultivation is not included in this category. Arable land is not meant to indicate the amount of land that is potentially cultivable.

*Land under permanent crop*- land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest such as coffee, vines, citrus etc. but excluding land under trees grown for wood and timber.

*Non-arable and permanent*- any other land not specifically listed under item “ arable and permanent crop” e.g. permanent meadows and pastures, forest and woodland, built-on areas, roads, barren land etc. (FAO, 1997).

The dominant cereal crops are sorghum, maize, wheat, pearl millet and barley. Sesame and cotton are grown for commercial purposes. Different fruit (Oranges, mangos, Banana etc.) and vegetables enjoy the weather of Eritrea, and Eritrea was one of the fruit and vegetable exporting countries to Europe and the Middle East in the 1960 and early 1970<sup>th</sup> (FAO, 1994a). Cattle, sheep, goats and camel are among the important livestock resources of the country.

## 1.8 Infrastructure

Roads are the main component of infrastructure for successful agricultural production. Most main roads of Eritrea were damaged during the war for independence and also the railway, which used to link the port of Massawa and Agordat via Asmara. After independence, the government put transportation facilities in a priority list and started the rehabilitation programme immediately. Since then, as far as road construction and maintenance is concerned, a lot has been achieved and still continues. Currently the road construction works are in an advanced stage and they have reached the town of Barentu (western low land). The railway construction is in progress and it is left with only some 25km to reach the capital. This shows the determination of the government, but a lot needs to be done to change the situation to normal.

Other secondary roads have also given much emphasis like Dekemhare-Mai Aini, which was identified as one of the potential irrigation area (Hazemo plains and Tseroena). Generally it can be said that, development of infrastructure facilities are very important for quick delivery of inputs to farms and outputs to markets. In addition to roads, improving the market situation for local and international trade is very important and Eritrea is a country with two seaports and these can play important roles in developing the agricultural situation in the country.

## 1.9 Land tenure system

After independence Eritrean land policy was based on three basic framework legislation, Proclamation n. 58/1994 of 24<sup>th</sup> August 1994, Proclamation n. 95/1997 of 19<sup>th</sup> May 1997 and Legal notice n. 31/1997 of 19<sup>th</sup> May 1997. The general features of this framework legislation can be summarised as follows:

- \* All land is owned by the state; therefore, every legal right on land must be granted by the Eritrean government.
- \* The law recognises three main types of land rights: usufruct on land in farm, housing land in rural areas and leasehold.

- \* Rights can not be transferred, except where expressly provided for by law.
- \* Illegal transactions are null, void and punishable as a crime.
- \* The Land Commission through its local branch, the Land Administration Body (LAB), will grant all rights on land. The Land Commission was originally intended to be an independent authority but was eventually incorporated into the Ministry of Land, Water and Environment.

Expropriation can be ordered only for proposes of development and capital investment projects aimed at national reconstruction or other similar purposes. Compensation for expropriated land is to be paid in cash or in kind after the two parties have agreed on the amount (Castellani, 2000).

### 1.10 Conclusion

Eritrea is a country that came into existence after 30 years of war against Ethiopia and it was officially declared a nation on the 24<sup>th</sup> of May 1993. It is a young country with 3.9 million people. The country's natural resources, like many other sub-Saharan countries, are not abundant, especially its rainfall. Generally it can be said that, the total annual rainfall tends to increase from north to south; from less than 200 mm at the north to over 700 mm in restricted areas on the southern border. Because of this, Eritrea is one of the countries categorized as a drought prone nation according to the UN.

The only existing soil map is in a small scale of the FAO and this doesn't tell much concerning the conditions of soils in Eritrea. Eritrea is divided into six agro-ecological zones depending on climate, landscape, soils and vegetation cover. This classification is important in directing a detailed resource survey that can help in the identification of suitable areas of land for a particular purpose.

From the available reports of the FAO, Ministry of agriculture and Ministry of Land, Water and Environment there is not enough data to suggest that proper resource surveys and land evaluation specifically for Eritrea have been conducted. To elaborate this the agro-ecological report of the Ministry of Land, Water and Environment

(1997) states that “ It is important to recognize that the agro-ecological zone map has been compiled on the basis of existing data, with relatively limited field checks. Some of these data, particularly that related to soils, is of questionable accuracy, and there remains a clear need for systematic surveys of soils and other natural resources to be carried out”. From this statement one can understand the shortages of data for proper planning and this project is to highlight the need for such resource surveys for evaluating the land according its capacity to be used with out eroding and degrading the environment. In the next chapters the importance of land evaluation, suitability and capability classifications and their differences, major land capability and suitability classifications of the world and finally a land suitability classification strategy for Eritrean situation will be proposed.

Land resources, methods of caring and use, are described in strictly scientific terms and they are recommended on how they should be used. Land evaluation is a practical means for showing the short links between the land as an ecological system and the biological and technological services it can be expected to provide. It is a means to be used as diagnostic criteria for land suitability, but they do not themselves define suitability. Land qualities are very important in determining how a land (with its natural resources) characteristics could be used for a given land utilization type. It does not, however, indicate if one land utilization type would be better than another kind of land utilization. They can also indicate alternative land uses that the land show suitable arrangements to evaluate for future land utilization type. Therefore, systematic land evaluation is necessary for the purpose of judging land utilization both for land use and for land improvement (Vick, 1975). But what is land evaluation?

## 2.2 What is Land Evaluation?

Vick (1975), citing Brookman and Smith (1973), defines land evaluation as the process of collecting and interpreting basic inventories of soil, vegetation, climate and other aspects of land in order to identify and make a best comparison of planning