VOLUME I

REFUGEE CAMPS AND ENVIRONMENT
Landscape and deforestation in Dadaab region (Kenya)

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TABLE OF CONTENTS

I - Terms of reference

1 - Area of study

Dadaab refugee camps (Dagahaley, Ifo, Hagadera)

2 - Objectives:

2.1 - Census and study of the general existing data:

Climate, soils, vegetation. Bibliographical study.

2.2 - Definition of the lanscape units

Several factors will be taken into account:

22.1- soils (type, potentialities, characterization of soils surface)

22.2- vegetation : Status and structure in relation to the soils and topography. Analysis of vegetal associations Under present conditions firewood harvesting is one of main aspects for environmental management. Several points are to be determined:

- real needs for firewood and the estimation of wood quality (in term of calories)
- consumption and carried quantities
- production of deadwood by the different species (study of vegetative cycles, quantities of deadwood / species/year)

22.3- erosion (estimate and typology). Relationship between soils, soil surface, density and vegetal ~~land~~ cover type).

3 - Results

3.1 - Landscapes types map and potentialities

3.2- Localization and extension map of firewood collection zones (map of the potentialities for firewood)

4 - Recommendations

4.1 - Definition of representative zones : they should allow to following landscapes evolution through several simple criterias analysis, linking socio-economical aspects (fire wood consumption, carrying costs,...) and landscape transformation (soils, vegetal cover, erosion...)

4.2 - Definition of criteria of use of the natural resources : according to the various landscapes (environmental protection and follow-up of the landscapes evolution).

4.3 - Proposal for a methodology : for the knowledges and data diffusion .

II - MAIN CONCLUSIONS

The essential problem associated to the installation of refugee camps in a semi-arid area like that of Dadaab, is that of the firewood supply (and, for a smaler part, of timber and construction poles). This wood collection should not affect too much such particularly fragile environment. **The importance of this relation wood resource / deforestation is thus obvious.**
However the landscape approach used for the physical environment study revealed **the strong relation between the wood resource and the type of landscape**. The landscape or the segment of landscape are concepts which are based on a global analysis of the environment and are defined by a whole of varied criteria like soil, climate, vegetation, hydrological regime, topography, biological activity, etc. All these criteria thus play an important part in the characterization and the evolution of the wood resource.

1 - Landscapes

On a relatively limited surface, compared to the extent of the district of Garissa, **it exists a great diversity of lansdcape segments, sometimes strongly differentiated, with extremely various potentialities of wood regeneration** taking into account the soils and hydrological characteristics of this area. These segments (or cartographic units) are gathered in four principal types landscapes, which are caracterized by the texture and the color of soils of surface which are the criteria most easily identified in the field and which practically correspond to the traditional perception of the inhabitants of this area.

- the landscape on red dark sands (*Rama gadud*) **(P1).**
- the landscape on red soils with sandy surface horizons and sandy- clayey horizons in depth (*Ber gadud*) **(P2).**
- landscape on reddish soils with sandy or sandy-clayey surface horizons and loamy-clayey horizons in-depth (*Ber gadud* and punctuated structure with ponds) **(P3).**
- landscape of beige-reddish soils or gray-beige, loamy-clayey (*Ber Gagud / Ramaat / Adable*) **(P4).**

To each one of these landscapes and even to each one of the segments (or cartographic unit) do correspond a specific type of vegetation, an intensity of the biological activity, deadwood resources and particular capacities of regeneration which are summarized in the following tables. One can however note some remarkable associations between the various factors which characterize these landscapes.

- with the sandy dark red landscapes :
  . excessively poor soils
  . the absence of biologic activity and the weak transformation of the vegetal material
  . an homogeneous vegetation but of rather high shrubby type, which apparently does not produce deadwood

- with the landscapes of sandy red soils:
  . soils still very poor but having some physicochemical characteristics slightly more favorable (pH, content and type of organic matter)
  . a better biological activity and a better transformation of the vegetal material
  . a more heterogeneous vegetation **with a** arboreous **layer** sometimes rather important producing the deadwood.

Table 1: Principal caracteristics of the landscapes and their potentialities

TYPES OF LANDSCAPE			
SAND - >90 % de Sg+Sf * - <10 % A+Lf * **(P1)**	**SANDY SOILS** - 75 à 90 % de Sg+Sf * - <20 % A+Lf * **(P2)**	**SANDY TO SANDY-CLAYEY SOILS** - 60 à 75 % de Sg+Sf * - < 30 % A * **(P3)**	**LOAMY-CLAYEY SOILS** - > 30 % A * - > 15 % Lf * - < 30 % Sg+Sf * **(P4)**
CARTOGRAPHIC UNITS			
2, 5 (unit 1 could be associated in some places)	**3, 4** (unit 9 could be associated in some places)	**6, 7, 8, 9, 10** (unit 3 and 12 could be associated in some places)	**11, 12, 13, 14** (unit 1 and 3 could be associated in some places)
Ph			
acidic	acidic to neutral	slightly acidic to slightly basic	neutral to basic
ORGANIC MATTER CONTENT			
vey low to low	low to very low	very low	low to medium
NITROGEN CONTENT			
very low to null			
C/N (organic matter status)			
weakly transformed	moderatly transformed	moderatly to weakly transformed	moderatly to well transformed
INTENSITY OF BIOLOGICAL ACTIVITY			
null	null to weak	high to very high	high to very high
ESTIMATED DEADWOOD POTENTIALITY			
null to low	low to moderate	moderate to high	moderate
VEGETAL COVER			
Dry and woody forest with high shrub and low trees. Moderatly dense and regular, average height (3 to 5m)	Shruby savannah moderatly dense, woody in some places, almost regular, averages height of shrub (2 to 5/6m)	Shruby savannah moderatly to weakly dense, woody in some places, irregular, spotted and scattered, averages height of shrub (1 to 5/6m)	Herbaceous and shruby savannah weakly dense, woody in some places, very irregular, spotted and scattered, averages height of shrub (1 to 3 m and 5/6 m).
RUN OFF			
No run off, no erosion. (very fast infiltration of total rain water)	Very weak to weak sheet flood. Fast infiltration of rain water	Sheet flood and small gullies. In some placesrun off through a slightly marked drainage pattern.	Floodable areas (small basin, valley floor,...).
SAMPLES			
1, 8	**5, 14, 15, 17**	**2, 4, 7, 11, 16, 19**	**3, 6, 9, 10**

* ** Sg = coarse sand, Sf = fine sand, Lg = coarse silt (or loam), Lf = fine silt (or loam), A = clay

Table 2 : Landscapes characteristics

Éch	UC	Landscapes (defined by soils)	Texture	pH	Organic matter content	C/N (organic matter status)
1	2	SAND **(P1)**	- >90 % de Sg+Sf * - <10 % A+Lf *	acidic	low to very low	weakly transformed
2	8	SANDY AND SANDY-CLAYEY SOILS **(P3)**	- 60 à 75 % Sg+Sf * - < 30 % A	slightly acidic to slightly basic	very low	moderatly to weakly transformed
3	14	LOAMY-CLAYEY SOILS **(P4)**	- > 30 % A - > 15 % Lf - < 30 % Sg+Sf	neutral to basic	low to medium	moderatly to well transformed
4	9	SANDY SOILS(P2) and SANDY AND SANDY-CLAYEY SOILS **(P3)**	- 60 à 75 % de Sg+Sf - < 30 % A et - 60 à 75 % de Sg+Sf - < 30 % A	acidic to neutral	low to very low	moderatly to weakly transformed
5	9	SANDY SOILS(P2) and SANDY AND SANDY-CLAYEY SOILS **(P3)**	- 60 à 75 % de Sg+Sf - < 30 % A et - 60 à 75 % de Sg+Sf - < 30 % A	acidic to neutral	low to very low	moderatly to weakly transformed
6	14	LOAMY-CLAYEY SOILS **(P4)**	- > 30 % A - > 15 % Lf - < 30 % Sg+Sf	neutral to basic	low to medium	moderatly to well transformed
7	12	LOAMY-CLAYEY SOILS **(P4)**	- > 30 % A - > 15 % Lf - < 30 % Sg+Sf	neutral to basic	low to medium	moderatly to well transformed
8	5	SAND **(P1)**	- >90 % de Sg+Sf - <10 % A+Lf	acidic	low to very low	weakly transformed
9	13	LOAMY-CLAYEY SOILS **(P4)**	- > 30 % A - > 15 % Lf - < 30 % Sg+Sf	neutral to basic	low to medium	moyennement à bien transformée
10	12	LOAMY-CLAYEY SOILS **(P4)**	- > 30 % A - > 15 % Lf - < 30 % Sg+Sf	neutral to basic	low to medium	moderatly to well transformed
11	10	SANDY AND SANDY-CLAYEY SOILS **(P3)**	- 60 à 75 % de Sg+Sf - < 30 % A	slightly acidic to slightly basic	very low	moderatly to weakly transformed
14	3	SANDY SOILS **(P2)**	- 75 à 90 % de Sg+Sf - <20 % A+Lf	acidic to neutral	low to very low	moderatly transformed
15	4	SANDY SOILS **(P2)**	- 75 à 90 % de Sg+Sf - <20 % A+Lf	acidic to neutral	low to very low	moderatly transformed
16	3	SANDY SOILS **(P2)**	- 75 à 90 % de Sg+Sf - <20 % A+Lf	acidic to neutral	low to very low	moderatly transformed
17	3/4	SANDY SOILS **(P2)**	- 75 à 90 % de Sg+Sf - <20 % A+Lf	acidic to neutral	low to very low	moderatly transformed
19	8	SANDY AND SANDY-CLAYEY SOILS **(P3)**	- 60 à 75 % de Sg+Sf - < 30 % A	slightly acidic to slightly basic	very low	moderatly to weakly transformed

* Ech = Sample, UC = Cartographic unit, Sg = coarse sand, Sf = fine sand, Lg = coarse silt (or loam), Lf = fine silt (or loam), A = cla

- to the landscapes of sandy or reddish sandy-clayey soils are associated :
  . more varied soils, potentially less poor (higher content of clay).
  . an always important biological activity and, generally, a rather good transformation of the organic matter, variable according to the places, taking into account the greatest heterogeneity of the soils.
  . a fairly dense, shrubby and raised vegetation, producing deadwood.

- to the landscapes of **limono**-argillaceous and beige-reddish or gray-beige soils:
  . soils definitely more argillaceous allowing the stagnation of rainwater in the lowlands and having some potentialities (push back possible certain raised and shrubby species) but generally with a basic PH. The installation of some cultures was observed.
  . a rather strong biological activity and a strong transformation of the organic material.
  . an herbaceous vegetation (zone of pasture) with a raised layer sometimes important and well developed near the wettest zones and which can be a source of deadwood.

2 - Deforestation

In 1995

- Each camp is surrounded with a more or less circular halo of nearly absolute degradation. This halo diameter which includes the surface occupied by each camp varies from 3 to 6 km. The surfaces totally denuded following the three camps settlement covered 3107 ha. 846 ha, that is 27% of this surface, accounts for the camps and their infrastructures (Dagahaley, ifo and Hagadera).
- Beyond this halo, a second more diffuse degradation belt is to be observed.
- The total surface having undergone a total and diffuse degradation reaches 5282 ha.
- Ifo exhibits the largest degradation. Dagahaley situation on the bank of the Lag Dera Valley disturbs this concentric disposition.
- Compared with the total surface of Garissa District (43392 km2) this degradation only represents 0,12% of the territory.

Table 3 : Surface status in 1995

CAMP	Area (ha)	Very high degradation (ha) *	High degradation (ha)	Total (ha)
Dagahaley	272	643	827	1470
Ifo	308	1499	1270	2769
Hagadera	266	965	78	1043
Dadaab	60	132	-	132
Total	**906**	3239	2175	5414

* : this acrage includes the area of the camp (blocks, infrastructures)

In 1998

- The surface completely or partially degraded reaches 8616 ha (that is 0,2% of the Garissa District). Approximately half of this surface (4117 ha) squares with the very heavy degradation halos which rose in three years up to 1010 ha.
- The increase of very heavy degradation surfaces between 1995 and 1998 accounts only for Ifo camps and mainly Dagahaley.
- The very heavy degradation halo around the Hagadera camp is the same as in 1995.
- The diffuse degradation areas existing between Dagahaley and Ifo in 1995 constitutes a one unit.

Table4 : Surface status in 1998

CAMP	Area (ha)	Very high degradation (ha) *	High degradation (ha)	Low degradation (ha)	Total (ha)
Dagahaley	272	1260	390	536	2186
Ifo	308	1897	988		2885
Dagahaley and Ifo				1619	1619
Hagadera	266	960	-	966	1926
Dadaab	83	203	175	-	378
Total	929	4320	1553	3121	8994

* : this acrage includes the area of the camp (blocks, infrastructures)

These first figures led us to retain a zone of study sufficiently vast in order to better evaluate the relative importance of the impact of the refugee camps in this environment considered as particularly sensitive.

3 - Wood resources

- The hypothesis of degradation being explained by the needs of firewood for the refugees kept in mind, all the calculations and observations show that cleared or degraded surfaces are very distinctly less than surfaces which would have been necessary for supplying the needs of the population within 7 years.
- Consequently, supplying with firewood is not the direct cause of observed deforestation.

This observation simply confirms the fact that refugees preferably use deadwood as energy resource. Deadwood collection, naturally existing on the ground does not entail an environment degradation.

- Insofar as refugees have no possibility of storage collected firewood, gathered quantities correspond to the immediate needs (2 to 4 days).
- This practice excludes the green wood cuttings by refugees as well as its carrying and its storage in the camp before use (time of drying).
- Land clearings linked with camps and infrastructure settlements (notably in Ifo), collection of timber for building huts, planting of live-fences and pastures would be the main cause of deforestation.
- Between 1991 and 1998, dead wood resources relatively close to the camps must have been very important. They allowed the refugees to fill their fire wood needs without strong degradation of the environment.
- Within a range of 5 to 10 km around the camps, dead wood resources are today bare bones. - Distances to trek across are more and more important.
- The lengthening of these distances may explain the growth of firewood trade in these three camps observed between 1996 and 1998. It accounts also for the more and more important share taken by men for collecting firewood (wheelbarrows, donkey-carts).
- The collection and woody supply system spontaneously set up by refugees has been partially changed in June 1998 into wood distribution organised by UNHCR and GTZ.
- This distribution founded on deadwood collection per private entrepreneurs within a range greater than 30 km proceeds from two hypotheses :

disappearing of deadwood within a range lower than 30 km.

- A remaining constant deadwood resource further.
- These hypotheses do not take completely into account the existence of deadwood within the range of 30 km and the environment diversity.
- Regeneration capacities of the environment allow to look, through selected cuttings, to a deadwood supply (after drying) non insignificant.
- To-day knowledge do not permit to evaluate the available deadwood stock inkeeping with the different environments units. Generally the times necessary for this stock reconstitution is

unknown. A complementary study on one hectare sample plots localised in respect of the different environment units must be set up.

4 - In terms of methods and diagnosis

- The aerial photographs and, still more, the satellite imagery interpretation bears risks when this interpretation has not been accompanied with fieldwork at the time of pictures taking.
- Without a continuous observation of environment problems it is all the more difficult to rebuild the different phases of a supposed degradation process because the memory of setting up of the Dadaab camps does not seem to have been saved.
- The starting hypothese of the present diagnosis relied heavily upon the idea that refugees presence is inevitably accompanied with an important deforestation. Conversely to the observed reality, this hypothese supposes that refugees cut green wood to supply their needs for firewood.
- It is following this hypothese that varied environment actions set up by GTZ took place (energy saving, reforestation, live fences, environment education).
- The absence of a global analysis of the refugees practices to supply their firewood needs and of the evolution of these practices is to be regretted. Similarly, the lack of an environmental monitoring system since the beginning of the camps settlement considerably shortens the range of a a posteriori interpretations.

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CHAPTER I

LANDSCAPES

Impact of the refugee camps settlements on the landscape transformation in semi-arid regions (Dadaab - Kenya)

Alain BEAUDOU

IRD - October 1999

Foreword

Setting-up brutally tens of thousands of people on a piece of land causes a number of changes which can (depending the cases) accelerate, slow up, or develop new changes in physical or human environment.

In order to observe these changes, understand their different mechanisms, and moreso estimate (or measure when possible), their impact on the environment, it is **absolutely imperative to carry out a preliminary survey of the landscapes statuts** before pitching up any refugee camp. This "ideal" requirement allows for a better follow up of any transformation. Unfortunately, many camps are being pitched in extreme cases of emergency which do not take into account any possibility of carrying out a preliminary study of the place that hosts the refugees.

Even if the life span of the camps is not known, **it is necessary to carry out, as quickly as possible, a study of the physical and human conditions of the land in order to determine the "zero state" of the landscape and to select as well as define a number of simple indicators** which will enable the follow up of major changes so as to keep under control any development occurring in this existing complex system environment/refugees.

This chapter will deal with the physical environment and with its climatic, morphological, pedological and botanical components. The "landscape" approach enables us to gather these different branches in only one system of understanding and to describe their relationships and come up with a global view of the milieu.

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I- SOME DEFINITIONS

First of all , let us clearly define the word "**environment**". This definition is necessary because the word has often been used to cover up very different intentions.

The word expresses a perception of the ecosystem in which we live and which we consider our "environment", perceived as a "relational actual experience" with precise space and time dimensions (territory). In other words, environment may be defined as both the biophysical and socio-cultural setting made up of different components (climate, soil, cultures, economy, policy...). According to this definition therefore, the concept of environment gets a geographical meaning which is directly noticeable as it leads to the notion of landscape.

"**Landscape**" is another word so widely used that its original meaning is being distorted. In view of such an imprecision, it becomes necessary to come up with a definition which is in line with this study dealing with the physical setting.

Landscape is generally defined as an interfluve or a series of similar interfluves. Landscape can also be defined as an association of differentiated interfluves but linked to a noticeable organisation at a lower scale (local or regional) like very large mountains or hillsides or large plains and/or valleys. Therefore, the limits of landscapes superimpose, in most cases, on concentration lines of waters or on hydrological-basin limits.
Landscape is also an entity characterised by a **dynamic** which can find expression, from the upperside of the slope towards the downside, by the oriented succession of organisations reflecting displacements, accumulations, departures... Most often these organisations are in accordance with the current topography of the interfluve. This dynamic of landscapes is analysed using "**sequences**" **(catena)**, transects drawn up between the highest points of the interfluves and the lowest ones. The sequence is often put in the same category as the landscape.
The landscape is made up of **segments or units**. Every segment corresponds to a topographical homogeneous facet and/or to an anthropical facet to be distinguished by the same soil occupation (or land use). The first criterion of segment delimitation of landscapes corresponds therefore to the nickpoint (or break of slope) or to the slope inflexion. The criterion of change as far as the type of soil occupation is concerned, can sometimes be kept but its high variability, in accordance with time, significantly restricts its use as the main criterion.
Defining a segment depends on the following:

- the topography (shape, slope,...)
- the organisation of the pedological cover and the soil surface
- soil occupation (land use)
- expression of deep and surface dynamics of the soil (accumulation, departure,...)
- presence of particular organization like ponds, basin,...

" **Cartographic Unit** ", it is the surface delimited on a map. It corresponds, according to the scale, either with a landscape, or with a segment of landscape. For the map of Dadaab the cartographic units correspond to segments of landscapes.

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II METHOD

The method adopted for this study is based on a " landscape approach ". This approach takes directly into account the principal components of the physical environment:

- topography,
- soil,
- soil surface,
- hydrology, mode of water run-off
- vegetation and land cover,
- rate of covering of the surface

It is thus a " global " method which gathers and organises several elements which contribute to the characterisation of the landscape.

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III - ZONE OF STUDY

The camps are located on the equator at a hundred kilometres of the somalian border in a harsh environment. Strong heat allied with very weak precipitation's (350mm/an) never allowed of another activity but the very extensive pastoralisme. As in any semi-arid area, the low and stable density of population (< 2 hab/km2) constitutes in fact the essential condition of a protected and durable environment. The enormous surge of refugees should have important consequences on the environment, mainly on the level of the vegetation cover. The risk was all the more high since the firewood collection and **lumber** was not planned until a recent date and that the refugees provided themselves for their supply

One observes indeed, since 1995 (table 3), the existence of an aureole of important deforestation (compared to the surface of the camps). In 1998 (table 4) the degraded surface appreciably extended mainly with regard to the zone known as of " low degradation".

These measurements also show that the completely or partially degraded surfaces are in fact very lower than those theoretically necessary to the satisfaction of the daily requirements of firewood for the refugees. This observation is logically explained by the fact that the refugees seek above all the immediately usable deadwood. Cutting green wood induces a waste of time and output. The fact of collecting only deadwood, avoids the important clearings that the theory let consider.

Since mid 1998, HCR deals with the firewood supply. Such system modifies the previous informal firewood supply which becomes a commercial activity now invested by the market economy. The question is now to look at the possible consequences in term of development of an activity of cutting and drying green wood. This question should not be ignored within the framework of a rational management of the environment.

Currently the values of table 5 reveal the very low importance of the degraded surfaces, especially if one refers on the administrative division or even to the surfaces covered by an image SPOT. The low density of the vegetal cover, the diversity of the landscapes and the partial ignorance, for lack of measurements in the field, of the potentiality of vegetation regeneration, which, taking into account the characteristics of the soils and the climate, must be, in all the cases, rather weak, lead us to retain relatively vast zones of study. This choice is all the more justified that during the flights over this sector, we were surprised by the great density of human tracks until relatively long distances from the camps.

Table 5 : Comparison between different areas (km²) *

Area of the camps	10
Area of very high degradation around the camps in 1998	33
Area of high degradation in 1998	16
Area of low degradation in 1998	31
Total area of degradation (camps et « degradation ») en 1998	**90**
Area of cartographied zone (report avril 98)	1300
Area of cartographied zone (99)	3502
Area of Garissa district	45 000

*: the values are round

Compared to these different areas, the " degraded " surfaces represent then "negligible quantities":

- 2,6 % of the surface of the zone charted,
- 0,2 % of the surface of Garissa District

However, this may be too optimistic appreciation should be moderated.
Indeed , taking into account the reality of the requirements of firewood and wood construction, these low values raise several questions:

- do the current tools of observation and analysis make it possible to correctly estimate the influence of the refugees on their environment ?
- is the firewood collection not extremely diffuse ? Under these conditions it would have, for the moment, only very few visible effects on the environment (if the disappearance of the vegetal cover is considered like the only form of degradation. However the effects, in term of biodiversity, could be, henceforth, much more important. But it is particularly difficult to evaluate them without an attentive follow-up of the transformations of the vegetal cover as from one T zero time.

The great extent of the zone of study and the very precarious conditions of safety make difficult an exhaustive analysis in the field. It is thus, in major part, thanks to the air imagery that the landscape units were identified. Several complementary sources were employed:

- satellite images (1990, 1995 and 1998);
- air photographs (1979);
- mosaics of the refugee camps (July 1998);.
- reconnaissance flight (February 1999).

The photo-interpretation was then supplemented by two missions in the field (March 1998 and February 1999). The principal observations are localised on the map of landscape units.

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IV - COMPONENTS OF THE PHYSICAL ENVIRONMENT IN DADAAB AREA

The area of Dadaab is located, according to the agro-climatic map of Kenya (scale 1/1 000 000), in very arid zone with a ratio precipitations /evaporation lower than 15 %. The rainfall annual average is included between 150 and 300mm. Potential evaporation annual average oscillates between 2100 and 2500mm. The temperature annual average is placed between 24 and 30 °C (hot to very hot zone). The maxima ones lie between 30 and 36 °C, the minima between 18 and 24 °C. Always according to the agro-climatic map, the existing vegetation is described like "desert shrub" with a domination of the acacias on all the other species. The agricultural potentialities are extremely low, if not non-existent. These areas, very little populated (1 to 2 hab./m2) are traditionally the place of a very extensive pastoralism which practically does not disturb the ecosystem.

Severals aspects will be particularly analysed :

- Soils
- Vegetal cover
- Landscapes

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1 - THE SOILS IN DADAAB REGION.

The 1/1 000 000 soils map (Exploratory Soil Map and Agro-climatic Zone Map of Kenya - 1980) gives a very diagrammatic image of the soil cover of this area (fig. 1: extract of the chart of the soils - Area of Dadaab). The legend of this map was established according to the soils classification of F.A.O. - UNESCO used for the world chart of the soils. The soils are divided into two great groups :

1.1 - Alluvial soils of flooded plain :

The soils are thick, hydromorphic, rather rich in organic matter (6 to 8%) with vertic caracters, very muddy and sticking when they are wet, very hard in dry period (vertic gleysols). Accumulations of salts can appear. The agricultural potentialities of these soils are limited.

Photograph 1 : alluvials soils using for crops

The riverbanks can be used for fall farming with very short growing period and not very sensitive to salts (photo 1). But generally they constitute the best natural pastures of this area.

1.2 - Soils of sedimentary plains of sheet erosion deposits :

Several forms are identified:

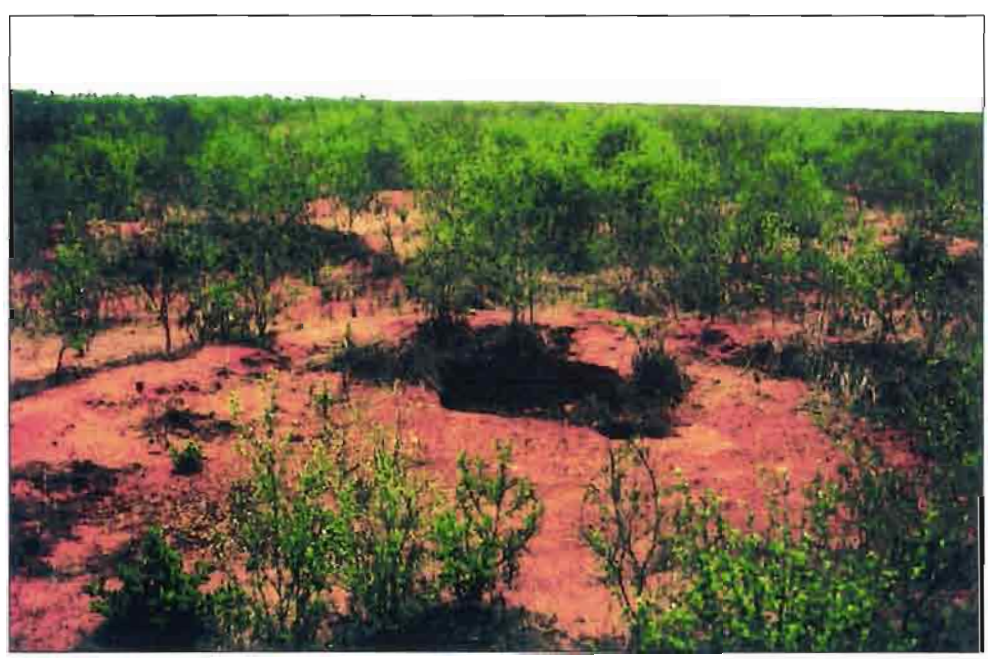
12.1- The sedimentary "red sand" plains :

of higher level coming from **eolian** and sheet erosion **deposits**. The quartzous elements deposited, come from baserocks generally **gneissic**. The soils are red, sandy, very deep, friable and very porous with or without clay accumulation horizons (**acrisols**).

The reserves in nutriments are in general very weak and the water holding capacity practically null (arenosols - Photo 2) or low (acrisols - Photo 3).

Photograph 2: Plain with red sands

Under these conditions, the growing of shrubs is very slow and the existing vegetation must be protected to the maximum.



Photograph 3: Plain with red sand and clay level in depth

12.2 - The sedimentary silty (loamy) plains, poorly drained :

(" sealing loam " plains) coming from loamy materials accumulated in bays during the plio-pleistocene (Photographs 4 and 5). Two great types of soils are easily recognisable:

* soils rich in sodium (**salsodic soils**), poor in soluble salts, except sometimes in-depth, but presenting in medium depth a horizon of clay accumulation rich in exchangeable sodium, often formed of small columns with rounded tops and interns structure always diffuse, very degraded by the excess of this exchangeable sodium.

The surface horizon is **powdery** in dry season. The depth horizons are very compact (**Solonetz**).

Photograph 4: Clayey plain with reduced drainage

Photograph 5: Easily flooded loamy plain with limited drainage

* **soils with very strongly differentiated profile** either by pedogenesis or by superposition of materials, with a bleach horizon, spotted by hydromorphy, generally at its basis, above a clayey horizon with an upper part very compact and showing an abrupt limit with the bleach horizon (planosols). Salt accumulation is frequent. Accumulations of salts are frequent.

In these plains with very low drainage, water retention is very important and water tends to accuimulate during the rainy season. The utilization of these soils are very restricted due, principally, to their very bad physicochemical characteristics..

12.3 - Clayey, gray sedimentary plains of the lower level :

The soils are developped on loamy reworked bay sediments, of plio-pleistocene age. These soils are very close to those described in the poorly drained plains (Solonetz). The contents of organic matter of the surface horizons seems sometimes rather high. Once again, their potentialities are very reduced taking into account the physicochemical characters of these soils.

Photo 6 : Lag Dera river flood plain

Soil Map of Dadaab area

(from « exploratory Soil Map and Agro-climatic zone Map of Kenya - 1980
Scale 1 : 1,000,000 - Kenya Soil Survey)

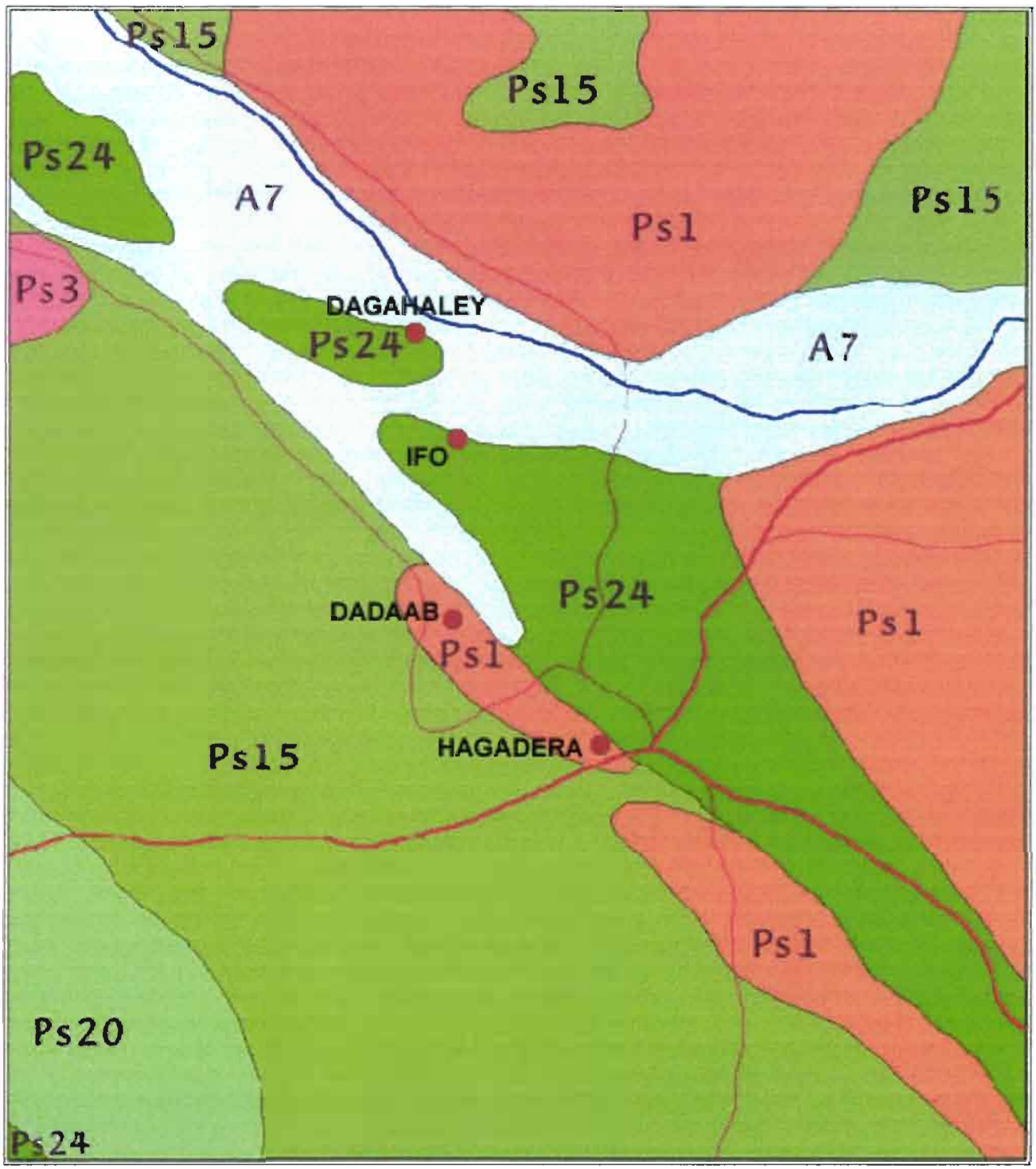


Figure 1 : Soils map and its legend

LEGEND OF SOIL MAP

A7

FLOODPLAINS (A7) : Soils developped on sediments mainly from bay deposits (older floodplains). Imperfectly drained, very deep, dark grey, very firm, slightly calcareous, with a slightly to moderately saline and sodic deeper subsoil. (Vertic GLEYSOLS, saline-sodic phase).

Ps1

SEDIMENTARY PLAINS (Ps 1) —mainly from sheetwash— : Higher level sedimentary plain (« red sand » plain). Soil developped on sheetwash and eolian deposits from undifferenciated basement system rocks (predominately gneisses). Well drained, very deep, dark red to dusky red, friable, sandy loam to sandy clay loam, acid. (ferralic ARENOSOLS).

Ps3

SEDIMENTARY PLAINS (Ps 3) —mainly from sheetwash— : Higher level sedimentary plain (« red sand » plain). Soil developped on sheetwash and eolian deposits from undifferenciated basement system rocks (predominately gneisses). Well drained, deep to very deep, dark red to dusky red, friable, sandy loam to sandy clay loam, acid. (ferralochromic ACRISOLS, ferralic ARENOSOLS and ferric LUVISOLS).

Ps15

« SEALING LOAM » PLAIN (Ps 15) : Soils developped on Plio-pleistocene bay sediments (Marafa beds). Imperfectly drained, moderately deep, brown, extremely firm, moderately calcareous, moderately sodic clay loam, with a topsoil of sealing sandy loam. (luvo-orthic SOLONETZ).

Ps20

« SEALING LOAM » PLAIN (Ps 20) : Soils developped on sheetwash deposits from plio-pleistocene bay sediments (Marafa beds). Imperfectly drained, deep, brown, extremely firm, slightly calcareous, slightly sodic clay loam, abruptly underlying a thick topsoil of sealing sandy loam. (solodic PLANOSOLS).

Ps24

LOWER LEVEL SEDIMENTARY PLAIN (Ps 24) —« Grey Clay » plain— : Soils developped on sediments mainly from various volcanic rocks. Imperfectly to poorly drained, very deep , dark greyish brown, very firm, slightly calcareous, moderatly to strongly saline, strongly sodic clay in places strongly calcareous and/or gypsic. (orthicSOLONETZ, saline phase).

Soils samples were taken on several sites in order to define their potentialities and to choose indicators of the transformation of the landscapes (in terms of fall of the fertility which will strongly influence the capacities of natural regeneration of the vegetation).

* *

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2 - VEGETAL COVER OF DADAAB AREA

Two studies make it possible to give a good representation of the current vegetation cover of this area:

- the map of the vegetation carried out by Odhiambo, B.D.O. and Ucakuwun, E.K (1998 and 1999)
- analysis of the degradation of the vegetation around the refugee camps of Ifo, Dagahaley and Hagadera realized in 1996 by Ogweno, D.C.O. and Ochieng, E.A.

The map of the vegetation reveals a certain number of types of vegetation cover which it is possible to bring closer, partially, of the soils units. It should however be noted that the scales of observation and restitution are not identical. According to these authors, while simplifying, it is possible to identify :

- on "red sand" sedimentary plains of the higher level, a dwarf shrubby vegetation (height of the " shrubs " between 1 and 6m) which ensures a cover of the soil surface lower than 50%. However the last field observations reveal that the height of the trees is much more homogeneous. The height of almost totality of the trees and shrubs lies between 3 and 5 m ; that confers on this unit an easily recognisable uniformity on the satellite images and the air photographs.
- on loamy sedimentary plains, with poor drainage it is possible to distinguish several units:

  * zones of dwarf shrubby vegetation with, in some places, circular areas of bare soil.
  * zones of shrubby and herbaceous vegetation (1 to 6m of height and density of covering of the soil surface of 20%).
  * zones of shrubby vegetation (1 to 6m height) at the edge of the axes of water run-off.
  * zones of dwarf bush vegetation (< 1m) with groupings of trees around seasonal water basins.

- on the clayey, gray sedimentary plains of the lower level several types of vegetation are identified:

  * zones of dwarf bush vegetation (< 1m) with groupings of trees around seasonal water basins.
  * herbaceous zones with some trees (cover of the soil surface <20%).
  * zones associating a shrubby savannah (1 with 6m height and a cover of soil surface of 20%) and a rather dense shrubby vegetation (height > 1m).
  * complex zones of woody savannah with groupings of degraded " dwarf ".trees and shrubby vegetation

- on the alluvial soils, of flooded plain a vegetation cover associating low shrubby savannah and a wooded savannah on the edges of the axes of water run-off.

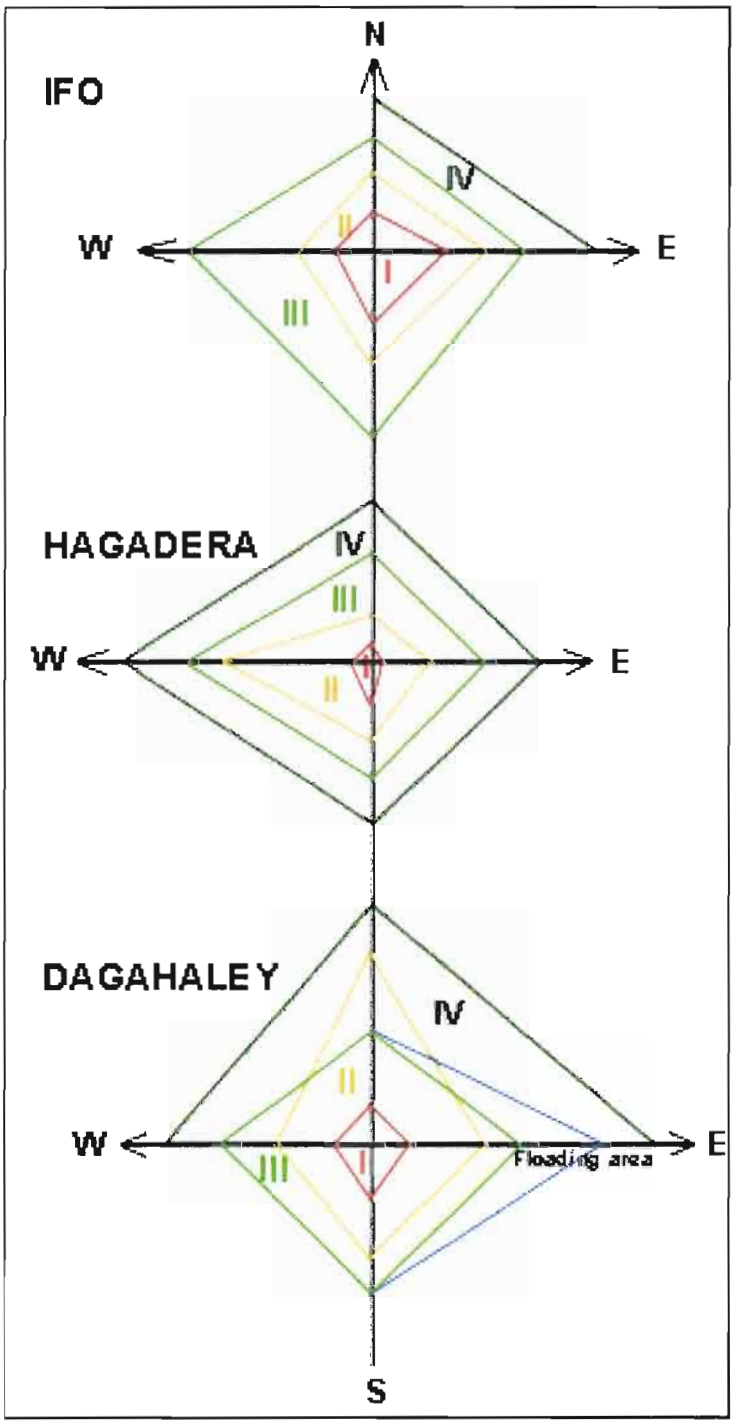

Figure 2 : areas of degradation around Dadaab refugee camps
Source : Ogweno, Ochieng, 1996 : report of a baseline vegetation ressource survey for GTZ-rescue II.

Concerning the distribution of the soils in relation with the vegetation cover two points are to be retained:

- the homogeneity of the vegetation on the red sandy plains
- the heterogeneity of the vegetal organisations present in the loamy plains with poor drainage and important erosion, linked to a greater heterogeneity of the soils cover.

The analysis of the vegetation status in 1996 by Ogweno and Ochieng underlines five classes of degradation which would be directly related to the the firewood collection (and wood for construction) by the refugees (fig.2):

- **Class 1:** zone of reforestation with a arboreous or bushy vegetal cover very reduced or even completely destroyed. The rehabilitation of these zones only can be made through replanting.

- **Class 2:** zone of natural regeneration (or protected areas). The arboreous or bush covers are reduced, even very reduced because of importance of the wood cuts. However these zones have a potential of natural regeneration provided that (if) they are protected.
- **Class 3:** zones of cuts. The wood exploitation must be strictly controlled to avoid overexploitation and the classification in class 2.
- **Class 4:** zones of new surfaces of cuts. The wood exploitation is normally oriented to the deadwood collection, but the live wood cuts start to appear.
- **Class 5:** virgin zones which in 1996 was still out of reach human action.

These various zones are distributed around the camps in a more or less regular way. Their extension was measured along tracks which makes it possible to give graphic representation (figure 2).

It is interesting to notice that the degradation of the vegetation is more important towards the west of Hagadera whereas in Ifo camps **no particular direction appears** but in **Dagahaley camptwo directions exist (north and east)**. It also should be noted that at the time of the study (1996) zones I of very high degradation are very small (**Hagadera**) or small (Dagahaley and Ifo) especially if one replaces this on a regional scale. In fact, in terms of biodiversity, the degradation of the vegetation affects in a very strong way relatively limited surfaces located in the immediate vicinity of the camps.

The table below gathers the average diameters of the classes of degradation around the three camps of Ifo, Hagadera and Dagahaley.

Table 6: average diameter of the classes of degradation

Localisation Class radius	IFO	HAGADERA	DAGAHALEY
class 1	1,5 km	0,3 km	1 km
class 2	3 km	1,5 km	3 km
class 3	5 km	4 km	4 km
class 4	> 5 km	5 km	5 km

By using the data present in this report it is possible to graphically follow the importance of the arboreous and bushy vegetation (figure 3), as well as the relative importance of the herbaceous vegetation, the litter and the bare soil (figure 4 -).

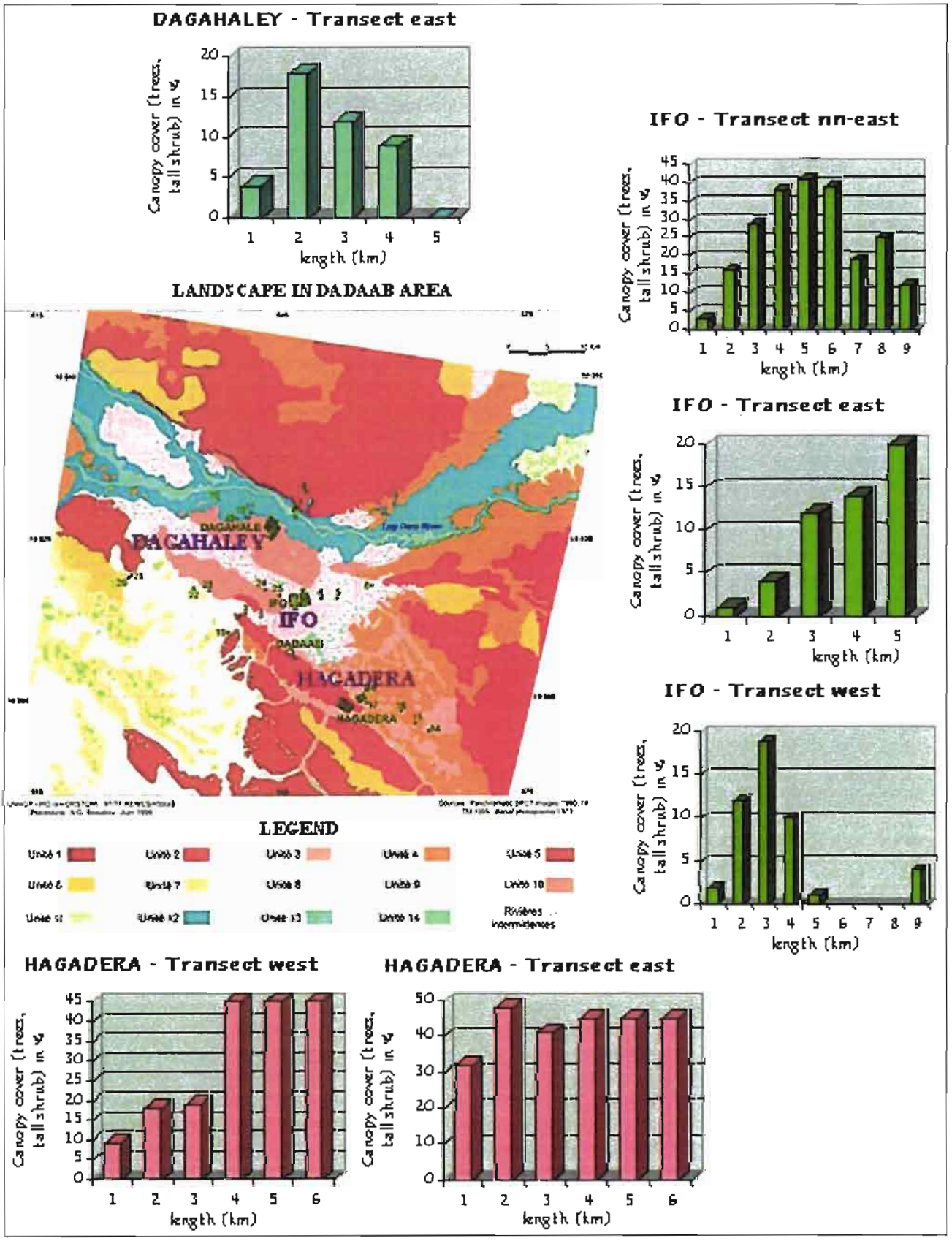

Figure 3 : Land cover by arboreous and bushy vegetation
Source : Ogweno, Ochieng, 1996 : report of a baseline vegetation resource survey for GTZ-rescue II.

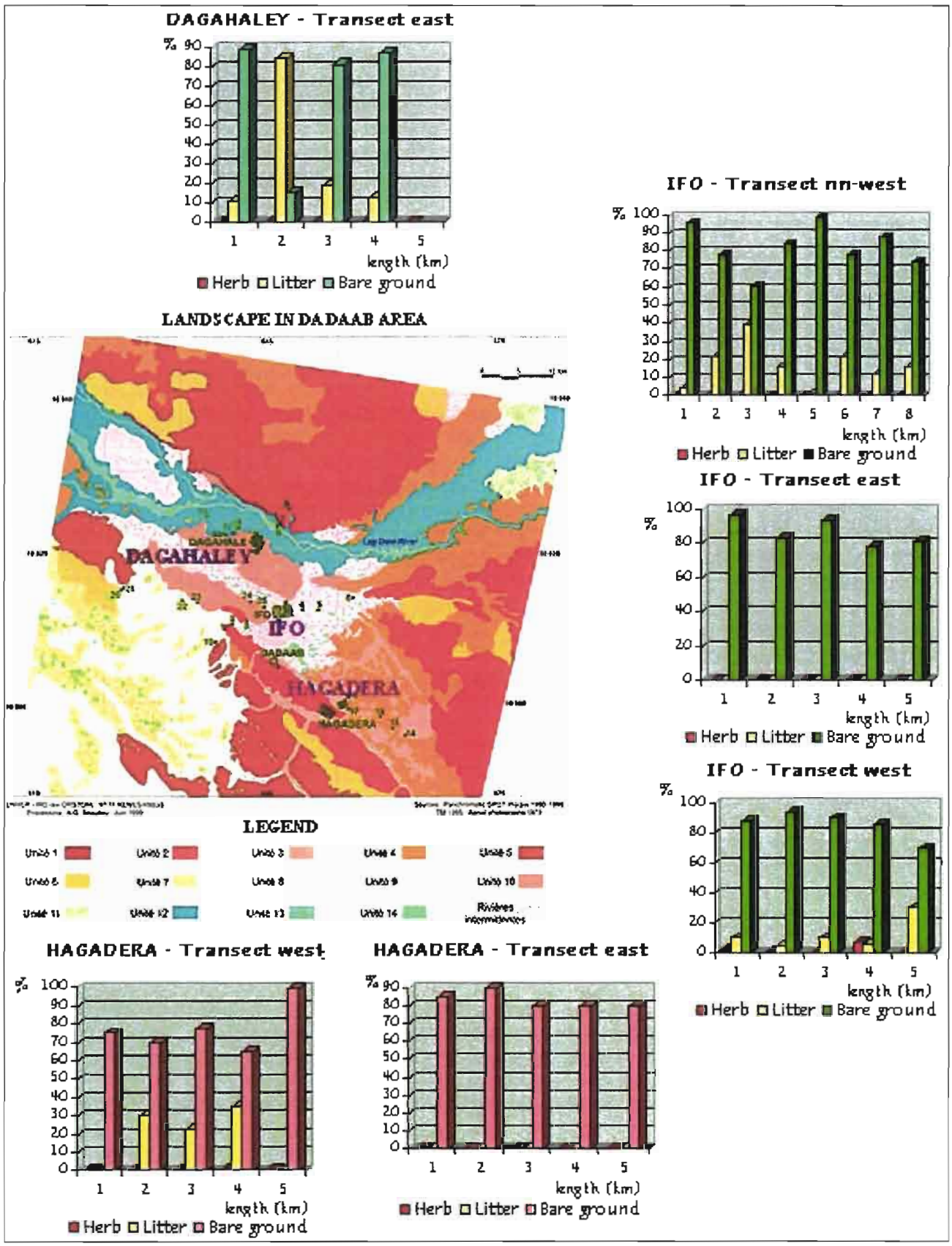

Figure 4 : Bare soil, herbaceous and litter cover

Source : Ogweno, Ochieng, 1996 : report of a baseline vegetation resource survey for GTZ-rescue II.

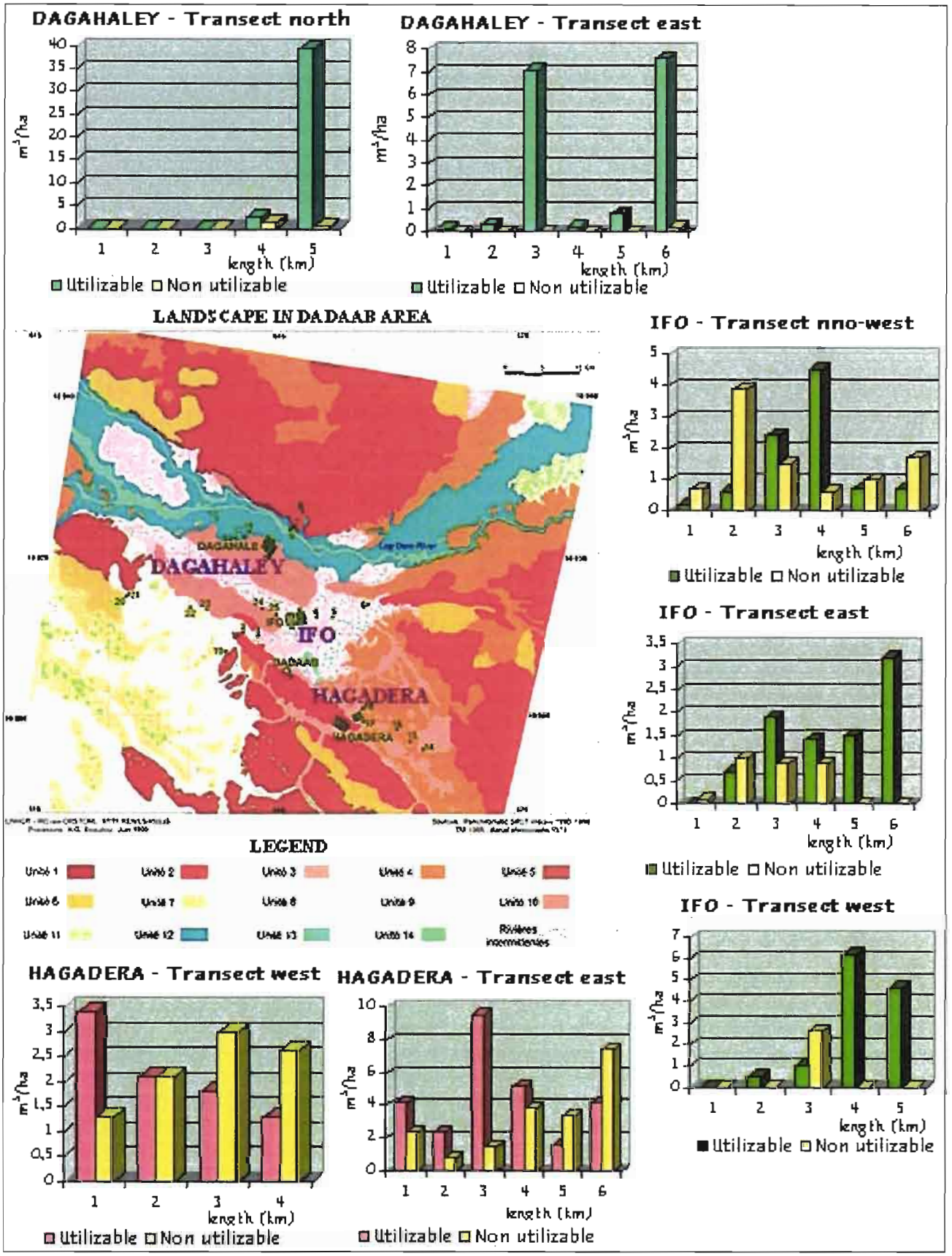

Figure 5 : Utilisable and non utilisable woody volumes resources (firewood)
Source : Ogweno, Ochieng, 1996 : report of a baseline vegetation resource survey for GTZ-rescue II.

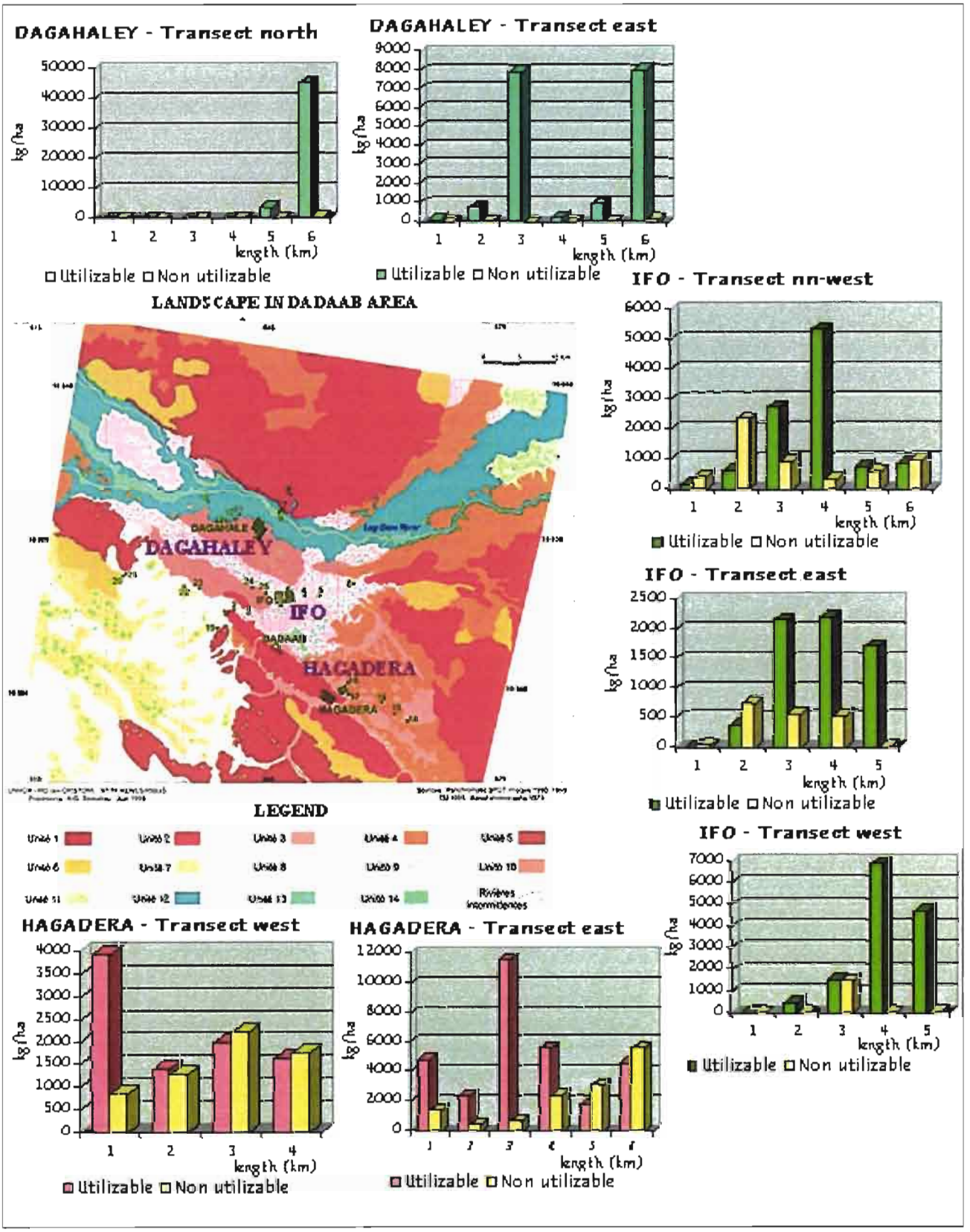

Figure 6 : utilisable and non utilisable biomasse (firewood)
Source : Ogweno, Ochieng, 1996 : report of a baseline vegetation ressource survey for GTZ-rescue II.

In the same way, the graphic representations according to the distance of the volume and usable trees (and non usable), and of the biomass (figures 5 and 6) make it possible to give a good indication of the status of the vegetation in the immediate surroundings of the camps in 1996 ; this date which represents the first analysis of the status of the vegetation after the installation of the camps.

- **the arboreous and shrubby cover :** very weak, even non-existent in the immediate surroundings of the camps ; it increases regularly according to the distance, except in Dagahaley when one approaches to the river and the seasonal flooded zones. Hagadera has a still important woody cover (especially towards the east) which after 2/3 km is higher than 30/40%. On the other hand in Ifo, only the north-north-west track has a still important woody cover, near to 30/40% at the third kilometre. Everywhere else this cover does not exceed 20%. The situation is identical in Dagahaley.

- **the herbaceous cover, litter and bare soil :** the analysis of the graphs underlines the quasi total absence of herbaceous cover. The importance of the bare soil is quite big. The litter, generally not very important, is not directly linked to the presence of an important arboreous cover, except in Dagahaley. However these observations strongly depend of the season of observation. It is probable that in rainy season the herbaceous cover would have been definitely more important as it has been observed in 1998, a particularly rainy year.

This thus suggests **seasonal vegetation follow-ups** in order to better evaluate the evolution of the vegetable cover.

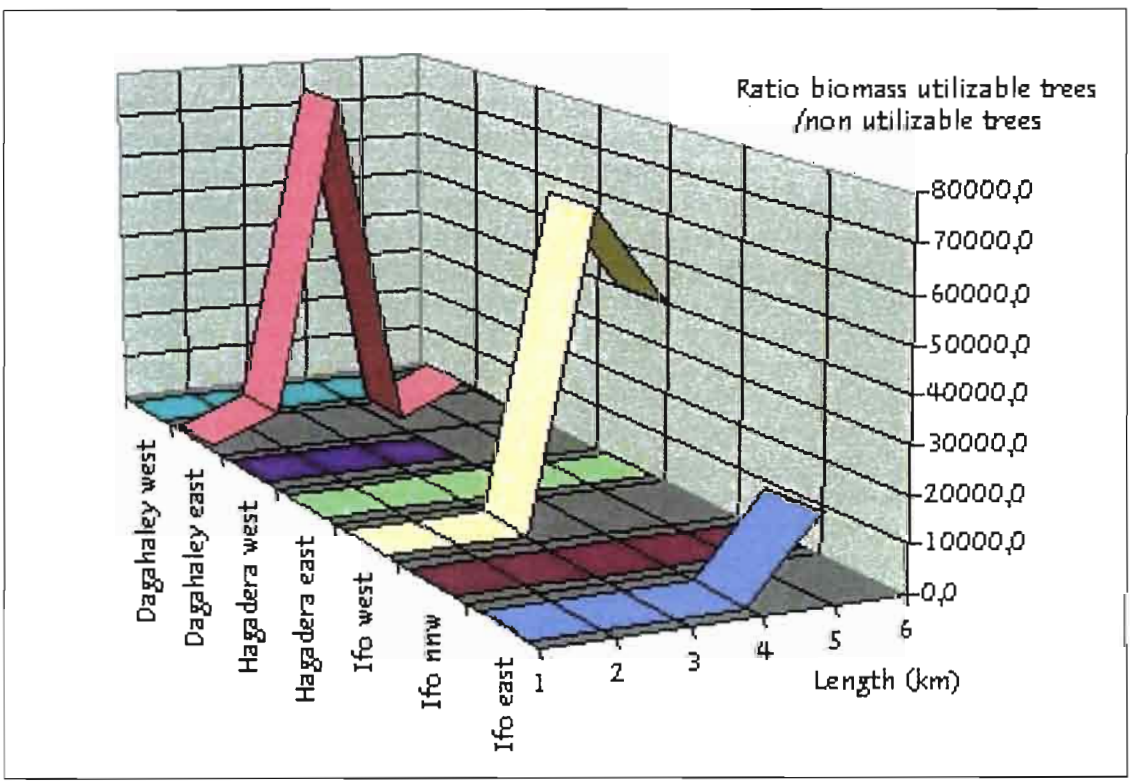

Figure 7: usable and non usable Biomass ratio (firewood)
Source: Ogweno, Ochieng, 1996: report of a baseline vegetation resource survey for GTZ-rescue II.

- **usable and unusable woody ressource for firewood:** the results are expressed in kg/ha or m3/ha (biomass). The two expressions of these measurements are very close. However it is noticed that the unusable quantities of wood are definitely higher in Hagadera while moving away from the camp. According to authors', in the zones non- or very few occupied, that could be, partly, an index of degradation of the vegetation. The measurement of the biomass is also an excellent indicator of the firewood reserves by comparison of the values "usable wood" (high density) "unusable wood " (low density). **High ratios indicating of the possibilities of reserve out of wood of heating. The " flat curves" indicate the absence of firewood reserve (fig. 7).**

Always according to this study, for the classes of degradation 1 and 2, strongly affected in terms of biodiversity, replantings are recommended and several species suggested according to three scenarios:

- creation of commercial activities based on vegetal productions (gum arabic, myrrh, incense, firewood and wood of constrcution). *Acacia senegal, Acacia seyal, Prosopis* replantings.
- reconstitution of the initial ecosystem by replanting varieties of local *Acacias (horrida, senegal, seyal, albida, mellifera, recifens, ...).*
- reconstitution of " green belts " by replanting a set of varied, local or introduced species. It is the current policy.

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3 - LANDSCAPE IN DADAAB AREA

The analysis of the old aerial photographs (1979), the Spot images (1990 and 1998), and a TM image (1995) associated with two field surveys made it possible to draw up a map of the landscapes. Samplings of soils were also carried out in order to specify certain criteria of fertility which could be used as indicators of the environment changes.

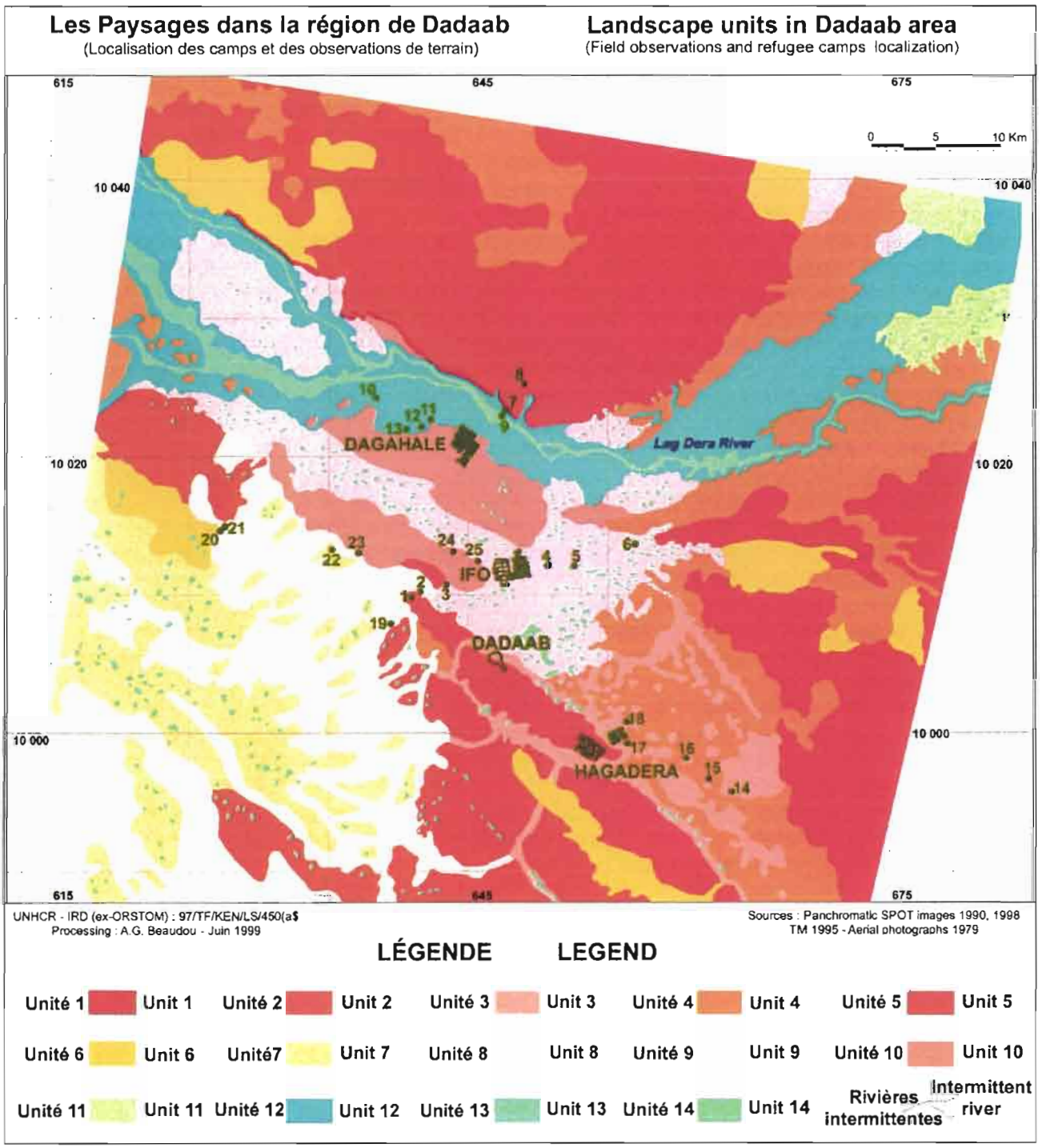
While using various criteria like:

- topography
- soils
- vegetation
- surface status
- the superficial run off
- erosion
- the soil fauna activity
- the vertical drainage

Fourteen cartographic units could be identified in this area (Figure 8). In spite of a sometimes reduced extension, because of their very specific characteristics, some of these small units are represented on the landscapes map. The most determining variables for the characterisation of the units refer to the soils, the mode of superficial water run-off, the vegetation and the soil fauna activity (termites). These variables give the best expression of the current dynamics of the landscapes, their functioning and their evolution.

These 14 cartographic units (or landscape segments) can be gathered in 4 principal types of landscapes defined by the soils superficial horizons *texture* and their *colour*. Actually, this first "field perception" do correspond to the local perception. In order to describe their environment, it is to be noticed that the inhabitants of this area use first of all the soil colour, and then a concept which corresponds to the soil texture.

3.1- Map and legend of the landscape units of Dadaab area :



LANDSCAPE	LANDSCAPE UNITS
P1	1, 2, 5
P2	3, 4
P3	6, 7, 8, 9, 10
P4	11, 12, 13, 14

LANDSCAPE UNITS DETAILED LEGEND (DADAAB AREA)

Unit 1

Alluvial ironstone (coarse sand, gravels and peebles cemented by iron) along the north banks of the Lag Dera river This unit could be associated with unit 12.

Unit 2

Landscape : flat plain with red sands soils with a very good and fast internal drainage. No erosion. Vegetation : dry forest, medium density, tall shrub and small trees (4 to 5m), regular, homogeneous..Soil covering : 40 to 50%. The fauna activity seem practically non-existent and no ant-hill is visible. (RAMA GADUD).

Unit 3

Landscape : alluvial concave plain of slight slope (1 to 2 %) with large depressions almost circular, aligned regularly and showing marks of an old hydrographic system. This landscape edges the red sandy soils of the unit 2. It is also, closely associated with unit 4 (pale red sandy and sandy clayey soils). Soils : beige and pale grey loamy and sandy-clayey soils, clayey and red spotted or mottled in depth, and always with a thin sandy surface horizon. Low or very low internal drainage. Vegetation : woodland savannah (*Acacia tortilis* dominant), mainly at uphill depression area. Herbaceaous and bushy vegetation slightly thick at downhill. Soil covering : 40 to 50 %. Some to many anthills (ADABLE).

Unit 4

Landscape : alluvial plain, flat and regular. Soils : pale red sandy surface horizons and pale red sandy-clayey depth horizons. The internal drainage is slowed down. Vegetation : mainly shrub and trees (medium and tall, less 3/4 m.), relatively homogeneous and regular. Soil covering : around 30 to 50 %. Important to medium biological activity. Many anthills. (BER GADUD, RAMAAT).

Unit 5

Landscape : alluvial plain flat and slightly irregular, with also an irregular external drainage (small ponds with low depth where water rainfall ponds for more or less long time. These ponds are similar to these of unit 3 or more wide spread but withe a very weak concavity). Soils : more or less intense red color, sandy or sand in the surface horizons, sandy-clayey or loamy-clayey in the depth horizons. The soil texture is directly dependant of the topographical location. Internal drainage is relatively slow in some places. These soils are between the red sand soils (unit 2) and the sandy and loamy clayey, red or pale red soils (unit 4). Vegetation :Dense tall shrub 4/4,5m), less regular than in unit 2. Soil covering : 35 to 45 %. Low biological activity. Some anthills in slow external and internal drainage area. (Intergrade between RAMA GADUD/BER GADUD).

Unit 6

Landscape : alluvial irregular flat plain with an irregular external drainage and concave areas which become ponds during a part of the rainy season. This unit is very close to unit 5. Soils are less red and more clayey. Clayey soils with a very slow internal and external drainage that explain the relatively numerous residual ponds. Superficial sheety flow. Vegetation : Irregular medium and tall shrub. Soil covering : 25 to 40 %. Biological activity is more important than in unit 5. Many anthills.

Unit 7

Landscape : alluvial weakly ondulated flat plain with an irregular external drainage and many concave rounded or oval ponds. Soils : very pale red color, loamy-clayey, often medium sandy in the surface horizons. In the ponds, soils are reddish-beige and loamy-clayey from the surface horizons. The depth horizons are characterised by strong vertic features and black color. Vegetation : Medium and dwarf shrub (less 2/2,5m.), irregular and low density. Soil covering : 25 to 35 %. Very high biological activity and numerous anthills. (RAMAAT).

Unit 8

Landscape : plain with very gentle slope and a temporary weak embeded, dendritic, more or less anastomosed river pattern but with large "valleys". Soils : reddish-beige or beige color, sandy to sandy-clayey in the surface horizons, sandy-clayey to loamy-clayey in depth horizons. In the « valleys » the soils are characterised, from 25/30 cm. by black or black- brownish vertic horizon in depth. Sheet and gully erosion types. Vegetation : medium and tall shrubs, wooded savannah along the valleys. Between the valleys the vegetal cover is a dwarf shrubby (1 to 2m high) savannah slightly dense with a « spotted » structure linked with anthills. Soil covering : 15 to 40 %. Very high biological activity. Very numerous to numerous anthills.

Unit 9

Landscape : alluvial plain, flat with numerous concave depressions. The size and the pattern of these depressions are variable (roun to oval, ten to hundred meters). Soils : red, with medium sandy to sandy-clayey surface horizons and sandy-clayey to loamy clayey deep horizons. In the many residual ponds with a very slow external drainage the soils, less red and sandy-clayey in the surface horizons show vertic pattern in depth (from 35/50 cm.) and a black-brownish color. The rain water follow a dense network of small channels which interlink the ponds. Vegetation : dwarf and medium (1/2 m.) shrubby herbaceous savannah, irregular (more dense close the ponds). Soil covering : 15 to 25 %. Very high biological activity. Very numerous anthills. (BER GADUD).

Unit 10

Landscape : alluvial flat plain, punctuated by small circular concave depression (ponds). Soils : reddish-beige, sandy-clayey to sandy in surface horizons, sandy-clayey to loamy-clayey in deep horizons. This unit which is close to unit 8 (south of Lag Dera river) does not show river pattern. The superficial run-off is only sheet flow or follow small and tiny channels which interlinks the residuals wet areas (recognizable by a more dense vegetation, and/or by the existence of anthills). Vegetation : Medium and dwarf shrubby savannah (1 to 2m) with marked or spotted structure. Soil covering : 15 to 35 %. High biological activity. Numerous to very numerous anthills. ("spotted" BER GADUD).

Unit 11

This cartographic unit is very close to units 4 and 12. Landscape : alluvial flat plain with some little round ponds. Soils : beige to beige-reddish, loamy-clayey in surface horizons, brownish-black and vertic pettern in depth. An organized drainage pattern channels the rain water flow. Vegetation : herbaceous, weakly dwarf, bushing savanna.

Unit 12

Lag Dera river flood plain. Soils with clayey-loamy, reddish-beige upper horizons and black vertic horizon in depth. The external banks show sandy soils or soils with a big amount of gravels or pebbles which are often cemented by iron. This is the ironcrust already described in unit 1. Vegetation : herbaceous savannah with *Acacia seyal* (few to many).

Unit 13

Lag Dera river mean water channel. Soils with clayey-loamy, reddish-beige upper horizons and black vertic horizon in depth. Vegetation : herbaceous savannah except during the wet season (run off).

Unit 14

This unit regroups the ponds of units 5, 6, 7, 9 and 10. These temporarly ponds are characterized by differents sizes (ten, hundred meters, or kilometers of diameter) and shapes (round, oval, irregular). The drainage is slow to very slow. The soils have from 25/35cm horizons with vertic patterns and black or brownish-black color. The duration of water stagnation, usually brief, is very fluctuating from year to year.

3.2 - Main types of landscapes in the Dadaab area :

The various segments of landscape or cartographic units are gathered in four principal types of landscapes :

- the landscape on red dark sands (*Rama gadud*).
- the landscape on red soils, with sandy surface horizons and sandy clayey horizons in depth (*Ber gadud*).
- landscape on reddish soils with sandy or sandy-clayey surface horizons and loamy-clayey horizons in-depth (*Ber gadud* and punctuated structure with ponds).
- landscape of beige-reddish soils or gray-beige, loamy-clayey (*Ramaat*).

Table 7: Types of landscapes and corresponding cartographic units

TYPES OF LANDSCAPE			
SAND - >90 % de Sg+Sf - <10 % A+Lf **(P1)**	**SANDY SOILS** - 75 à 90 % de Sg+Sf - <20 % A+Lf **(P2)**	**SANDY AND SANDY-CLAYEY SOILS** - 60 à 75 % de Sg+Sf - < 30 % A **(P3)**	**LOAMY-CLAYEY SOILS** - > 30 % A - > 15 % Lf - < 30 % Sg+Sf **(P4)**
CARTOGRAPHIC UNITS (SEGMENTS OF LANDSCAPE)			
2, 5 (by place, 1)	**3, 4** (by place, 9)	**6, 7, 8, 9, 10** (by place, 3, 12)	**11, 12, 13, 14** (by place, 1, 3)

Table 8 : Landscapes and cartographic units acreage

Cartographic units	CU areas (km²)	Landscapes	Landscapes acreage (km²)
Unit 1	7	Red sand (P1)	1114
Unit 2	584		
Unit 5	523		
Unit 3	114	Red to reddish sandy soils (P2)	635
Unit 4	521		
Unit 6	174	sandy to sandy-clayey soils (P3)	1262
Unit 7	236		
Unit 8	454		
Unit 9	277		
Unit 10	121		
Unit 11	51	Loamy-clayey soils (P4)	493
Unit 12	344		
Unit 13	59		
Unit 14	39		
TOTAL	3504		3504

32.1 - Red sand landscape with regular dry forest (1114 km2) :

Called Rama Gadud by the inhabitants of this area, it gathers **segments 2 and 5.**

321.1 - Flat and regular plain, characterized by red soils, very sandy, with very fast internal drainage (unit 2 : 584 km2) :.

No mark of visible erosion. The vegetation is a dry forest which gathers bushy forms and tall shrubs associated with rather small trees. This dry forest fairly dense, has a homogeneous and regular structure. The height of trees and shrubs is around 4 to 5 m. The soil cover varies between 40 and 50 %. The fauna activity seem practically non-existent and no ant-hills is apparent. (RAMA GADUD)

321.2 - Alluvial plain with red, very sandy soils, on slightly irregular surface associated with an also irregular external drainage (unit 5 : 523 km2) :

Soils with more or less intense red color, with very sandy textures (even of red sand) on the surface. However, some textural changes can be observed. Texture is more fine (greater high content of fine sands and silts) on the surface and the speed of rainwater infiltration decrease. In this case, the microrelief is characterised by slighty depth depressions. Texture in the lower horizons is always extremely sandy (82 % of sands) but with a content of fine sands more important. The practically non-existent silts in the horizons of surface become measurable in-depth.

Photograph 7 : aspect of the vegetal cover of unit 5

Therefore, in this segment exists depressive zones, similar to those of unit 3, where rainwater ponds. But, in this unit, the rainwater also ponds on vaster surfaces barely concave. This segment seems intermediate between the red sand segment (unit 2) and the segment with reddish sandy and sandy-clayey soils (unit 4). The vegetal cover is dense, less regular in the height and organization than that of the unit 2. Vegetal formations are made up of shrubs and bushes of high size (4/4,5m). The soil surface cover is about 35 to 45 %. The biological activity seems reduced and only some ant-hills are visible by places. (Intergrade Rama Gadud/ber Gadud).

In this landscape, it is logical to integrate segment 1 (7 km2). This is a hardpan with coarse sands, gravels and stones cemented by iron oxides and hydroxides. This hardpan is observed at the edge of unit 5, on northern bank of Lag Dera. The induration is not only relates to the sandy soils of unit 5, but also to the coarse alluvium of the Lag Dera river banks (unit 12). For this reason the hardpan levels can also be included to the silty-clayey river bed landscape.

Taking into account the very sandy nature of the soils of this landscape the infiltration of rainwater is total, even if it is slowed down by places (unit 5). The consequence is a peripheral intermittant flow underlined by the alignments of ponds quite visible and gathered in the unit 14.

The texture almost exclusively sandy of the soils also explains the absence of ant-hills and the absence of discernible biological activity. In this landscape the vegetal cover appears very homogeneous.

Photograph 8 : hardpan (unit 1). Observed at the edge of unit 5

The quantities of oil nutriments are very low and the regeneration of an arboreous vegetation or only shrub-like will be very leisurely. For this reason the wood harvest must be very limited.

In spite of a rather dense and homogeneous vegetation, but with shrubs and trees of relatively smal dimensions (3 to 5 m.), the deadwood reserves seem very low. One can also think that the totality of the deadwood was already collected, which is plausible taking into account the type of environment (excessively poor soils, woody of low diameters).

The arboreous and shrub-like vegetation, dominant, covers nearly 40 % of the soil surface. The bushy vegetation, less dense, covers only 15 % of the soil surface. The herbaceous layer, very sparse, occupies only 5 to 10 % of the soil surface. The total soil cover is about 60 to 65 %, at this period of observation (February). The species most frequently met are *Dalbergia sp, Commiphora, Jatropha,* (high woody layer) *Dyspora sp, Berberia sp,* (low woody layer) *Aristida* (herbaceous layer).

32.2 - Landscape of red sandy soils on the surface and sandy-clayey in-depth with homogeneous shrubby savanna (635 km2) :

This landscape regroups the cartographic units 3 and 4. In certain places the cartographic unit 9 present similarities with these two units. Actually, this landscape is characterized by the juxtaposition of two very caracteritic segments:

322.1 - a succession of ponds sometimes junctural, sandy and beige-reddish on the surface, sandy-silty, even clayey and mottled (red/beige) in-depth (unit 3 : 114 km2) :
They are large-sized ponds, more or less regularly aligned, in which water accumulates during the wet season and stagnates during two to three weeks on average. They could appear the " vestige " of a (old?) hydrographic network. Alignments of ponds could represent the trace of cut off meanders and the result of a correction of river as shows it

photograph 9. This type of formation is locally called by the term of ADABLE. This segment partially borders the red sand segment (unit 2).

The soils are beige-reddish, with always sandy surface horizons, sandy-clayey and clayey mottled horizons in depth. Therefore the internal drainage is very slow.

The biological acyivity seems very intense and a lot of anthill are visible in this unit.

The vegetation is a wooded savanna with a predominance of *Acacia tortilis*. The arboreous stratum (*Acacia tortilis, Cordia sinensis, Balanites orbicularis, Commiphora sp*) is principally located around the edgings of the ponds and of the valleys. So, the trees constitutevery particular alignment The arboreous layer recovers 30-40 % of the soil surface. The dwarf bushing out layer, rather few dense (represented by a perticuler variety of *Abutilon*), is mainly described in the lower part of this cartographic unit. It recovers only 10 to 20 % of the soil surface.

In other places the vegetal cover is less important. The arboreous layer (mainly with *Balanites, Acacia senegalensis, Commiphora* and *Cordia sinensis*) only recover 20 to 25 % of the soil surface. The dwarf bushing out layer is more diversified (*Abutilon, Boscia, Grewia*) but is always rather few dense (15 to 20 %).

Photograph 9: Alignment of ponds, remainders of old recut meanders

Photograph 10 : *Acacia tortilis*

In all situations the herbaceous layer is quite nonexistent (around 1 % of the soil surface). The total soil cover is between 40 and 60 %.
The presence of a rather dense wooy layer is at the origin of a rather large quantity of deadwood. This deadwood abundance could have be related to the particular conditions of circulation and ponding of rainwater.

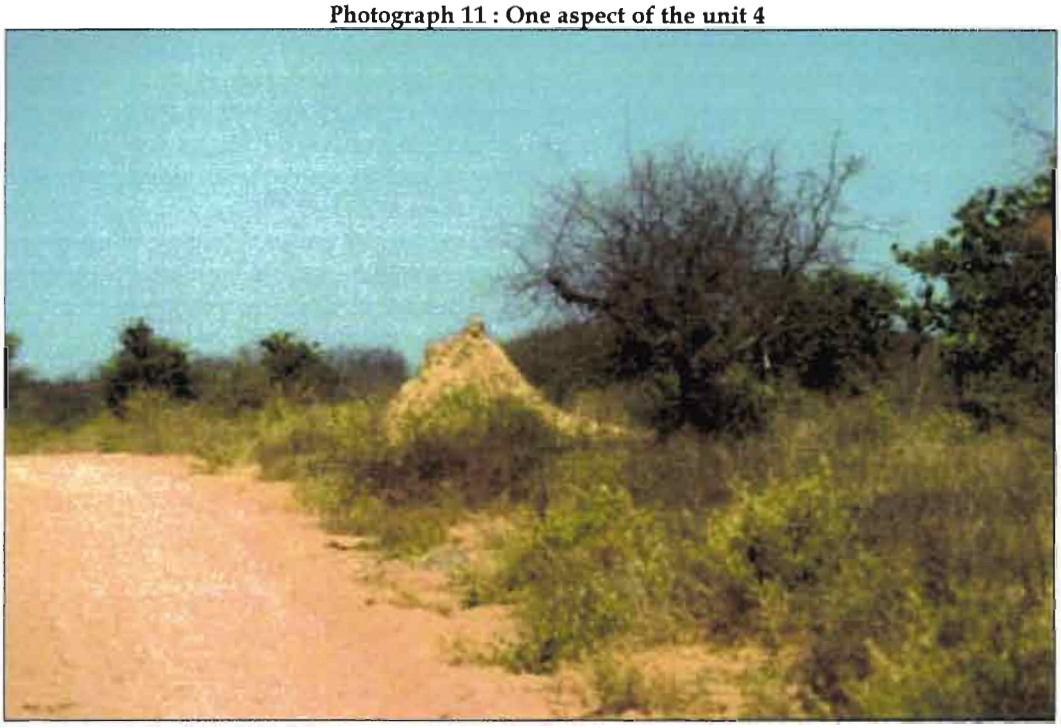
322.2 - a red plain, sandy and silty, covered by a shrubby and wooded savanna with a homogeneous structure of " bush " (unit 4 : 521 km2) :
It is an alluvial plain on plane and regular surface. We will see that in detail microrelief can be rather irregular.
The soils are sandy and red on surface, sandy-clayey in the lower horizons. The existence of this more clayey horizon in-depth differentiates these soils from those of the preceding landscape. They are locally called " Ber Gadud ", even " Rama Gadud " if the red color is sunk, or " Ramaat " when the red colour is cleared up. The more clayey texture of the lower horizons somewhat slowed down the internal drainage. There is however never stagnation of water except in slightly concave zones. One observes, indeed, one microrelief marked by the presence of very slight depressions, but of one, alternating with rather vast plane or slightly convex beaches.

The biological activity appears relatively intense and the ant-hills are relatively frequent.

The vegetal cover, in homogeneous layers, is however rather irregular. The woody and bushy layers are rather often of equal importance (20 % of the surface). However, in some sites, the woody layer appears more important (20/30 to 30/40 % of the surface).
The woody layer is mainly represented by *Dalbergia, Commiphora, Acacia tortilis, Delonix elata and Boscia.*
The shrubby layer is mainly composed of *Indigofera and Dysphora.* In all the cases the herbaceous layer seems practically non-existent (less than 1 %).
The total rate of covering of the surface remains relatively weak and ranges between 30 and 50 %. the height of the bushes and shrubs do not exceed 3/4m, that of the trees can reach 6/7 m.

In the same way that in the preceding unit the deadwood reserves seem relatively important

Photograph 11 : One aspect of the unit 4



Photograph 12 : Another aspect of unit 4

32.3 - Landscape on sandy or sandy-clayey reddish soils on the surface, silty-clayey in-depth - Ber gadud with ponds and punctuated structure (1262 km2) :

It is a landscape which gathers the segments (or units) 6, 7, 8, 9 and 10. These segments mainly differ by the mode of circulation of the superficial waters which is done either in sheet flood (UC 6, 7, 9 and 10) with the presence of many ponds, or in the form of rivers or intermittent brooks, rather little marked in the landscape.

323.1 - Segment on plane surface, irregular and external drainage slowed down in the concave zones forming ponds in rainy season (unit 6 : 174 km2) :
This segment is very close to the preceding segment (unit 5) but with less coloured soils, of a clearer red. In depth, the horizons seem still more clayey. The surface flow of rainwater is done in sheet flood and the infiltration is disminished by the presence of the clayey horizons.

The biological activity is very important and of many, even very many ant-hills mark the landscape.

The bushy and woody vegetation, high and medium is irregular. The rate of covering of the surface varies rather largely between 25 and 40 %. In this segment the ressources deadwood seem relatively important, but they remain to define with more precision, as for the preceding segments.

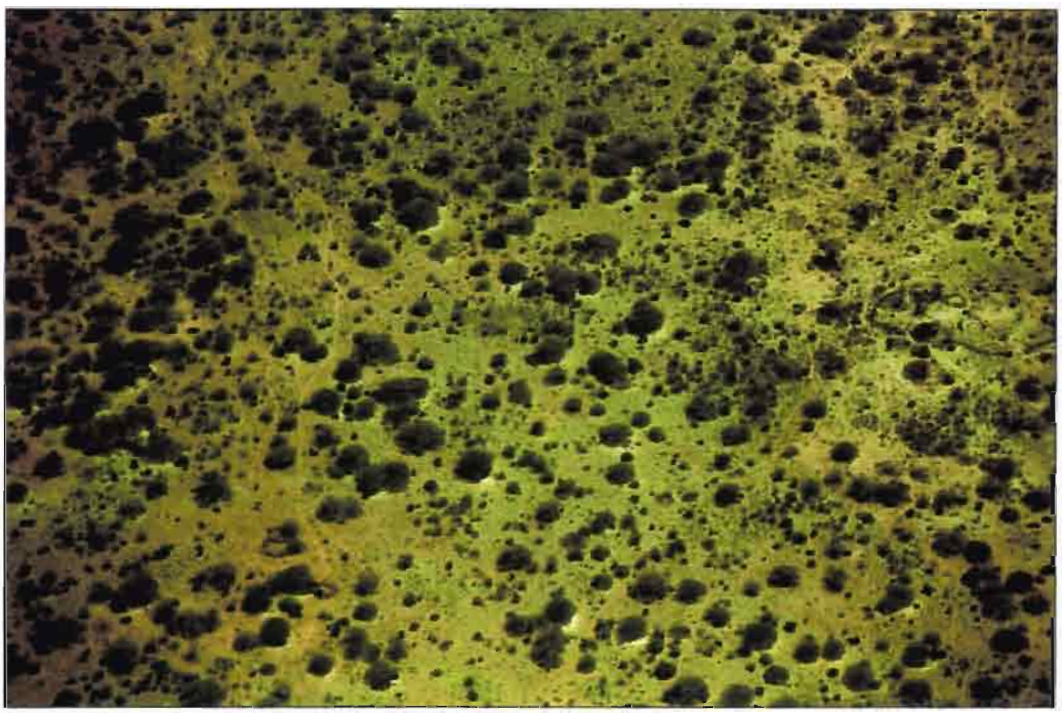


Photo 13 : Aerial photograph of unit 6

323.2 - Segment with flat surface slightly corrugated with many more or less round or oval ponds (unit 7 : 236 km2) :
The soils, very clear red, are silty-clayey, often sandy on surface (RAMAAT). In the concave zones (ponds) the beige-reddish and silty-clayey soils are characterized in-depth by dark brown or black vertic horizons.

The biological activity is intense and it is confirmed by the presence of very many ant-hills.

Photograph 14 : Puntuated savanna (unit 7)

The vegetal cover is a shrubby and bushy savanna rather sparse and heterogeneous (Ramaat with heterogeneous "bush"). The height of the shrubs and bushes does not exceed 2/2,5m, that of the trees of 4/5 m. The structure of the vegetal cover is close to that of units 5 and 6 in spite of its sparser aspect which gives to this unit a "punctuated" structure. The causes of this difference are difficult to determine, but several assumptions are possible (degradation due to the cattle, to firewood collection,... but also possibly due to a "natural" evolution related to a functionning slightly different of the system water/soil - less permeability, erosion in sheet flood or in small gullies more important,...). In this unit the wood potentialities are real but must be estimated with precision.

323.3 - Segment with gentle slope and temporary hydrographic network little encrusted in the landscape but definitely visible in the form of rather broad valleys (unit 8 : 454 km2) :

The beige or beige-reddish soils are sandy or sandy-clayey in the surface horizons, sandy-clayey or silty-clayey in-depth. In the valleys, where water run-off only episodically, the soils are characterized by the existence, from 25/30cm, of brown-black to black horizons with vertic pattern. In addition to sheet flood erosion, exists rather many gullies. They converge towards a true hydrographic network of dendritic type, more or less anastomosed.

The biological activity is very important with the presence of very many ant-hills.

Photograph 15 : Drainage pattern and gullies in unit 8

The vegetal cover forms a low and bushy savanna (1 to 2 m height), sometimes bushy and woody a bit higher (3/4 M. height) between the valleys and a wooded savanna (6/8 m.) along the valleys.

This not very dense savanna is characterized by a "punctuated" structure. The "punctuations" are related to the presence of ant-hills in their center. Th most frequent species are *Delonix eleta, Terminalia orbicularis* and *spinosa, Acacia reficians, Boscia, Cordia* and *Commiphora.* The cover of the surface is rather weak and very variable (15 to 40 %). The wooded layer seems to be at the origin of important resources of deadwood. The more currently collected comes from *Terminalia.*

Photograph 16 : Aerial photograph of punctuated bush in unit 8

323.4 - Flat slightly concave segment with very numerous depressions of variable forms and size, with irregular and slowed down external drainage (unit 9 : 277 km2) : The red soils (Ber Gadud) or clear red (Ramaat) are sandy-clayey to sandy on the surface, sandy-clayey to silty-clayey in-depth. In the very many ponds the soils, pale red and sandy-clayey on the surface, are characterized, from from 35/50cm, by the presence of vertic brownish-black horizons. The biological activity is very high (ant-hills).

The superficial run-off is follows primarily a dense network of thin channels more or less directly connecting to the ponds. A sheet flood also exists. This dense network of fine channels is also organized around the ant-hills.

The vegetal cover is a low bushy savanna (1 to 2 m) and irregularly wooded. The density of the vegetal cover is more important near the ponds. The structure of this vegetation is "mottled". Because of this structure the rate of soil covering will be extremely variable from one place to another. Near the ponds it can reach 60/70%. Elsewhere it will be lower than 5/15 %. In the situations with important vegetal cover the woody layer is represented by *Cordia sinensis, Acacia reficians and Commiphora.* This layer covers between 30 and 40 % of soil surface. The bushy layer, mainly represented by *Indigofera,* does not exceed 20 % of the soil cover. In certain zones only the herbaceous layer is present (Bai Gedud). The surface cover ratio is very weak and does not exceed 10 % in this period of the year (February). For all this unit the soil surface cover ratio does not exceed 25 % (15 to 25 %).

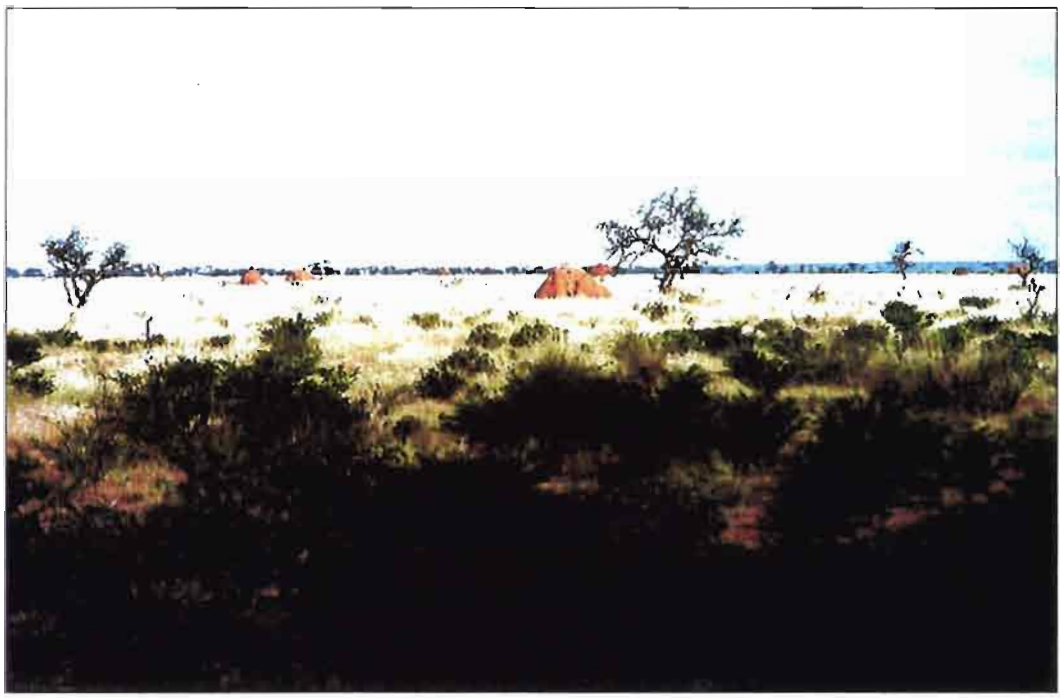
Photograph 17 : Run-off in unit 9

Photograph 18 : Details of run-off in unit 9

In this segment, the trees are sometimes numerous and their quantity, in precise areas of reduced surface lets consider deadwood resources which it is necessary to estimate with precision.

Photograph 19 : Another aspect of « punctated » bush

323.5 - Flat surface segment "punctuated" by small circular concave ponds and ant-hills (unit 10 : 121 km2) :



Photograph 20: Savanna with ant-hills

The beige-reddish soils on the surface, more red in-depth, are sandy-clayey or sandy on the surface, sandy-clayey to silty-clayey in-depth (Ber Gadud with "punctuated" structure).
The biological activity is very important. The presence of many ant-hill is one of the essential marks of this segment and it organizes the superficial flow of rainwater in sheet flood and fine drains. The presence of these ant-hills represents the essential framework of the segment.

Thus, around them, are set up more or less circular and very characteristic an concentric structures which gives to the landscape a quite visible mottled structure on the air images.

Photograph 21: Ant-hills savanna

The diameter of the spots varies from 10 to 40/60, meters. One distinguishes as follows:
- a more or less continuous crown of sandy deposits to the foot of the ant-hill.
- a crown more or less continuous, slightly concave, with muddy deposits (zones of accumulation of remaining water). In these wetter zones it can often be observed a specific vegetation which is the sign of weter conditions.

This unit which is closed to the unit 8, in the south of Lag Dera Valley, does not show any visible trace of hydrographic network. The superficial flow of rainwater seems to be done exclusively in sheet flood and by a dense network of fine channels connecting the temporary residual wetlands marked by the presence of termitières and/or by a denser vegetation.

The vegetal cover is a woody and low bushy savanna (1 to 2 m) with a " punctuated " structure even " striped " by places. The soil surface covering is weak (15 to 35 %) and relatively irregular. The vegetal cover is close to that of unit 9.

The presence of trees in quantities sometimes rather large, but on relatively limited surfaces is a potential source of deadwood of which the quantity and quality remain to be determined.

32.4 - Beige-reddish or gray-beige silty-clayey soils landscape -Ber Gagud / Ramaat / Adable- (493 km2) :

This landscape is not very wide. It gathers four cartographic segments or units (11, 12, 13 and 14), of surfaces of unequal importances. The most important segment is the major bed of Lag Dera River.

324.1 - Alluvial, plane segment with some small ponds (unit 11 : 51 km2) :
This segment is close to that represented by units 4 and 12.
The soils are silty-clayey, beige or beige-reddish on the surface, brown-black in-depth with vertic pattern.
An organized hydrographic network channels the water run-off.
The vegetal cover is a herbaceous low savanna slightly bushy.

324.2 - Flood plain of Lag Dera River (unit 12 : 344 km2) :
The soils are characterized on the surface by beige-reddish silty-clayey horizons, resting on brown-black clayey and vertic horizons. The most external edges present, by places, sandier soils (even rich in gravels of quartz rounded and ovoid) which can be cemented by iron oxides forming armoured levels (unit 1).
It is a segment covered with a herbaceous savanna with *Acacia seyal*. The number of the *Acacia seyal* is very variable.

Photograph 22 : Aerial photograph of temporary stream

Photograph 23 : Herbaceaous savanna with *Acacia seyal*

Photograph 24 : Vertic soils in unit 12, 13 and 14

324.3 - Mean water channel of Lag Dera River (unit 13 : 59km2):
Without water during the major part of the year.

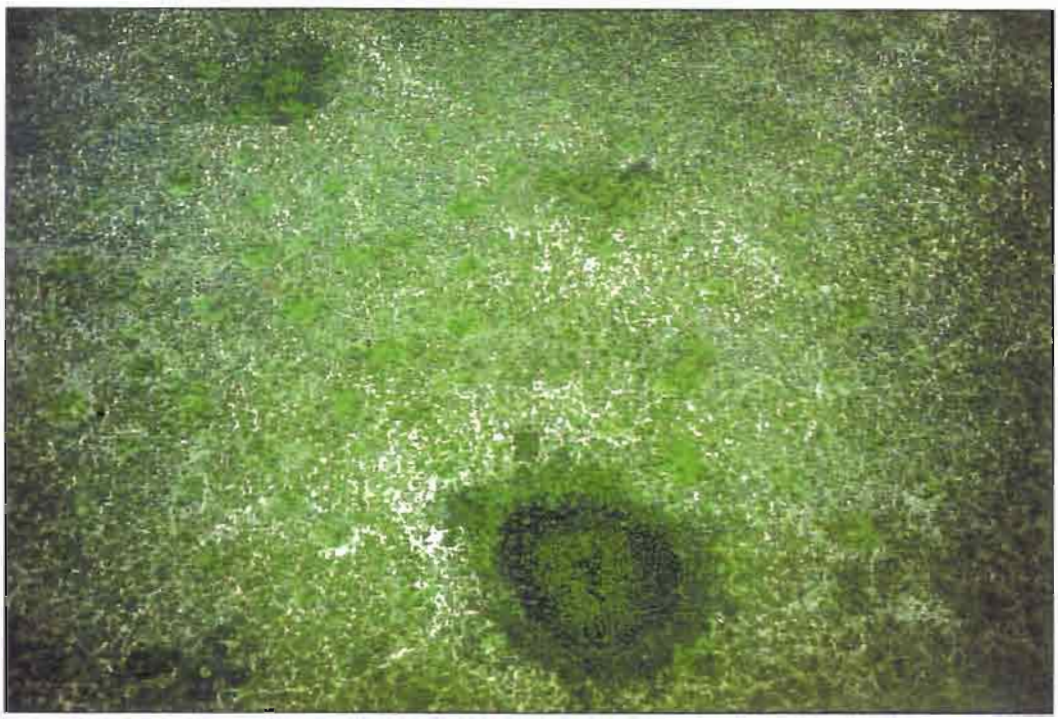
During the dry season is a landscape of herbaceous savanna growing on soils whose horizons of surface are beige-reddish, beige or gray-beige and of silty-clayey texture. The in-depth horizons are brown-black clayey and vertic.

324.4 - Ponds (unit 14 : 39 km2) :
The soils characters of these entities made it possible to gather them in only one cartographic unit. These ponds ponds present in various segments (units 5, 6, 7, 9 and 10) are temporary and correspond to concave depressions of very varied size. They can reach several hundreds meters in diameter, even several kilometers length for some and not exceed a few tens of meters for others.

These depressions are characterized by soils with slow or very slow drainage due to the presence, in low depth, of a brownish-black horizon, very clayey with marked vertic characters. The surface horizons has an silty-clayey texture and are characterized by colors varying between white and gray, gray--beige more or less dark.

The accumulation and the stagnation of water in these ponds are very irregular from one year to another but lasts, in general, only little time.

The vegetation which surrounds these ponds was described in the cartographic units which contain them.



Photograph 25: One pond in unit 14

Photograph 26 : vertic soils surface

In these semi-arid areas the landscapes were defined, for an immediate "field characterization", by the texture of the surface horizons and their color. However their more detailed study reveals other features quite characteristic and essential. One of most representative is that concerning the modes of circulation of superficial water which is very important for the analysis of the functionning of the landscapes.

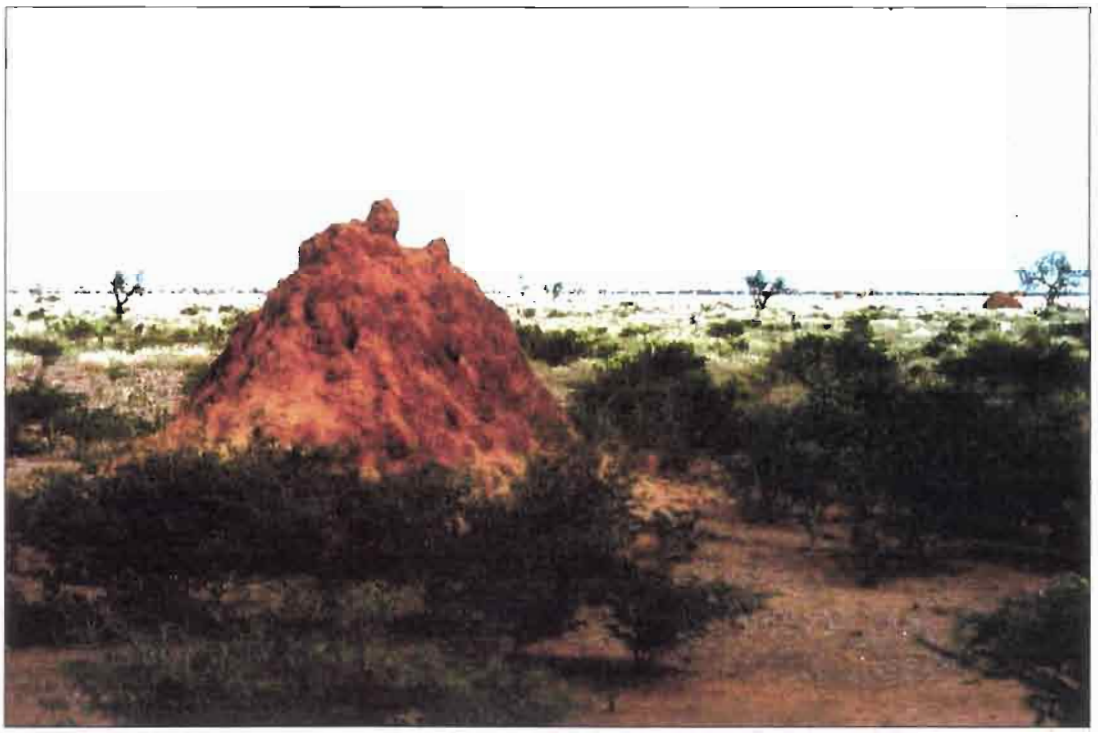
Several great types appear clearly that it is useful to recall in conclusion of this analysis:

1 - very permeable system, without superficial hydrographic network. All water infiltrates in a very sandy soils. Water reappears in edge of these wholes in the form of " cords " of ponds which circumscribe and delimit this system.

2 - system with differentiated permeability with a fast infiltration on the sandy plane zones and reappearance of water in a system of more or less aligned depressions forming the "beginning" of a superficial hydrographic network. In these depressions the permeability is slowed down by deposits of fine particles. Some flows sheet flood with a light erosion.

3 - system with average permeability on very weak or null slope, characterized by a flow sheet flood which is organized in an extremely dense and complex hydrographic hairy penetrating between the tufts of vegetation and the highest points of microrefief. Erosion is sensitive with appearance of sandy zones and clayey-silty deposits (photo 27).

Photograph 27: Deposits on soil surface (Sheet flood erosion)



Photograph 28: The "ant-hill system"

Two sub-types coexist, rather difficult to distinguish:

- a system with very many ponds of low-size rainy season.
- a system without ponds but where the ant-hills organize the circulation of water and are surrounded by depressions where water accumulates and develops a more important vegetation (photograph 28).

This system is characterized by the existence of a " mottled bush " (cf photo 21).

4 - system with average permeability and weak slope supporting a superficial flow organized in a dendritic network associated with a flow in sheet flood. Erosion in sheet flood is present as well as a gullying erosion.

5 – seasonal fluvial system with important risks of erosion of banks taking into account the climatic and hydrological features.

3.3 - Landscape Management

To simplify this analysis, we can possibly compare the management of landscape to the problem of wood collection (especially firewood, and also timber). Being directly linked to the collection of firewood, come later the problems of erosion and/or the preservation and reconstitution of a plant reserves. However, it is important to understand that the estimates given for the firewood vary greatly depending on the authors. Thus, in the Kakuma camp, we have 10 kg of wood distribution per month, per person (that is 0.35 kg/day). The other figures vary from 0.8 kg to 1.5 kg/day/person. In these circumstances, the estimates and approximations of the required reserves are difficult to achieve.

Ogweno and Ochieng (1996) have already undertaken a long botanical study on the management of landscape in this region. Their excellent analysis which is rich in data (the only fault being that the data is not spaced out), has already been cited in precedent paragraph. This study can be used like a starting point for the following of environmental evolution.

The existence of these crowns of deforestation enables us to suggest methods of managing the vegetal reserves (Ogweno and Ochieng, 1996). In the totally destroyed areas, it would be necessary to try to

reconstitute a diversified vegetal stock by planting different local and foreign species. The regermination period is however long and will thus make it necessary to protect these plantations.

In Dadaab area, wood is collected by the refugees and major risks are associated with it (banditry, rape, ... etc). The immediate consequence, that emerges around the camps is the creation of more or less regular concentric zones of vegetation degradation (figure 2). This degradation is not the same depending the geographical situation and the method of setting up of the camps. Thus, it is clearly more pronounced at Ifo, than it is in Dagahaley and even less so, in Hagadera. Whatever the case, a general outline of the distortion of the afforested plant reserves based on the distance of the camp can be defined. We observe a total disappearance of the afforested vegetation in the surroundings nearest to the camps (a distance not exceeding 2km, in Ifo in 1996). Then, slowly by slowly, as the distance increases, the trees and shrub vegetation return to their initial state and the predominat, less utilised species like firewood near the camps tends to diminish as you move further.
A reafforestation policy was set up by GTZ who supply plants (trees nursery) and plantation techniques. In Ifo, we observed the spectacular results of this "reconstruction of the vegetal milieu" effort. It exists at two levels:

- At the camp level: Encouragement to plant trees near the shelters allowed for a rebuilding of the relatively dense tree cover (photo 29).

Photograph 29. Ifo camp : impressive results of reaforestation promted by GTZ

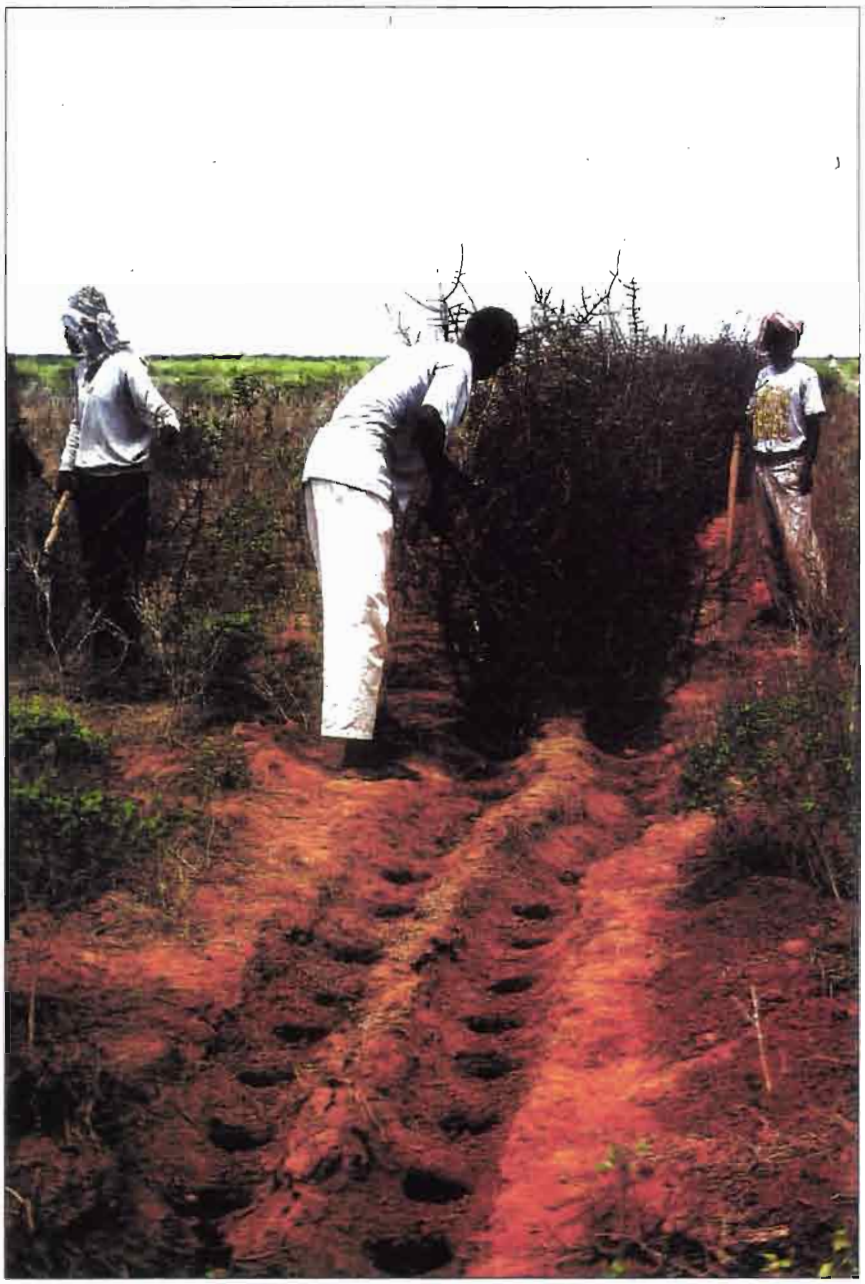
There are varied species (15) with varied orchads (pawpaws, mangoes, passion fruits, guavas, avocados,..). The used water is used for irrigation.

- "The Green Belt": In the more degraded areas, the schemes are fenced using planted hedges (commiphora plantation according to well defined regulations that allow for the maximum trapping of rain water - photo 30).

Inside the perimeters trees are replanted, according to a precise arrangement which enables to get back the rain water and to conserve it (Photo 31)

The trees are planted in threes inside a semi-circle depression. If all the three trees grow, two of them are cut after two or three years. If only two of them grow, one is cut. Generally, a refugee

family is in charge of such protected area , and get therefore the permission to plant in it. Each of these families is selected by the whole community. The most cultivated plants include, maize, sorghum, vegetables, sesame, cow-peas, and pigeon-peas.



Photograph 30 : Planting of a *Commiphora* live fence

Presently, the protected pieces of land are set aside for natural regeneration. (Photo 31)

Currently, 16 pieces of land were demarcated, planted or set aside for natural renovation around the Ifo Camp. The dimensions of these "Green Belts" are diverse and range between one and eight hectares. The oldest one was set up in February 1994.

Though small in surface, and neither able to meet the demand in firewood, nor compensate the losses at the bio-diversity level, these reafforestation land parcels the significant advantage of proving the still existent capacity of regeneration of the landscape, even in the areas most affected by wood collection.

Photograph 31 : an example of reafforestation in a "Green Belt".

Photograph 32 : an example of regeneration in a "Green Belt".

Conclusion

The system selected to meet the need in firewood obviously causes significant degradation in the immediate surroundings of the camps. Reafforestation can therefore be seen to compensate excessive wood collection. However, it appears to be more or less an "unmatched fight", given that the demand is usually higher than what the surrounding milieu of the camp can offer.

Since July 1998 the firewood is given to the refugees by UNHCR. This fuelwood is only deadwood ant it is collected in Dadaab area by private collectors. For the moment, the natural wood supply in unaffected. Meanwhile, we can ask several questions about firewood supply :

- what are the real available quantities of firewood ?
- firewood supplies shall be sufficient to insure the refugees supply during a long period ?
- untill how many kilometers will be go for hervesting dead wood to stay inside acceptable budgetary limits ?
- What is the capacity of the environment to produce dead wood ? At what speed ?
- if the natural supplies of dead wood exhausts too quickly it will be necessary to set up selective cut of live wood and to foresee the setting up of drying areas.

On the other hand, **it is absolutely necessary to place degradation at the level of the landscape and the region.** We thus realise that the impact of this degradation can be minimised. The most affected areas being not more than two to three kilometres (from the surrounding of the camp), the distance is very short on the regional scale. Some vegetation areas which have undergone "natural" degradation, and which are clearly visible on aerial images, have actually identical dimensions. It is also to be noted that the results of re-plantation are such that the camps pose a "more re-afforested" aspect than the surrounding Savanna (especially in the Ifo camp).
Last but not least, one point should not be ignored: the sensitisation and involvement of different actors in the field participating in environmental management (bio-physical milieu). Therefore Environmental Working Groups (EWG) were created. They comprise refugees, local community representatives and agencies.

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V - RECOMMANDATIONS

Following the foregoing study, a number of recommendations can be proffered.

1 - If possible **a preliminary study of the environment and landscape (based on the definitions of terms in paragraph 1),** should be done before setting up camps. This method is generally practically impossible to carry out, given the extreme cases of emergency that accompany the setting up of camps. After all, it is always desirable to carry out such a kind of study as quickly as possible in order to characterise the **"original state"**, f the milieu which enables a regular follow-up of future transformations.

Such a study particularly emphasise on the following:-

- Characterisation of the bio-physical milieu (soil, vegetation, climate, water flow and erosion)
- Anthropological, demographic, and socio-economic characterisation.
- Cartographic representation of the results.

2 - **Definition of Pertinent indicators** that are easy to identify and measure and that allow for a follow-up of the environmental transformation:

At the vegetation level : (cf. Ogweno and Ochieng, 1996)
At the soil level : fertility criteria (ongoing analysis) defining the soil quality (pH, nutriment composition, carbon composition ...)
At the soil surface level: identification and location of erosion and accumulation zones, definition and importance of erosion types... (ravine, lay erosion ...)

3 - **Defining a method of environmental monitoring** (involvement of local structures, of refugees, and of participant NGO's... Cf. Environmental Working Groups).

4 - Research of varied and cheap fuel in order to reduce firewood consumption (for instance, blocks of charcoal dust, similar to those used in China, Vietnam, but necessitating the use of "charcoal stove")

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CHAPTER II

FIRE WOOD

Environment, Deforestation and Provision of Firewood in the Refugee Camps Environment (Dadaab - Kenya)

Alain BEAUDOU Luc CAMBRÉZY

IRD - October 1999

I - HISTORICAL BACKGROUND

Until recently, when an organized system of distributing wood to refugees was put in place, collection of wood by refugees was practiced in different ways. The most widely used, was that by women who moved in groups of between 5 to 10 people. Their activities were limited to a stretch of between 5 to 10 kilometers around the camps. They collect low quality wood on a small scale. The average weight carried, according to sources, is estimated to be between 15 and 25 kg (GTZ).

In the past, this activity which was traditionally reserved for women has seen new techniques develop with many playing a more active role. In the first technique, there is the use of wheelbarrows for artisan constructions using timber. In the second one, donkey carts are used. In the first case, men or young boys disappear into the bush for some hours and return with an average weight of 30 kg (Owen 1998). Donkey cart owners on their part disappear for two to three days usually in convoys. They usually bring back heavy, good quality wood, which is then sold to established markets inside the camps. Ox-drawn carts usually carry an estimated weight of 150 kg.

The growth of this activity as observed on the markets since 1995, reveals several phenomena. It also explains the growing difficulty for refugees (especially women) to find dead wood within an acceptable perimeter of the camps. This problem has greatly evolved their culture, since men are now more actively involved in the provision of firewood, something that did not exist in the past. The growth of these markets also seemed to indicate that refugees consecrated most of their money to the purchase of firewood. Economic studies on the evolution of these markets over the past few years (volume of wood sold, price changes, purchasing power of refugees, etc) and the changes in wood collection systems (donkey carts in particular) should have enabled the diagnosis of the real problem before the recent establishment of an organized system of distribution of wood by HCR and GTZ.

Before we analyze the extent of the areas cleared or degraded, it would be useful to briefly mention the different environmental activities undertaken by GTZ (under the aegis of HCR). They can basically be summarized as:

- The distribution of improved ovens that enable refugees to economize the firewood,
- Creation of tree nurseries and distribution of plants to refugees as a reafforestation measure in the camps (blocks and "green belts")
- Setting up "green belts" that are protected and/or reafforested
Protection of the blocks and the diverse infrastructure through planting of *Commiphora* fences

The green belts stand on a total of 188 hectares. The estimated length of the plant hedges is 253 kilometers (about 253 hectares). Considering the fact that only the green belts exist to regenerate the environment, the total area replanted or protected equals 4.5% of the total surface degraded in 1998 (see below).

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II - DEFORESTATION : Sources and Methods Used

Setting up camps as an urgent measure to satisfy the immediate timber and firewood needs of the refugees pushed the analysis and preliminary studies on the environment and resources to the second stage. This study should be a prerequisite for any rational management of an environment. Faced with development of camps and their impact on the environment, the first studies were only completed four years later (Ogweno and chieng 1996). Only recently, under the HCR/IRD (ex-ORSTOM) agreement a cartography of the vegetation in the region was completed using aerial photographs of 1979 (Odhiambo and Ucakuwun, 1999). Finally, a study was conducted under the aegis of GTZ on organized distribution of firewood in the camps (Owen, 1998).

This report aims at completing the knowledge on the environmental situation by giving a cartographic and quantitative analysis of the real impact of the presence of refugee camps on the environment. The approach taken to draw out the question of deforestation was derived from the following observations:

- Around the Dadaab camps, observation of deforestation on the ground, the level of movement undertaken by refugees to collect firewood greatly showed the necessity of moving the study to a micro-regional level. The pertinence of this choice was subsequently shown by the results of the current study; moreso by the evidence of the importance of the relationship between the availability of wood and consumption.
- To draw a f this degradation, the choice of the zone to be studied was limited to a stretch of about 15 kilometers around the city of Dadaab, approximately the geographical center of the area occupied by the three refugee camps (Dagahaley, North Ifo and South Hagadera)
- Given the importance of the area to be studied and the very precarious security conditions which greatly limited the possibilities of detailed field work, intensive use of aerial images was naturally chosen as the most effective method
- Several other complementary sources were used: a) Satellite imagse (1990 to 1998), b) Surveys by flight (February 1999)
- These sources were completed by fieldwork (March 1998 and February 1999)

As pertains to methodology, direct or indirect knowledge of the field (survey flights) was at the backbone of the method used to interpret the satellite images. Two methods were used: 1) Analysis of the state of the surface and especially the surfaces cleared in 1990, 1995 and 1998, 2). Comparative analysis of the panchromatic SPOT images of 1990 and 1998 showing the changes in the cleared surface between these two dates. These two methods lead to this very convergent results in terms of the affected area and the localization of these points.

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III - DEFORESTATION AND SURFACE STATUS : Changes between 1990 and 1998.

1 - SURFACE STATUS IN 1995 (MAP 2.1) :

Table 1 : Surface status in 1995

CAMP	Area (ha)	Very high degradation (ha) *	High degradation (ha)	Total (ha)
Dagahaley	272	643	827	1470
Ifo	308	1499	1270	2769
Hagadera	266	965	78	1043
Dadaab	60	132	-	132
Total	906	3239	2175	5414

* : this acrage includes the area of the camp (blocks, infrastructures)

Comment :

- The total surface degraded (52km2) corresponds to 0.12% of Garissa district.
- The size of the area that experiences most degradation around the Ifo camp vis-à-vis other camps must be emphasized. This can be explained by several factors:
  - History : Ifo was the first camp to be set up in Dadaab after clearing the area with a bulldozer. However, the size of this initial clearing is ignored - and it is usually justified by attributing it to security reasons - around the perimeter of the camp itself
  - The Ifo camp equally seems to have acted as a receiving center for the new refugees in the region
  - During certain years, the Ifo camp received more refugees than the other camps
  - The size of the family in 1996 was 4.1 in Ifo compared to 5 in Dagahaley and Hagadera. This means a bigger number of huts (10,638 in Ifo as compared to 6,115 in Dagahaley and 8,199 in Hagadera) corresponding to equally high needs in timber (Source, Nyandiga, 1996).

2 - SURFACE STATUS IN 1998 (Map 3.1 and 3.2) :

Table **2** : Surface status in **1998**

CAMP	Area (ha)	Very high degradation (ha) *	High degradation (ha)	Low degradation (ha)	Total (ha)
Dagahaley	272	1260	390	536	2186
Ifo	308	1897	988		2885
Dagahaley and Ifo				1619	1619
Hagadera	266	960	-	966	1926
Dadaab	83	203	175	-	378
Total	929	4320	1553	3121	8994

* : this acrage includes the area of the camp (blocks, infrastructures)

Comment:

- The total area degraded (90 km2) is equivalent to 6.9% of the area studied. Thus, in three years, the total area degraded increased by 2.7% (3580 ha).
- If on the overall, the increase in the area degraded would seem high, the same area is minimal if placed on a micro regional scale, moreso within the scale of Garissa district.
- The zones that experience the highest level of degradation increase by 1010 hectares from 1995 (+24.5ha), but they are limited to the Dagahaley camps (+49%) and Ifo (+21%).
- There was no increase in degradation in the already degraded ring around the Hagadera camp

- The absence of "medium degradation" in Hagadera in 1998, which was very low in 1995, can be explained by the difficulty in comparing the TM and SPOT image. Appearance of a zone of relatively high and intense degradation can be observed.
- There is appearance of a continuous, intense degradation between Ifo and Dagahaley
- The diversity of environments, to a large extent explains the contrasting changes. Thus, the situation in Hagadera could be explained by the maladjustment to wood resources needs near the camp (Low bushy strata)
- With an increase in the area occupied by Dadaab town, a ring of serious degradation equally develops (+70 ha) to which 175 ha of medium degradation must be added.

3- CHANGES IN THE ENVIRONMENT BETWEEN 1990 AND 1998 (MAP 1, 4 AND 4.1) :

At the back of the preceding maps, which reveal the presence of bare soil, these maps are a result of statistical processing between the two panchromatic images of 1990 and 1998. They interpret any significant changes between these two dates, whatever their nature (erosion, agriculture, modification of the vegetation cover, etc). It should thus be understood that the surfaces represented below could be more than the exclusive surfaces with bare soil.

Table 3 : The importance of soil occupation changes

CAMP	Area (ha)	High change * (ha)	Low change (ha)	Total (ha)
Dagahaley	272	1291	1178	2469
Ifo	308	2359	3479	5838
Hagadera	266	938	4575	5513
Dadaab	83	244	247	491
Total	929	4832	9479	14311

* : this acrage includes the area of the camp (blocks, infrastructures)

Analysis of the results using Map 4, only takes into account the supposed areas affected in the camps and in Dadaab. Thus, some vital parts that fall within the study are omitted (Lag Dera, West and South East of the Map) in which the observed changes are caused by natural phenomena (such as erosion) or other human factors not caused by refugees. Thus the total area of 143 km2 accounted for constitutes to 0.33% of Garissa districts.

Differences Compared with the Preceding Table :

- Like in the preceding maps, the impact of refugee camps can clearly be seen
- There is little difference between areas that have undergone great changes (4832 ha) to those that have been heavily degraded (4320 ha). The difference is mainly in Ifo camp.
- The main differences observed arise when comparing the degraded and less degraded areas (4674 ha) on the one part and the areas that have undergone slight changes (9479 ha) on the other.
- In the case of Dagahaley and Ifo, these zones constitute approximately all the areas originally identified as having undergone little or intense degradation.
- In the case of Hagadera, the extension of the modified surface - much bigger than the degraded area (cf Table 2 and Map 3.1 and 3.2) - seems to be a zone of immense transformation caused by the diverse human activities of both the refugees and the local people alike (pastures and herding of animals, collection of wood).

Reasons for these differences :

- In one case, a study is made of the evolution between two periods (1990 and 1998), and in the other, the surface cleared in 1998 is measured.
- In one case, a global transformation of the environment is analyzed, comparing the reflected values between 1990 and 1998, while in the other, cleared surfaces are the ones analyzed.

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IV - FIREWOOD RESOURCES :

Contrary to the most common hypothesis, *refugees use dead wood adequately.* This is easily explained if you consider the pastoral and rural origin of these refugees, who use traditional methods of cooking. Knowing very well that it is extremely hard to light a fire using green wood, and that one would need to use two times the required amount of wood (and time) to obtain the same quantity of energy than would be the case with dead wood, we conclude that cutting green wood would be the last option considered by refugees. To meet the same energy needs, they would need to use (and thus carry with them) twice the amount of wood for cooking, and to lose a lot of quality time to light the fire and keep it burning. As such, this option will only be used in specific situations such as need for timber to construct huts (green wood is preferred). Finally, it is worth noting that refugees hardly stock wood. Thus, there is little chance that refugees would consider the whole process of cutting green wood, transporting it to the camp and leaving it to dry before using it.

The different results explained above must be related to the wood demand of the refugees. Working with these results however, poses a number of problems :

- uncertainty of the population figures and changes
- uncertainty of the real firewood demand
- irregularity in the times of timber needs by refugees (as a result of the movement of refugees and the time-span of their constructions).

Moreover, the environmental data in this region and in this particular type of environment are still very limited. For instance, the gross volume of the wood available as well as the actual quantities of material produced by a hectare per year is ignored. As such, apart from the study carried out by Ogweno and Ochieng' (1996), interpretations are often derived from works undertaken in other regions or other countries in the inter-tropical zone without and the important role of comparison totally ignored.
Finally, in all the writings of botanists of foresters, the question of dead wood is ignored. It is thus impossible, to estimate the stock of dead wood without measuring particular terrain (see recommendations). It is a known fact that all ecosystems naturally produce dead wood. However, the processes of producing this dead wood, (depending on different circumstances and over time can be subjected to parasitic attacks, floods or extraordinary catalysts, or even on the contrary, to abnormal drought) is greatly ignored. The time required to regenerate a stock of dead wood equivalent to that earlier removed is also ignored.

1 - THEORETICAL PRODUCTION OF WOOD USING CARTOGRAPHED AREAS :

The estimates explained below are derived from all the three camps and from the population of the constituency of Dadaab (inhabited by 115,000 people). Given the high uncertainty of the actual use of firewood, two calculations are used based on 1kg and 1.5 kg of dry wood per person per day. Several periods are considered: 1991 to 1995 (that is 4 years or 1460 days); 1995 to 1998 (that is 3 years or 1095 days); 1991 to 1998 (that is 7 years or 2555 days).
The rate of degradation of the different cartographed areas was established as follows:

Table 4 : Rate of degradation

Type	Percentage
Very High degradation	100%
High degradation	50%
Low degradation	25%

1992 - 1995 Period
- 11,500 inhab. X 1 kg x 1460 days = 167,900 tons of wood used

- 11,500 inhab. X 1.5 kg x 1460 days = 251,850 tons of wood used

1992 - 1998 period
- 11,500 inhab. X 1 kg x 2555 days = 293,825 tons of wood used
- 11,500 inhab. X 1.5 kg x 2555 days = 440,737 tons of wood used

1995 - 1998 Period
- 11,500 inhab. X 1 kg x 1095 days = 125,925 tons of wood used
- 11,500 inhab. X 1.5 kg x 1095 days = 188,887 tons of wood used

Table 5 : Firewood consumption

Period	Consumed wood (t)		Total degraded area (ha)	Theoretical quantity of wood (T/ha)	
Consumption	1 kg/day /hab.	1,5 kg/day /hab.		1 kg/day /hab.	1,5 kg/day /hab.
1992 – 1995	167 900	251 850	4236	39.6	59.5
1992 – 1998	293 825	440 737	5876	50	75
1995 - 1998	125 925	188 887	1640	76.8	115.2

From this estimation and according to the periods considered, the theoretical gross tonnage of wood available per hectare would be between 39 and 115 tones. The changes in the surface between 1995 and 1998 were much smaller than the areas which would be required for use by the people during this period. This is expressed by the theoretical quantities of wood on an hectare which is far from reality (see Table 6).

2 - ESTIMATION OF DEGRADED SURFACES USING THE GROSS VOLUME OF WOOD AND THE THEORETICAL NEEDS OF THE PEOPLE :

From the observations recorded (FAO, 1997), in the most optimistic hypothesis, gross production of wood in the Dadaab region is not more than 10m3 per hectare.

Table 6 : Firewood production of several kinds of vegetation

Type of vegetation	Gross volume	Precipitations (mm)
Savannah grasslands (Sandy soil)	1,4 à 6,3 m3/ha	445 à 575
Savannah grasslands (loamy soil)	4,5 à 10,1 m3/ha	500 à 700
Savannah grasslands (Clayey soil)	2,7 à 8,7 m3/ha	450 à 575
Spotted bushes	14,7 m3/ha	450
Southern Sudan Savannah grassland	15,4 à 18,9 m3/ha	980

Source: Managing natural forests in the dry tropical zones: FAO - CIRAD, 1996

An average density of 0.6 to 1 corresponds to 6 to 10 tons/hectare. For an estimated consumption of 115 tons/day, the surface cleared daily varies from 11.5 to 19.5 ha. Under this hypothesis, the surface theoretically degraded would be:

Table 7: Theoretical surfaces that have been totally cleared (ha) for a density of 0.6.

Période	Surface théorique défrichée (ha)	
Consumption	1 kg/jour/hab.	1,5 kg/jour/hab.
1992 – 1995	28032	41756
1992 – 1998	**49056**	**73073**
1995 - 1998	21024	31317

Comment: It must be kept in mind that this estimation is based on the assumption that green wood was cut. If we take into account that the wood used was dry wood, we must double the estimation of these surfaces. Conversely, the calculation established with a 0.6 density of wood would have to be lowered in a case where the density is 1.

From this estimation, the total cleared surface would thus be included in 1998 between 490 and 720km2. This surface has to be compared to the results from the cartography according to which the actual surface cleared is only 58km2. Thus, all these estimations proceed from the hypothesis in which the surface cleared at different periods corresponded to the required needs and was sufficiently catered for the wood needs of the people. The difference between these two values gives proof of the fact that the people in this region primarily seek dry wood to satisfy their energy needs and that this wood was readily available. These two arguments fall under vegetation preservation.

Thus, the cause of deforestation around the camps brings us to other hypotheses:

- Clearing to set up camps and general infrastructure (about 1000 hectares)
- Cutting of timber to construct and maintain huts, kitchens, latrines and general infrastructure buildings
- Collection of *Commiphora* to make hedges (253 ha corresponding to 253 km of hedges planted with a width of 1 meter)
- Pastures (goats, ...)

All these practices originate from the changed low production of dead wood. On the other hand, it is difficult to envisage high voluntary production of dead wood to satisfy the firewood needs. Thus, the green wood cut must be dried before use. However, the absence of stocking capacity renders this hypothesis least probable.

3 -CAPACITY OF ENVIRONMENTAL REGENERATION :

According to various sources, productivity of this type of environment is extremely variable. Owen (1998) sees this variation as ranging between 500 to 1000 kg per hectare; A study by FAO (1997) shows the variation as being between 0.1 to 2.5 m3/ha (that is 60 to 1500 kg). On the basis of an average production of 750 kg/ha of green wood, the surfaces that would be targeted for partial clearing without increasing reafforested surfaces are between 560 km2 (at 1kg/day/inhabitant) and 840 km2 (at 1.5kg/day/inhabitant). This surfaces correspond to a circle of 13 to 16 km radius[1].
Though relatively low, the capacity of regeneration of the environment has no doubt played an important role in giving an explanation on surfaces of relatively low clearing. Moreover, one can envisage removal of green wood without it being synonymous with deforestation[2].

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[1] It must be remembered that this estimation is based on quantities of green wet wood

[2] The capacity of natural regeneration in the degraded zones is high. The abandoned blocks of the Dagahaley camp have seen high regrowth of grassy vegetation following the floods of February 1998. In Ifo, in the immediate surroundings of the camp (thought to be "barren"), the floods led to dissemination and regrowth of young *Acacia tortilis* plants.

V - DISCUSSION AND RECOMMENDATIONS

All the above explanations are dependent on a lot of measured inexact data (actual daily consumption, number of inhabitants ...). Besides, knowledge regarding availability of dead wood remains very sketchy. According to Owen (1998), it varies between 1.5 to 2 tons per hectare. Taking these figures into account, the surfaces already totally collected would constitute a circle of 20 to 30 km radius.

Therefore, the assumption that the availability of dead wood is now less than 20 km around the camps, does not take into account the very major changes in the environment. We cannot thus say that the availability of dead wood varies proportionally with distance. Observation of the terrain shows that there exist significant quantities of dead wood within distances less than 20km of the camp. It thus seems that the real potential of dead wood of the different environments is unknown. A further evaluation based on a square survey must be conducted. The local people, who are capable of identifying and locating zones of high and low productivity (together with the types of soil) must thus be narrowly associated with these estimations. These will enable a proper quantification of dead wood in different environments.

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