ENVIRONMENTAL STUDY OF DEGRADATION IN THE SOOL PLATEAU AND GEBI VALLEY: SANAAG REGION OF NORTHERN SOMALIA

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Testimonial

"In the area of Badhan/Xubeera, fifty years ago, I endured mosquitoes, swampland and grass so tall that the families sometimes lost their baby camels from the herd. I remember being tied to the family hut to prevent me from wandering away and being lost in the foliage. In Xubeera, the remnants of the Sultan's palace can still be found in a vast wasteland that once produced the best grassland and the best horses in Somalia"(Fatima Jibrell, Horn Relief).[1]

"Before, in the area of Hadaaftimo, the cattle could get lost in the Doomaar. This grass was very tall. Now, it can't even hide a kid (goat) because of soil erosion" (Hadaaftimo).

"'In front of us, the area was a very thick woodland with high grasses. A camel of five years could disappear in it. The area was degraded over the years with the reduction of the rain, cutting of trees and livestock coming for water, which increased overgrazing" (Ceel-Buh).

[1] Somalia Natural Resources Management Network, workshop 3, September 20th-October 3rd 1997, p 6

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Acronyms and Abbreviations

AGNPS	Agricultural Non Point Source Pollution Model
ASAL	Arid and Semi Arid Lands
BRI	Buraan Rural Institute
CIGR	International Commission of Agricultural Engineering
EC	European Commission
ERDVR	Emergency Relief and Drought Vulnerability Reduction
ETM	Enhanced Thematic Mapper
FAO	Food and Agriculture Organisation of the United Nations
FEWSNET	Famine Early Warning System Network
FSAU	Food Security Analysis Unit of the FAO
FEZ	Food Economy Zone
GoK	Government of Kenya
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ICRAF	International Centre for Research on Agroforestry
IIASA	International Institute for Applied Systems Analysis
IRIN	Integrated Regional Information Network
ITCZ	Inter Tropical Convergence Zone
ITF	Inter Tropical Front
IUCN	World Conservation Union
KARI	Kenya Agricultural Research Institute
KENSOTER	Kenya Soils and Terrain
KSS	Kenya Soil Survey
LADA	Land Degradation Assessment Programme
MSS	Multi-Spectral Scanner
NDVI	Normalised Difference Vegetation Index
NGO	Non-Governmental Organisation
NOVIB	OXFAM Netherlands
PINEP	Pastoral Information Network Programme
PYL	Pastoralist Youth Leadership
RMSN	Resource Management Somali Network
SWALIM	Soil, Water and Land Information Management
SEPADO	Somali Environmental Protection and Anti-Desertification Organisation
SACB	Somalia Aid Coordination Body
TM	Thematic Mapper
TNG	Transitional National Government
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children’s Fund
UNOCHA	United Nations Office for the Co-ordination of Humanitarian Affairs
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme

Introduction to Horn Relief

Horn Relief is an African-led international organisation with a mission to support pastoral livelihoods in pursuit of a peaceful, self-reliant and greener future. Since its inception in 1991 in response to Somalia's devastating humanitarian crisis and civil war, Horn Relief has grown from a small grassroots organisation to one able to advocate for and leverage much-needed resources for its partner communities internationally and regionally. Horn Relief is based in Nairobi, operational throughout northern Somalia and is currently expanding its operations to include southern Somalia and Kenya.

In recognition of the central role that the natural environment plays in the lives and livelihoods of pastoralist communities, and in Somalia's future in general, environmental protection and rehabilitation is at the core of all of Horn Relief's work. To that end, the organisation has closely monitored the status of gullies, water sources, and rangelands for over a decade. Also, Horn Relief has been a leader in the campaign to develop alternative energy sources such as energy improved stoves and solar lighting and cookers, which led to the first large-scale distribution of highly efficient solar cookers to poor households in Somalia in 2005-2006. The organisation has also engaged in extensive lobbying and advocacy efforts against the charcoal trade, resulting in the ban of charcoal exportation from Puntland in 1998. Horn Relief's results-oriented actions with rural communities, their livestock, and their environment have won awards, including the largest global environmental prize, the Goldman Environmental Prize in 2002, and gained recognition from the international community as a whole.

Executive Summary

Horn Relief began alerting the international community, in particular the Somalia Aid Coordination Body (SACB) of the looming humanitarian crisis, caused in part by environmental factors, in northern Somalia since 2001. In 2003, the international community began to acknowledge the crisis and its environmental component, particularly as a result of reports from the Food Security Analysis Unit (FSAU). This dire situation was linked to a persistent drought affecting the primary source of livelihood for the population: transhumant pastoralism.

Numerous studies undertaken have associated environmental degradation processes in the Sool Plateau livelihood zone with both natural and anthropogenic factors, mainly natural disasters and change in land use.

A multidisciplinary team comprising an ecologist, a soil specialist and a social anthropologist was tasked to assess and ultimately increase understanding of the complexity of the environmental problem. The broad objective of this study was to assess the status (nature and severity) of environmental degradation, particularly land degradation and the socio-economic impacts thereof on the pastoralists of the Gebi Valley and Sool Plateau.

The study consisted of two phases: Phase one began with a two-week desk study in Nairobi involving literature review, rainfall data analysis and preliminary interpretation of satellite imagery of Gebi Valley and Sool Plateau (Sanaag Region); In Phase two, the team undertook a 21-day field study in collaboration with Horn Relief field staff.

Field work was carried out in 21 sites selected from the desk study, hot-spot analysis and from consultation with Horn Relief staff. Field survey methodologies included: (1) Interviews based on a qualitative questionnaire; (2) FAO/Africover land cover classification forms; (3) Line transect and quadrant techniques for vegetation sampling; (4) SWALIM water source survey forms; (5) Reference to a Kenyan soil-survey manual for land and soil description; and (6) Soil sampling and analysis to assess physical and chemical properties.

Land-cover changes over a 15-year period (1988-2003) were assessed using Computer Aided Land Cover Classification by ERDAS Imagine software; FAO's Africover Land-Cover Classification System; and ground observations for species composition, land cover and herbaceous biomass.

The main findings on land-cover changes over the period in question are:

- 52% of forest has been lost on the Sool Plateau
- A 32% decrease in shrubs open (20 to 65% of total cover), especially in the Gebi Valley and Xadeed
- A 40% decrease in grassland, especially in the Gebi Valley and Xadeed
- A 4% decrease in sparse vegetation (1 to 5% of total cover) in the Sool Plateau, Gebi Valley and Xadeed
- A 370% increase in bare land in the Sool Plateau, Gebi Valley and Xadeed
- Dry herbaceous biomass in 2005 by vegetation type stood at 120 kilograms per hectare (kg/ha) of sparse vegetation; 460kg/ha.of grassland; 200kg/ha.of trees open and 1400kg/ha.of shrubs open

The last prolonged drought (2000-2004) in the area in question, as reflected in the NDVI data, dried up all the palatable vegetation used as forage by the different categories of livestock (cattle, camels and shoats). Livestock died of starvation and, according to the local community, there was deterioration in water quality, which the study has not conclusively linked to the drought. Global Acute Malnutrition reached alarming rates. Due to scarcity, water prices increased as did the need for water trucking to settlements and grazing areas. Animals were too weak to walk to water sources and there were heavy losses of pack camels, which are used to carry water and goods.

Recourse to coping strategies for the drought was limited: migration became difficult due to the geographic and temporal extent of the drought. Many destitute and poor pastoralists relied on charcoal production and grass harvesting as alternative livelihoods.

The study area is currently undergoing considerable land degradation as a result of soil erosion, negative land-cover change, increasing bare lands, overgrazing, heavy runoff during rainy seasons, strong winds in dry seasons and the clearing of vegetation.

The major causes of soil erosion include water (flash floods in the 1971-1972 cyclone; *El Nino* in 1997-1998; and heavy downpours in 2004), wind, trampling by livestock, vehicles tracks on innumerable unpaved roads, and the clearing of vegetation.

The localities most affected by all types of soil erosion are: Ceel-Doofaar, Cawsane, Mindigaale, Raad-Laako, Badhan, Hadaaftimo and Yuube, in the Gebi Valley; and Carmaale, Ceel-Buh, Buraan, Dhahar, Sherbi and Waaciye, in Sool Plateau.

The rugged and steep topography surrounding the floodplains facilitates runoff water forming flash floods, accelerating various forms of water erosion including splash, sheet, rill and gully. Rills and gullies have damaged or destroyed almost 50% of floodplains, which were the primary grazing lands for livestock during dry seasons.

Strong winds erode about 190-300 mt/ha. of soil annually from an already denuded bare surface, per the team's calculations. The impact of wind erosion can be observed in the Xubeera area of Gebi Valley: drifting sands accumulate around shrubs and dry wood lying on the ground whenever a path is blocked, forming sand mounds.

Sinkholes are also characteristic of the study area and contribute considerably to water and sediment loss by diminishing the water- retention capacity of the soils. Sinkholes have been observed in soils with an underlying shallow limestone formation in Mindigaale and Xingalool areas (Gebi Valley and Xadeed).

The major consequences of soil erosion are numerous. There is direct loss of thousands of tonnes of productive topsoil in every flash flood, which in turn causes hundreds of hectares of land surface to be dissected by gullies or newly formed streams on the flood plains. Grass and trees are swept away from the primary grazing lands (for example, in Cawsane). Large quantities of rain water are lost as runoff through streams and gullies to the ocean or through percolation into sinkholes. Soil fertility and soil water retention are diminished, thereby hampering the productive capacity of the floodplains that formerly were the primary grazing lands in the areas. Lastly, soil deposition occurs in riverbeds and berkeds whereas settlements and roads are threatened by gullies.

The collapse of the Somali government led to the neglect or abandonment of range management systems or Seere (reserve grazing land for dry periods) in Gebi Valley and modern rotational grazing on the Sool Plateau. At the same time, since 1991 efforts at water development by drilling boreholes and digging permanent wells as well as constructing underground and house berkeds (water reservoirs) especially on the Sool Plateau coincided with an increase in permanent settlements. The consequences of these factors are intensified overgrazing and land denudation around settlements and water points, water pollution affecting livestock and degraded water quality of surface water sources and storage facilities.

Many new illegal enclosures have been established on communal rangelands outside of the areas designated for enclosure in rangeland established by the British (47 farms) and the government of Somalia in 1975 as part of rangeland concessioning and the formulation of a post-drought recovery strategy. These post-1991 illegal enclosures are used for grass harvesting (Raad-Laako) and for small-scale farming (Ceel-Doofar, Mindigaale, Hadaaftimo, Yuube, Damala-Xagarre, Dhahar).

During the drought, charcoal burning intensified as an alternative source of livelihood for destitute pastoralists and in response to internal market demand. The study estimates that approximately

80,000 trees are cut every month in the Sool Plateau. While this figure is much lower than elders' estimate of 400,000, it is still a considerable amount.

The communities of Gebi Valley and Sool Plateau have attempted to conduct several conservation and rehabilitation initiatives including control and policing of charcoal burning and grass harvesting. Elders convinced local residents to stop burning and to destroy kilns with the help of local patrols sponsored by the community. However communities require considerable external support to have more impact.

Over the last 14 years, Horn Relief has participated in environmental campaigns against charcoal burning, and successfully convinced the Puntland Authority and other local organisations to ban charcoal exports in 1988. Horn Relief has also worked hard to raise environmental awareness among local communities, to promote resolution of resource-based conflicts (typically over charcoal and water), and to support small-scale soil and water conservation projects.

Many advancing and destructive gullies in the most damaged areas of Gebi Valley villages (Cawsane, Mindigaale/Dawli, Badhan, Hadaaftimo and Carmaale) and Sool Plateau villages (Ceel-Buh, Xingalool, Wardheer, Baraagaha-qol, and Dhahar) were contained or managed through Horn Relief micro-projects to construct: rock dams, check dams, stone-protected soil bunds, regular soil bunds, drop structures, excavated drainage channels, semi-circular soil bunds and to rehabilitate roads and diversion works. Most of the interventions were successful in diverting water, reducing gully head advancement, promoting soil deposition and enclosing sinkholes in the different sites. It was noted that an increase in water detention and soil water retention for about 50 square kilometres in the rehabilitated areas ensured sufficient moisture for pasture growth and the increase of biomass production. Only 20% of the sited structures were destroyed by heavy rainfall and floods (Cawsane, Mindigaale, Raad-Laako and Hadaaftimo in the Gebi Valley; Ceel-Buh on the Sool Plateau).

The recent prolonged drought, predictably, affected the vegetation and the livelihood of the local communities. Water became scarce and perennial palatable vegetation dried out. More than 80% of livestock was lost through starvation or water-scarcity related stress. Primary grazing land was lost (almost 50% in the floodplains) due to gully expansion or the removal of productive topsoil by floods and increased loss of rain water running off into streams and then to the Indian Ocean. Additionally, there is an ongoing increase in new settlement centers, with construction of berkeds occurring in primary grazing lands, and undiminished charcoal burning for income generation by the destitute population, collectively contributing to land-cover destruction and the shrinking of seasonal grazing areas.

The study's recommendations

- Restock destitute pastoralists with animals and pack camels to allow them to recover economically and to allow migration to areas with good pasture and adequate water
- Restore the practice of reserved grazing lands and/or apply modern rotational grazing systems to allow regeneration of vegetation
- Support initiatives to increase water retention and soil conservation
- Combat commercial deforestation and illegal de-vegetation and promote reforestation.
- Monitor water availability and quality for human and livestock use
- Monitor and evaluate the durability of soil conservation structures
- Strengthen mechanisms for forecasting drought and floods
- Promote consensus on interregional migration

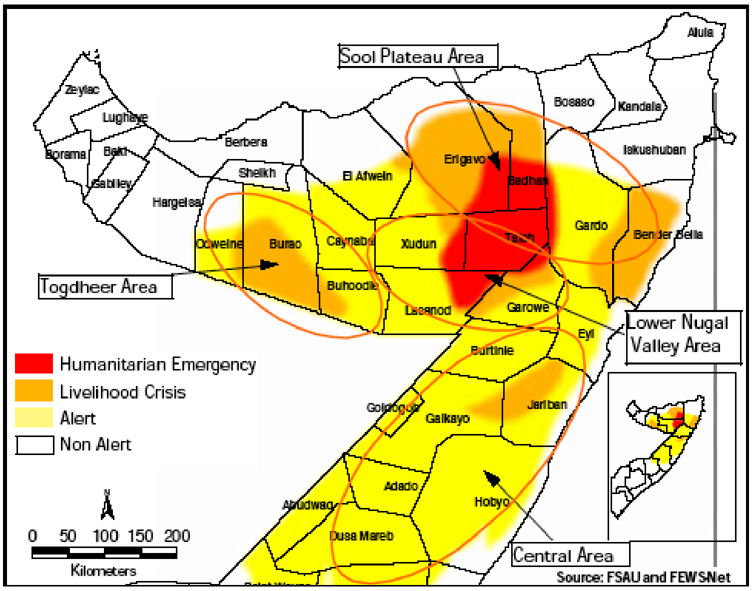
Introduction

FSAU and Horn Relief understood early the environmental dimension of the humanitarian crisis in the north, especially in the Sool plateau (FSAU Flash, 2004:1/Horn Relief Drought Assessment Report, 2003). This dire situation was linked to a persistent drought affecting the primary source of livelihood for the population: transhumant pastoralism.

1. The 2004 Humanitarian Crisis

The Food Security Analysis Unit (FSAU) has developed a methodology to analyse food security in Somalia. The organisation divided Somalia into livelihood zones, also called Food Economy Zones (FEZ) and established indicators that could be monitored to assess levels of food security. In early 2004, a part of the Sool Plateau livelihood zone was declared a humanitarian emergency area requiring urgent humanitarian assistance. Global acute malnutrition climbed as high as 20%. Heavy livestock losses (80% of camels, 40-50% shoats), displacement of pastoralists to urban centres and increasing outbreaks of human disease were reported.

The situation was attributed to a persistent drought affecting the prime source of livelihood of the population: transhumant pastoralism. In fact, FEWS-NET indicated that the Normalised Difference Vegetation Index (NDVI) or vegetation profile in the FEZ had been sub-normal for seven seasons.



1.1 Major identified Causes of Environmental Degradation

Several assessments have concluded that environmental degradation in the Sool Plateau livelihood zone is attributable to natural and anthropogenic factors, mainly natural disasters and changes in land use. Among these:

The occurrence of drought

In 1974, Somalia is reported to have experienced its worst ever extended drought. The drought, known to Somalis, as “Daba Dheer” (long-tailed) due to its severity and long duration affected many thousands of families in central and northern Somalia. Many lost all their livestock and were relocated by the Somali Government to the fertile southern areas and adapted to new livelihoods as farmers and fishermen. The most recent drought, which persisted for four years (2000-2004) in northern

Somalia, also devastated livestock (FSAU, 2005). The large number of livestock deaths from this drought pushed tens of thousands of people into destitution and dependence on social support with minimal prospects of returning to pastoralism.

Soil erosion

When flooding from the Golis Mountains occurs during rainy seasons, soils in the Gebi Valley and Sool Plateau experience severe sheet, rill and gully erosion. The soils of the Gebi Valley are of alluvial origin and hence are highly susceptible to soil erosion during the rainy seasons. However, these soils become encrusted and compacted in dry seasons. Alkalinity and salinity are also common soil problems in the region (Hassan-Sufi, March 2005).

The cyclones of 1971-1972 (Duufaan), flooding related to *El Nino* (1997-1998) and heavy rainfall in 2004 exacerbated extensive erosion in prime rangelands. Sand-dune formation is evident wherever strong winds prevail in areas of degraded and bare, sandy soil surfaces (UNDP, 2001).

Establishment of settlements in wet grazing lands

The establishment of settlements in wet grazing lands has devastated vegetation that would otherwise serve as a windbreak (IUCN, 1997). This trend has been heightened by an increase in the number of permanent water sources. Around settlements and water points range degradation is notably more severe (EC, 2005).

Deforestation of critical tree species

The most-severe environmental degradation process, prevalent in almost every part of Somalia, is the depletion of acacia tree species. A UNDP study claimed deforestation throughout Somalia reduced forest cover to as low as 10% over the last decade (UNDP, 2001). Deforestation is attributed to: fuel wood and charcoal production; cutting of timber for construction, clearing of land for new settlements and dry-land agriculture; excessive browsing and grazing by livestock; and vegetation clearing for building materials in new settlement areas (UNDP, 2001). Deforestation leads to loss of biodiversity (i.e. loss of important wildlife habitat) and soil degradation (i.e. erosion, reduction in water-retention capacity, soil encrustation and compaction). Vegetation degradation leads to an increase in soil and ambient thermal conditions. The occurrence of these conditions exacerbates the problem of drought vulnerability and increases the burden on residual open range, which is being exhausted.

1.2. Local Awareness of Environmental Degradation

A household survey conducted on environmental concerns in Somalia (UNDP/WB, 2003) revealed that most households are aware of local environmental problems. Survey correspondents ranked specific environmental concerns as follows:

1) Drought (28.5%),
2) Deforestation (13.8%), including charcoal production (7.8%)
3) Soil erosion (8.2%),
4) Uncollected garbage (4.8%), especially nylon bags in the supply of Khat in the study areas, which has affected the livestock as well as the vegetation.

However, conservation and rehabilitation initiatives are few: overall, little is currently being done by agencies or local authorities to stop the continuous land degradation in Somalia. Because of the lack of central government (and non-recognition of the Somaliland and Puntland States), none of the UN Conventions such as the Convention to Combat Desertification (CCD) and the Bio-diversity Convention (BDC) have been ratified. In addition, there is no national environmental action plan. Although Somaliland has introduced a strategic range-management plan, it has yet to be implemented due to lack of resources (UNICEF, 2002)

2. Gaps and Research Questions

Horn Relief has undertaken environmental initiatives in the Sool Plateau and Gebi Valley areas of Sanaag Region of Northern Somalia for over ten years and recognises that the growing environmental crisis in the area threatens the very survival of local communities. Although there is a wealth of information available on the livelihoods, climate, food security and to a degree, the environment in the region, there are several existing gaps in background intelligence and information, particularly quantitative data to gauge the level of the environmental crisis. These are due in part to four key issues of concern:

1. Existing data is inadequately centralised, consolidated and documented
2. Detailed information regarding key environmental issues of concern and their scale remains unavailable (particularly at the level needed for project planning in a given area)
3. Pastoralist communities' indigenous knowledge of historical trends in environmental change and how they have affected livelihoods in the region is undocumented. Existing information systems are inadequate to track environmental change, an essential element to effectively recognise and avert environmental crises
4. Awareness creation and training in natural-resource management is clearly lacking from project planning aimed at improving food security and addressing issues of drought vulnerability, mainly due to the gaps mentioned in points 1, 2 and 3

The environment is the natural, social, cultural and economic surroundings of a certain area of interest (Trust, 1979). In this study, environmental degradation encompasses land degradation as well as human pollution and invasion of vegetation predators.

The UN CCD defines land degradation as a natural process or a human activity that results in land no longer being able to sustain properly its economic functions or the original ecological functions (ISO 1996, FAO 1988).

3. Objectives of the Study

The broad objective of the study was to assess the status (nature, extent and severity) of environmental degradation, especially land degradation and its socio-economic impacts on the pastoralists of the Gebi Valley and Sool Plateau.

The specific objectives of the study are fivefold:

1. Determine the environmental issues in the area
2. Determine the main causes of the environmental problems
3. Determine the effects of the outlined environmental problems on the livelihood of the communities
4. Outline the strategies for coping with drought in the study area
5. Outline the main environmental threats to the livelihood of the local communities in the area

This exhaustive study was intended to provide a better understanding of the mechanisms available and measures taken to counter environmental degradation and the effects of drought and desertification on communities in the two study areas. The outcome of this study should, going forward, constitute a baseline against which the results of future annual environmental surveillance can be measured.

4. Description of the Study Area

The study area is located between latitudes 10° 43' 40.4" and 9° 14' 1.4" north and longitudes 41° 51' 43.8" and 43° 45' 51.6" east. It covers an area of about 307,000 ha. It is bounded in the north by the escarpment of the Golis Mountains, in the east by the Daroor Valley, to the south by the Karkar Mountains and in the west by a strip of Sool Plateau and the upper edge of the Nugaal Valley. This is the ecological definition of the Gebi Valley and Sool Plateau, which differs from FSAU's Food Economy Zoning (FEZ) definition.

The Gebi Valley

The Gebi Valley landform comprises barren whitish and pinkish weathering hills, eroded into round-topped hills occurring singularly or in rows surrounded by gently sloping pediments separated by outcropped ravines, plains and recently formed alluvial plain between them. The hills are of Karkar formation with some layers of anhydrites near the top of the range. The anhydrites weather into naturally rolling mostly flat downland and small flat-topped hills formed of thin limestone.

The plains consist of quaternary deposits, mainly formed in a continental environment with some marine influence. The composition is mainly silty clay with secondary fine sands. Many streams (toggas) cross the plains flowing toward the coastline of Indian Ocean, and rounded stones, gravel and sandy deposits typify their course. Coarse deposits are predominant in the areas out of the toggas and close to the hills, while clay and silts are dominant in flood plains. The recent alluvial plains constitute parcels or narrow strips of relatively smooth land created from flood deposits formed adjacent to many river channels in the area distributed between the hills.

The altitude in the Gebi Valley area ranges from 1,300m above sea level (a.s.l) from Yuube in the North to 1000m (a.s.l) at Ceel-Doofar in east; and from 1,300m (a.s.l) from the north foot slope of Al Madow at Raad-Laako to 900m (a.s.l) at Ceel-Buh to the south at Togga Saar.

The overall shape of the terrain is characterised by generally sloping topography, varying from gently undulating (2-5% slope gradient) to very gently undulating (0-2% slope) mostly on the alluvial plains.

Soils are developed commonly on the flat to very gently undulating terrain with depths ranging from shallow to very deep. They are low to moderately drained with variable levels of fertility, but lack of sufficient rain and occasional floods hinder potential production of good pasture.

Although human activity has removed most of the original trees and tall shrubs in many parts of the territory and the surface of the hills is totally bare, the plains and floodplains present variable degrees of vegetation cover. The vegetation of the plains is predominantly herbaceous varying from fairly dense to sparse cover; while in the flood plains there is a range of sparse to dense trees along the rivers and scattered in small depression sites, their composition mainly of Acacia species. Large tracts of the flat and depressed areas (45% of total surface) in the floodplains have fairly dense grasses and herbs, this area encompasses part of the target area of Horn Relief's rehabilitation efforts to halt gully erosion and sinkholes; other portions have sparse herbaceous plants or are totally bare.

The area is used as communal grazing land, excepting a small proportion of illegal enclosures used for grass harvesting by people living close to the settlement of Raad-Laako. There is newly introduced farming in small plots in areas close to water-source points in a few settlements like Mindigaale and Ceel-Doofar, but this is negligible. In the areas surrounding Hadaaftimo and Yuube villages much of the grasslands are privately owned or have been appropriated since 1990 following collapse of the government. These are used for grass harvesting or grazed by family stocks.

The Two Parts of the Sool Plateau

The Sool plateau forms a large part of eastern Sanaag that can be divided into two main parts, namely Xadeed, which is plains land bisecting two tracts of forest plateau, one to the north (Sool Plateau North) and one to the south (Sool Plateau South). Both have the same landscape evolution and distinctions between the two are based on lithological and ecological differences. Topography ranges from a large, nearly flat plateau to a gentle slope nearer the direction of the Indian Ocean. The altitude of this area ranges between 1,100m (a.s.l) and 900m (a.s.l).

The Sool Plateau Proper

The Sool Plateau is mainly covered by the Karkar Formation constituting sedimentary rocks of limestone and gypsum, not dissected by valleys. Its eastern side is delineated by the Buraan scarp, while the south-eastern side joins with the north-eastern edge of the Sool Hawd Plateau. It is characterised by flat and gently undulating topography covered by quaternary alluvial deposit fill depressions. Overall slope is usually from 2-5%.

Soil development in the alluvial plain is of variable depth, from shallow to moderate, and often not dissected by valleys and it is underlain by shallow marine deposits that extend into the eastern highlands of Karkar.

Land in the Sool Plateau has consistent vegetation, locally called *Ood,* comprising Acacia woodlands and tall grasses, which becomes progressively thinner before disappearing altogether at the point of confluence with Xadeed.

In this zone the only accepted land use is communal grazing, but there is intensive tree cutting and charcoal burning for sale to the major urban settlements in North-eastern Somalia (Puntland).

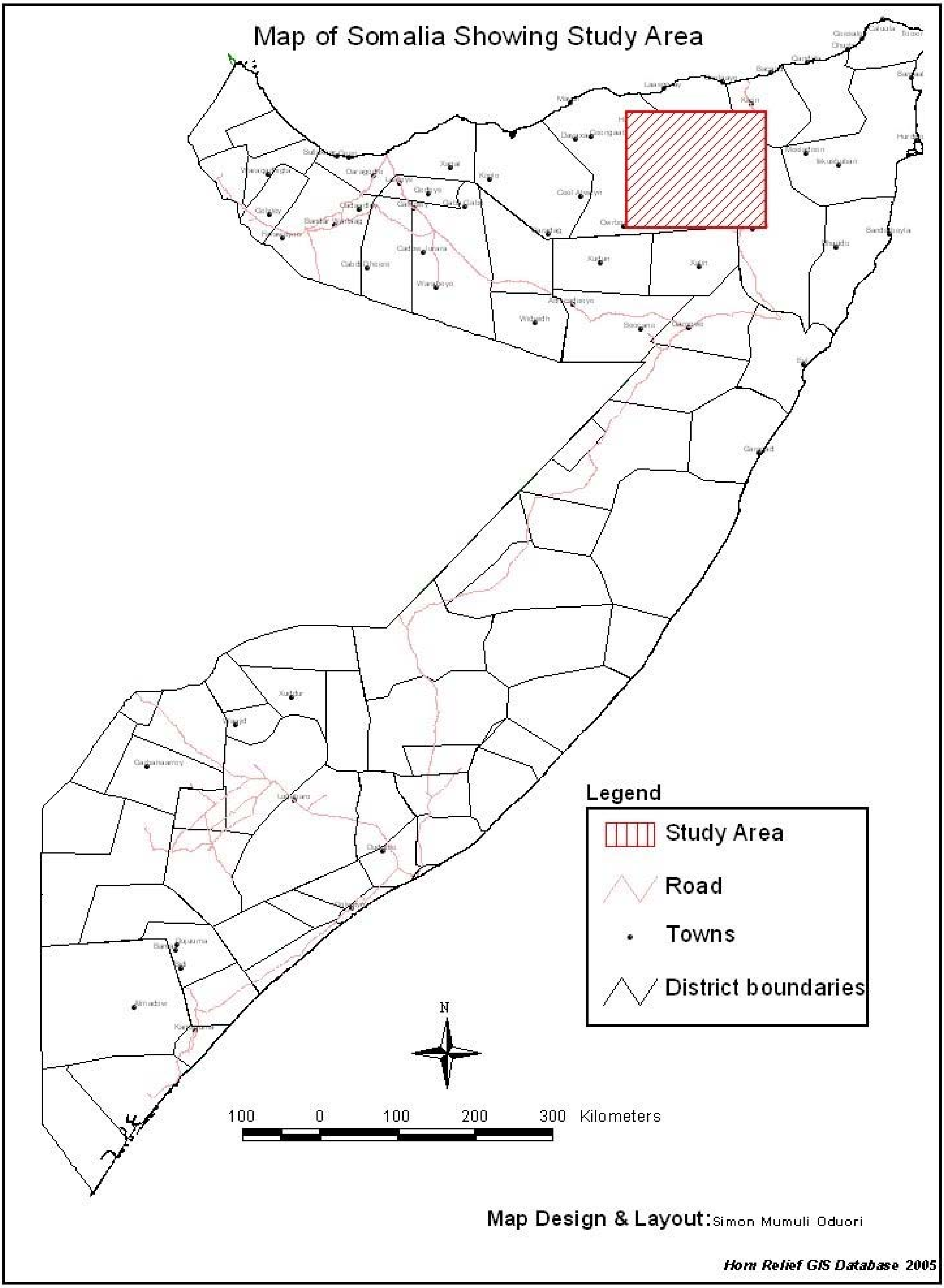
Xadeed

Xadeed is a tract of land that covers the middle of a large area of the Sool Plateau, beginning south of Carmaale village and extending as far as the depression zone south of Xingalool village. It has a rock formation of Gypsum and anhydrite of the Taleex formation underlain by Nubian sandstone and Auradu limestone, which outcrops along the northern margin of the Sool Xadeed Plateau. Most of this area is covered by gypsum and gypsiferous soils with minor areas of limestone. The areas covered by gypsum are completely bare, with some pebble layers covering a few places. Drainage is nearly absent in areas covered by gypsum; karstic depressions and sinkholes are widely spread in these zones.

Runoff water from toggas draining the area between Jiidali and Yuube at the western Hadaaftimo floods in transitional flat depressions before it spreads to the large Xadeed Plain area southwest of Carmaale, Shimbiraale, Damala-Xagarre and Xingalool to Baragaha-qol. Among settlements in Sool Xadeed are Xingalool, Sibaayo and Damala-Xagarre.

This flood-prone area is covered by gypsiferous soils and thin reddish sand-covered limestone. It is characterised by dense herbaceous vegetation cover, but areas featuring gypsum outcrops are entirely bare. Many sinkholes are found scattered around in the area, but are more concentrated in areas surrounding Xingalool and often coincide with patches of Acacia trees.

The land is used for communal grazing of livestock and for wildlife; local communities practice wildlife conservation in the region.


Map of Somalia Showing Study Area
Legend
Study Area
Road
Towns
District boundaries
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100 0 100 200 300 Kilometers
Map Design & Layout: Simon Mumuli Oduori
Horn Relief GIS Database 2005

5. Methodology of the Study

This study was undertaken by a multidisciplinary team in two main phases: a preliminary desk study followed by a field survey.

5.1 General Bibliographical Review

Two teams of environmental experts spent six weeks compiling and collating information from various local and international organisations, research and academic libraries with specific information on Somalia.

Among the organisations consulted were: Horn Relief; UNDP Somalia; FAO Somalia; Food Security Analysis Unit Somalia(FSAU); Somalia Water and Lands Information Management (SWALIM) of FAO Somalia; AFRICOVER of FAO; Famine and Early Warning Systems Network (FEWS-NET); IUCN; European Commission (EC); FAO's Land Degradation Assessment (LADA) Programme; National Land Degradation Assessment and Mapping in Kenya (a collaborative effort between UNEP and the Government of Kenya); Kenya Soil Survey (KSS) of the Kenya Agricultural Research Institute (KARI); Somalia Aid Coordination Body (SACB); The World Agro-forestry Centre (ICRAF); and the Pastoral Information Network Programme at the University of Nairobi (publishers of Africa Pastoral Forum).

During this desk study, the environmental experts held consultations and discussions with Horn Relief's management, scientists, consultants, technicians attached to the organisations mentioned above, and a visiting Somali, Mr. Abdullahi Mohammed Hassan (Sufi) from FSAU's Field Monitoring Unit based in the focus areas of Gebi Valley and Sool Plateau.

5.2 Interpretation of Satellite Imagery and Identification of Hot Spots

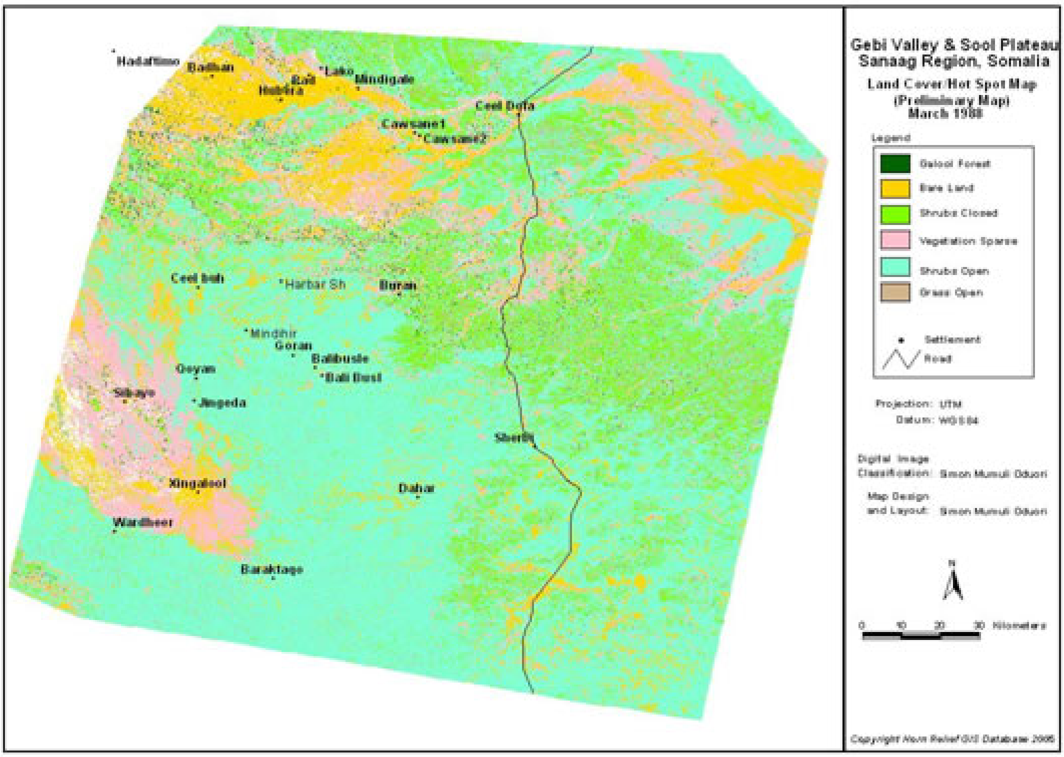
Defining Hot Spots and Bright Spots

According to FAO's LADA (Land Degradation Assessment in Drylands) Manual, a hot spot, for environmental purposes, is an area where land degradation is particularly severe, with actual or anticipated effects of high impact on-site or off-site; or where the land is particularly vulnerable and threatened by degradation. A bright spot is an area without significant land degradation that is stable, naturally or under the present conditions of sustainable management, or alternatively a formerly degraded or vulnerable area where land protection or land rehabilitation have been successful or are underway (LADA 2005).

Pre-Fieldwork Analysis

In September 2005, a preliminary Landsat TM image interpretation was undertaken aimed at identifying hot spots in preparation for fieldwork in Gebi Valley and Sool Plateau. The interpretation was done on three images, acquired from Africover, at different periods (March 1988, January 1995 and November 2001). See the maps below.

A computer-aided classification was performed using the ERDAS Imagine 8.3 software. In this process, the classification was controlled. This entailed providing information on training sites to the system (by expert knowledge) from which the spectral signature of each class was calculated. The classification was done using the Maximum Likelihood Algorithm. The computer-aided classification was precise, rapid and easily repeated.



Gebi Valley & Sool Plateau
Sanaag Region, Somalia
Land Cover/Hot Spot Map
(Preliminary Map)
March 1988
Legend
Galool Forest
Bare Land
Shrubs Closed
Vegetation Sparse
Shrubs Open
Grass Open
Settlement
Road
Projection: UTM
Datum: WGS84
Digital Image Classification: Simon Mumuli Oduori
Map Design and Layout: Simon Mumuli Oduori
N
0 10 20 30 Kilometers
Copyright Horn Relief GIS Database 2005
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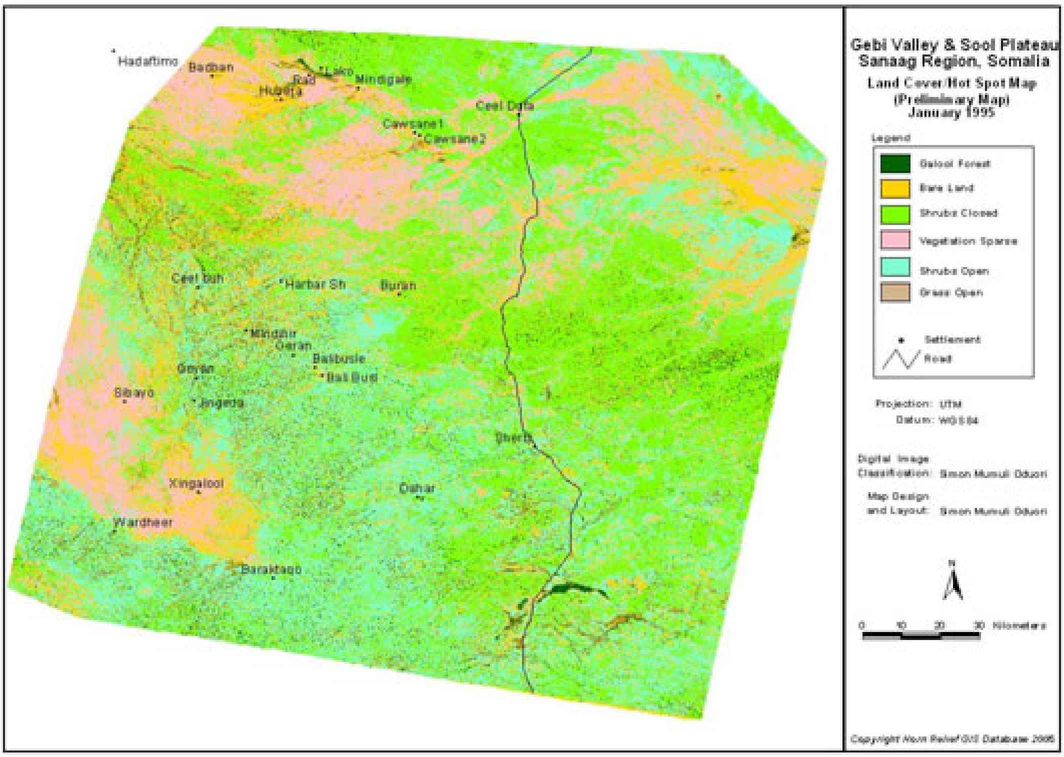
Badhan
Lako
Rad
Mindigale
Hubera
Ceel Dofa
Cawsane1
Cawsane2
Ceel buh
Harbar Sh
Buran
Mindhir
Goran
Balibusle
Bali Busi
Goyan
Sibayo
Jingeda
Sherbi
Xingalool
Dahar
Wardheer
Baraktaqo



Gebi Valley & Sool Plateau
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Legend
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Digital Image Classification: Simon Mumuli Oduori
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N
0 10 20 30 Kilometers
Copyright Horn Relief GIS Database 2005
Hadaftimo
Badhan
Lako
Rad
Mindigale
Hubera
Ceel Dofa
Cawsane1
Cawsane2
Ceel buh
Harbar Sh
Buran
Mindhir
Goran
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Bali Busi
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Sherbi
Xingalool
Dahar
Wardheer
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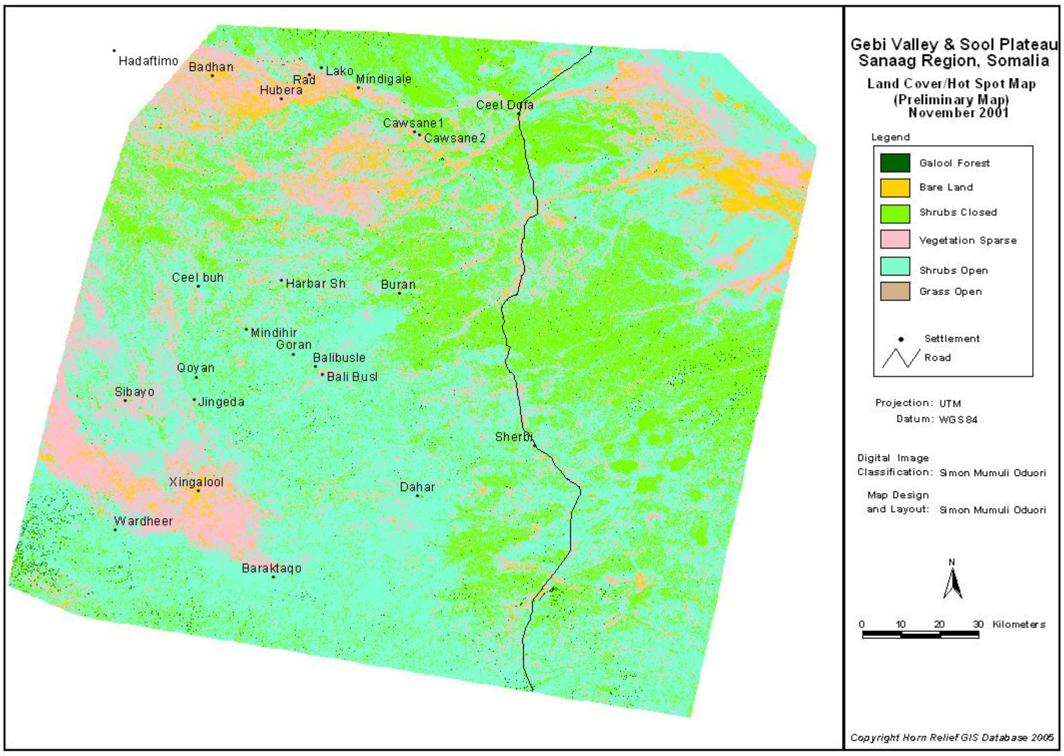


The results of the exercise revealed that hot spots are located in important settlement areas (with a population of above 15000 persons). In Badhan, Raad-Laako and Xingalool, for example, the surrounding areas have been severely degraded, with bare land being conspicuous since at least 1988. Xingalool was created in 1958 and Badhan in 1971. The maps also show an increase in the extent of these hot spots over the years. This trend is evident, for example, in the areas around Xingalool between 1988 and 1995.

It is noteworthy that the three hot spots are located within Evaporate of Taleex (ET) formations, which are recent alluvial deposits located in depression sites (lowlands) where human-settlement density is high due to water accessibility. In the Gebi Valley, these coincide with the three flood plains: Cawsane, Raad-Laako and Xubeera.

Based on preliminary analysis, degradation within these settlement areas is so pronounced that even in the wet season plant growth is limited, as evidenced in the images from November 2001 which coincides with the Deyr or short rains. However, following the onset of the rains, herbaceous material germinates and the January 1995 image reveals herbaceous vegetation present all over the region. However, hot spots in these images remain visible throughout, even during the rainy season, with most of them featuring exposed soil. The area stretching between Badhan and Xingalool has experienced increased degradation over the years, as the results of the analysis of the images show.

Ground observation data by the Horn Relief team in Somalia confirms the results of the computer-aided satellite imagery classification. The area between Badhan and Cawsane including Raad-Laako and Mindigaale is characterised by the presence of pronounced gullies. Gullies are also found between Badhan and Ceel-Buh and south of Dhahar. Some gullies are large, visible and in some instances appear in the interpreted maps as pockets of degraded, bare land.

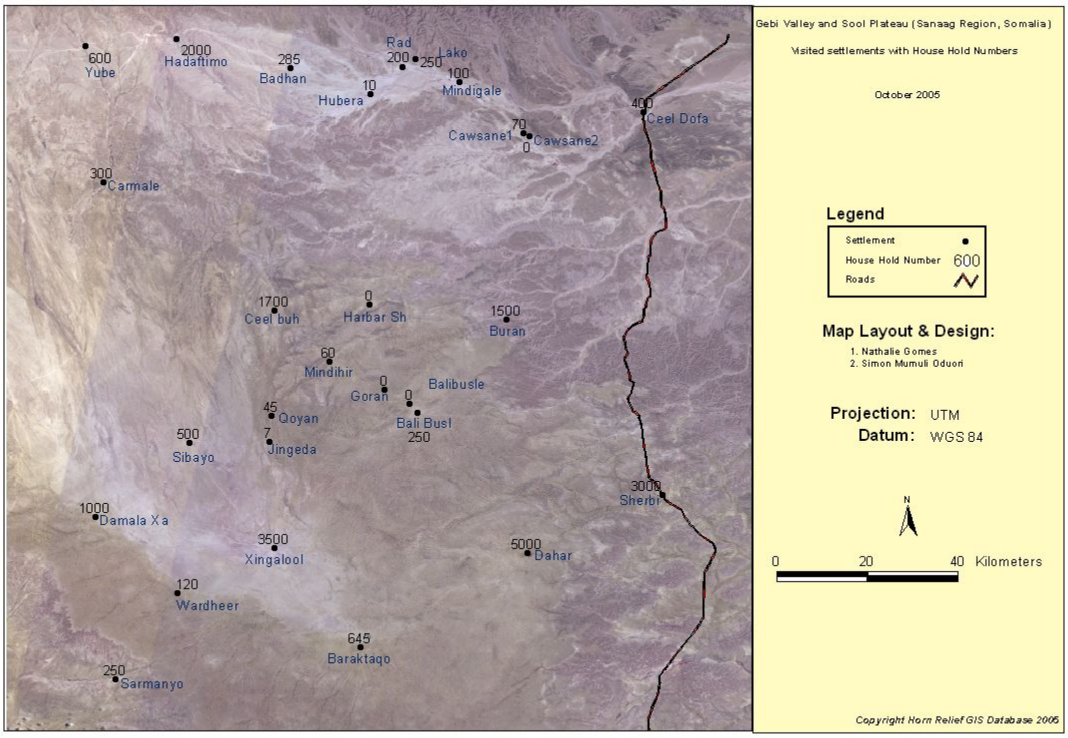
5.3 Methodologies for the Field Survey

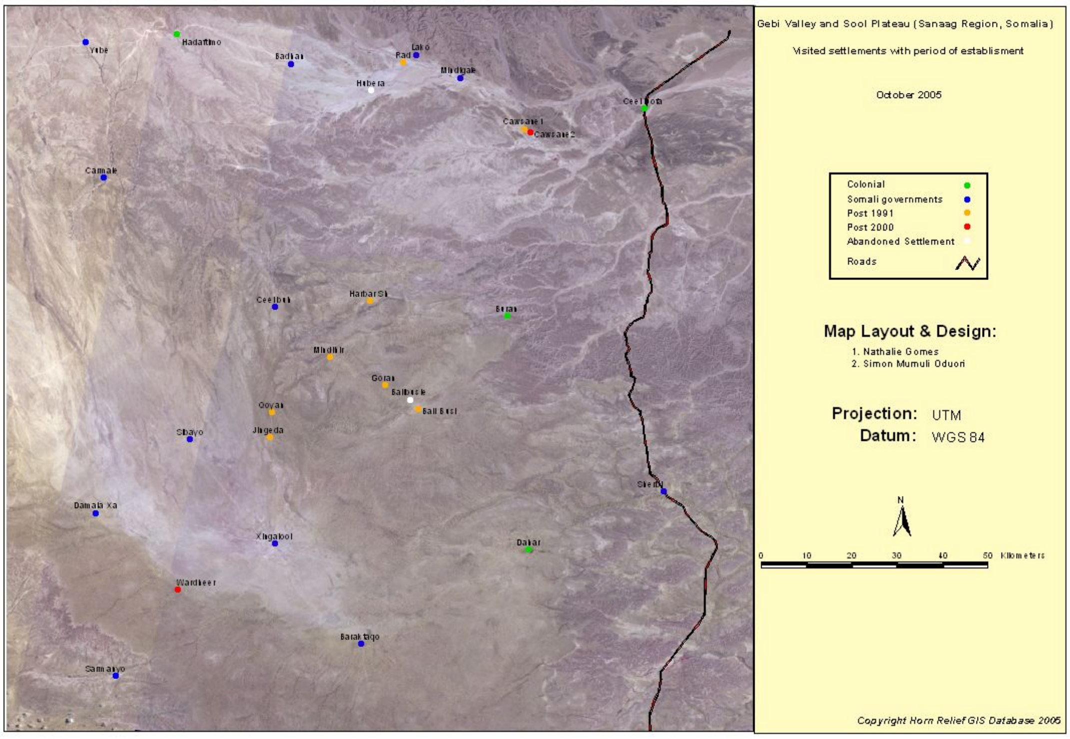
The team of experts spent three days training Horn Relief staff members on environmental concepts and data collection. During the training, the team selected sites for the field survey based on the Preliminary Satellite Image interpretation and in consultation with Somali-based staff of Horn Relief.

Between September 21, 2005 and October 11, 2005, which coincides with the end of the short dry season (Xagaa) and the beginning of the short rainy season (Deyr), the team assessed a total of 20 settlements and their surrounding environments. These comprised:

- Seven settlements in Gebi valley (Ceel-Doofaar, Cawsane, Mindigaale, Raad-Laako, Badhan/Xubeera, Hadaaftimo and Yuube)
- One settlement in the Karkar mountains (Buraan)
- Nine settlements in Sool plateau (Ceel-Buh, Mindhicir, Bali-Busle, Carmaale, Dhahar and Sherbi in Sool Plateau North; and Wardheer, Sarmaanyo and Baraagaha-qol in Sool Plateau South)
- Three settlements in Xadeed (Xingalool, Sibaayo and Damala-Xagarre)

Due to time constraints, the team was unable to visit the Golis Mountains (Al Madow) and the coastal areas (Guban), which form part of the local pastoral ecosystem.





All the localities visited are in Sanaag region except Sarmaanyo, which falls within Sool region, and Sherbi and Ceel-Doofar which form part of Bari region. Yuube, Carmaale and Damala-Xagarre are located in Cerigaabo district. Hadaaftimo, Badhan/Xubeera, Mindigaale, Raad-Laako, Ceel-Buh, Mindhicir and Wardheer are part of Badhan district. Cawsane, Buraan, Bali-Busle, Baraagaha-qol, Xingalool and Dhahar are situated in Dhahar district. The majority of the settlements are home to the Warsangeli, except Sarmaanyo which is inhabited by Dhulbahante, and half of Damala-Xagarre, in which Dhulbahante also predominate. The village of Sherbi belongs to a group called Dishiishe.

The estimated population of the study area as of 2005 is 21,509 households, or 150,000 persons. However, these figures may not be entirely accurate for the following reasons:

- They do not necessarily include all pastoralists
- A number of permanent settlements on the Sool Plateau located in Sool Region and Puntland (along the tarmac road and east of this road) were not assessed

5.4 Procedure for Field Survey Work

The study applied a routine procedure throughout the process of fieldwork for Gebi Valley and Sool plateau. The first part of the morning session was used to mobilise the respected resident elders, women and youth groups of the various settlement centres or villages. Gatherings occurred in selected positions like in the shade of trees, halls, spacious rooms or school classrooms. The field survey exercises in each settlement were conducted as follows:

1. Discussions were held with the most respected local community elders, women and youth who were able to converse clearly about relevant local environmental problems on behalf of the community.
2. The gatherings were preceded by introductory speeches from the three experts (namely Nathalie, Simon and Musse). During these introductions, a detailed account was made of the aim of the field visits.
3. Following the introduction, the team requested the full cooperation of the elders during the field visits with respect to the research in general and to responding to the questionnaire specifically. During this session the team moderated debate, undertook interpretation and took notes.
4. The qualitative portion of the general questionnaire was administered. (See annex 1)
5. Elders were asked to share their local knowledge of their environment, and to respond to specific questions pertaining to settlement history, population estimates, local land degradation, droughts, impacts of drought, local coping strategies for drought, cyclones, land-resource-use-related problems and desertification, traditional environmental conservation techniques used and modern approaches to soil conservation.
6. At the end of the session elders were asked to identify from among their number three individuals familiar with local environmental problems. Each of the three would then serve as a guide to a member of the team during the field exercises in the vicinity. Areas of focus included assessment of the most serious damage in terms of: soil erosion; tree cutting and charcoal burning; grass harvesting for sale; and local water sources points.
7. The three members (Nathalie, Simon, and Musse) of the original team then separated from each other and formed three new teams each with two assistant enumerators and the guide picked from among the elders. This was to allow each expert to undertake a practical and specialised observation and investigation. Nathalie's (social anthropology) team visited water-source sites in the area used both for domestic needs and to water animals. Musse's (soil) team investigated areas with problems of soil erosion. Simon's team (ecology) visited sites where tree cutting, charcoal burning and grass harvesting were carried out. The ecology team also collected data on land and vegetation cover and frequency, and herbaceous biomass.
8. The SWALIM-designed questionnaire was used to collected data on water sources. The Kenya Soil Survey data form was used to collect data on soils while a modified FAO-Africover data form was used to collect data on land cover and land use. Specially designed forms were used to collect data on charcoal burning and vegetation.
9. Data collection was supervised by the three experts with the help of the assistant enumerators.

Notes on the Ecological Survey

The results of the preliminary interpretation made in Nairobi formed the basis of the ecological fieldwork. Samples sites for field verification were selected based on the different land cover hot spots identified in the interpretation of the preliminary satellite image.

The output of the initial satellite-image interpretation was a preliminary land cover map showing hot spots in the study area. Subsequently, stratified random sample points were selected in each land-cover stratum. The x and y coordinates of these points were entered in the handheld Garmin Global Positioning Systems, GPS, as waypoints. These waypoints were used for navigation to the sample points for field-data collection. Data was collected on land cover, land use and vegetation frequency, cover, height and species composition, and clippings of herbaceous material for dry herbaceous biomass estimation. Classification of the various land-cover classes was based on the Africover-FAO Land Cover Classification System, LCCS. For each class, data on the constituent classifiers was collected. FAO's Land Cover Classification software was then used to classify the land-cover classes. All the land-cover types were visited and ground truth data collected on the above listed attributes. Selection of the sample points was based on accessibility.

The line transect method (Heady 1983, Crocket 1963, Johnston 1957) was used to estimate both woody and herbaceous vegetation parameters. The line transects measured 100m in length. The woody layer was sampled along the same transect. The woody crown interceptions (McIntrye 1953, Heady 1983 and Westman 1984) were recorded and the following woody vegetation attributes determined: species name, frequency, crown cover and height class. At 20-metre intervals, basal clipping of the herbaceous plants was done.

Notes on the Soil Survey

The soil survey was undertaken to explore and map the severity of soil erosion, particularly in the gullies of Gebi Valley and Sool Plateau. Findings could then be used to form conclusions and recommendations for suitable interventions aimed at soil conservation. The survey, which began on September 16, 2005 was not aimed at making a detailed survey of the land degradation of the study areas, but to acquire corroboration on the ground in selected areas identified on the desk-study satellite images as hot spots. The methodology used for the fieldwork was in line with standard methods used for soil survey and utilised in the Manual for Soil Survey and Land Evaluation of Kenya, 1987.

The field survey focused on the following:

- Geology
- Landform
- Slope
- Vegetation cover
- Land use
- Soil Physical Properties (depth, colour, texture, structure , compaction, sealing/crusting)
- Chemical analysis (pH, salinity and sodicity, content of carbonates)

Chapter 1: Identifying and Tracking Hot Spots from Remote Sensing (1988-2003)

This chapter discusses the results of the final interpretation of satellite images. These results are based solely on the field observations.

1. Methodology for Field-data Analysis

1.1 Land-Cover Classification

The gathered plant samples were classified using the Africover-FAO Land Cover Classification software, (LCCS), for easier establishment of classes from field data. Several classes were merged to produce manageable classes. Merging of the classes was done because of the small scale at which the mapping was carried out.

1.2 Estimates for Herbaceous Biomass

Clipped vegetation matter was later oven dried at 80^{o}C for 48 hours and then weighed to determine the dry herbaceous biomass (Muchoki 1988). Appendices 2 and 3 show the data forms used to collect data on the herbaceous vegetation layer.

1.3 ERDAS Imagine Land Cover Classification

As mentioned previously, a computer-aided classification was performed using the ERDAS Imagine 8.3 software. In this process, the classification was controlled. The process involved giving the system knowledge in form of training sites, from the field samples, out of which the spectral signature of each class was calculated. The classification was done using the Maximum Likelihood Algorithm. The computer-aided classification was more precise and rapid, and is one that can be repeated easily. After several trials, final land cover/hot spot maps were generated for 1998 and 2003.

2. Results

The computer-aided classification process produced maps (see below) with the following classes of vegetation:

2.1 Galool Forest

Galool Forest comprised 5.2% of the focus area in 1988 but only 2.9% in 2003. The forest is called Galool forest because ***Acacia bussei*** (Galool in Somali) is dominant. Other woody species in this forest included ***Acacia tortilis*** (Qurac), ***Boscia miniimifolia*** (Meygaag), ***Salvadora spp.*** (Cadey), ***Acacia nilotica*** (Maraa), ***Cadaba herterotricha*** (Higlo), ***Ziziphus Mauritania*** (Gob) and ***Cadaba somalensis*** (Qaalanqal). Galool Forest covered an area of about 162,467.5 ha. in 1988 (Figures 4 and 5**)**. However, by 2003, Galool Forest covered an area of about 78,211.89 ha. A total of 84,255.61 ha. of Galool forest were lost in the 15 years, equal to a loss of 52%.

2.2 Shrubs Open

Shrubs Open comprised 45.1% or 1,397,528.28 ha. of the focus area in 1988 and 34.8% **(**94, 9957.83 ha.**)** 15 years later, a 30% decrease. The dominant woody species here include ***Acacia bussei, Acacia tortilis*** and ***Solana spp.*** Other woody species in this forest included, ***Boscia miniimifolia*** (Meygaag), ***Salvadora spp***. (Cadey), ***Acacia nilotica*** (Maraa), ***Cadaba herterotricha***

(Higlo), ***Ziziphus Mauritania*** (Gob) and ***Cadaba somalensis*** (Qaalanqal). Herbaceous species include ***Anthropogon spp.*** (Duur), ***Chrysopogon aucheri*** (Dureemo), ***Sporobolus variegatus*** (Duxi), ***Dactyloctenium spp.*** (Saddexo), ***Sporobolus spp.*** (Sifaar), ***Eragrostis haraensis*** (Gubungub), ***Cynodon Dactylon*** (Doomaar Madow), ***Paspalidium desertorum*** (Gargaro), ***Digitaria scalarum*** (Xul or Domar Cad), ***Olea chrysophylla*** (Weyrax), and ***Chloris spp.*** (Xarfo).

2.3 Sparse Herbs/Shrubs

Sparse Herbs/Shrubs constituted 33.5% **(**1,038,259.89 ha.**)** and 36.3% **(**993,558.69 ha.) of the study area in 1988 and 2003 respectively, a decrease of 44,701.2 ha. (4%). The woody plant species included ***Euphorbia spp.*** (Xagar), ***Boswellia spp.*** (Moxor), ***Balanites spp.*** (Kidi), and ***Acacia spp.*** Herbaceous species included Sifaar, Gubungub, Rako, and Yamaarug.

2.4 Grassland

In the focus areas, grassland constituted 402,896.52 ha. or 13% in 1998 and 236,149.74 ha. (8.6%) in 2003. This represents a decrease of 166,746.78 ha. (roughly 40%**)** in grassland cover between 1988 and 2003. The dominant species included Sifaar, ***Chrysopogon aucheri*** (Dureemo), ***Spropolus variegates*** (Duxi), ***Anthropogon kelleri*** (Duur), Gubungub, Rako, and Yamaarug.

2.5 Bare Lands (soils and rock)

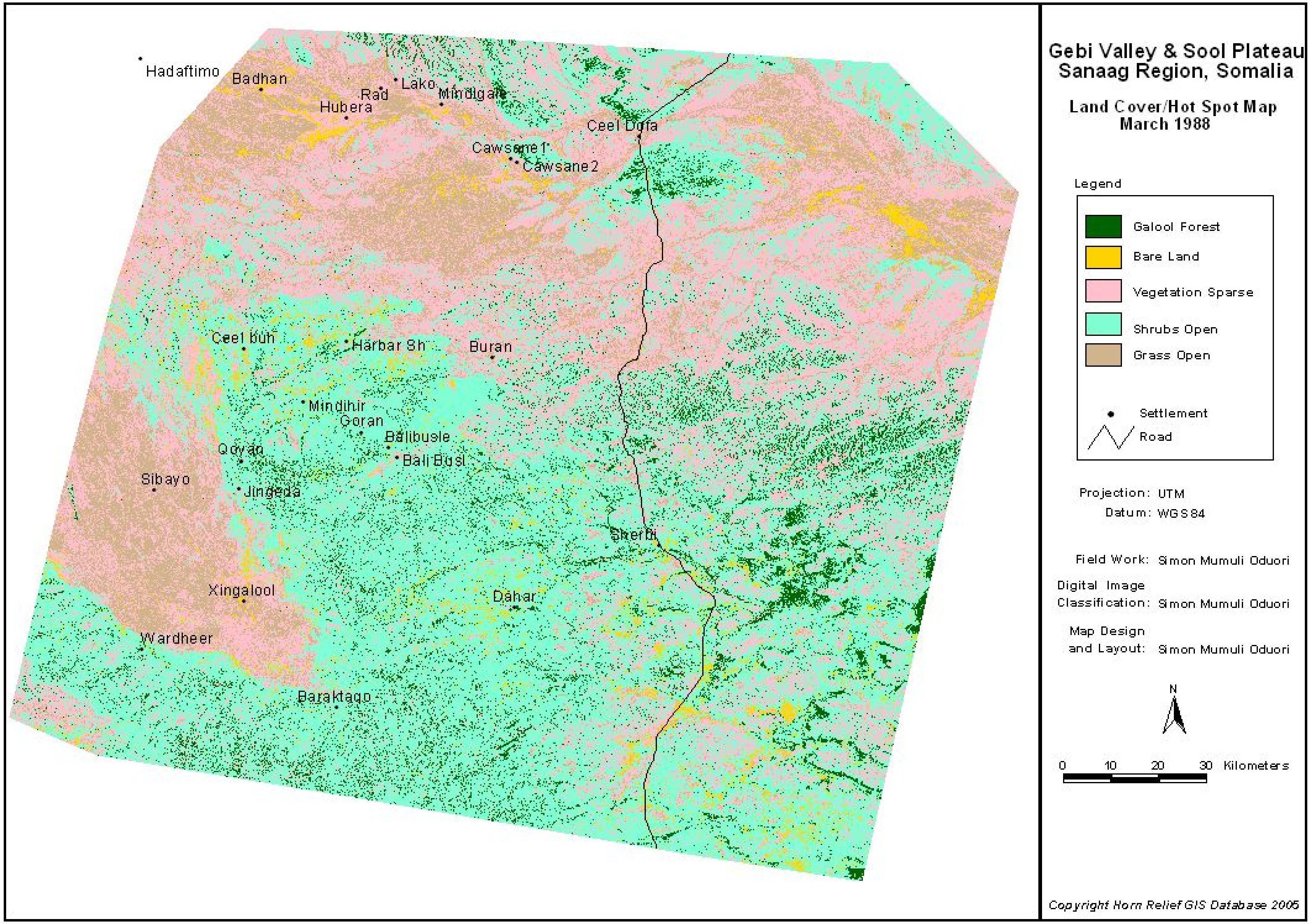
Bare soils and bare rock constituted 3.3% or 100,715.49 ha. in 1988, and 17.4% **(**475,901.73 ha.**)** in 2003, of the target areas. In other words, bare land increased by 375186.24 ha. or 370% during the period in question.

Table showing Size and Proportion of land cover in study area and Herbaceous Biomass

1988 attributes						
	Bare Soil	***Forest***	***Shrubs Open***	***Grassland***	***Sparse Herbs/Shrubs***	***TOTAL***
Ha	100715.49	162467.46	1397528.28	402896.52	1038259.89	3101867.64
%	***3.3***	***5.2***	***45.1***	***13***	***33.5***	***100.1***
2001 attributes						
	Bare Soil	***Forest***	***Shrubs Open***	***Grassland***	***Sparse Herbs/Shrubs***	***TOTAL***
Ha	623342.97	66960.45	107245.96	485887.14	824070.15	2107506.67
%	**29.5**	**3.2**	**5.1**	**23.1**	**39.1**	**100**
2003 attributes						
	Bare Soil	***Forest***	***Shrubs Open***	***Grassland***	***Sparse Herbs/Shrubs***	***TOTAL***
Ha	475901.73	78211.89	949957.83	236149.74	993558.69	2733779.88
%	**17.4**	**2.9**	**34.8**	**8.6**	**36.3**	**100**
2005 Herbaceous Biomass (Kg/Ha)	**NA**	200	1400	460	120	

The table and results above show distinct trends in land-cover dynamics in the study area. However, no conclusions can be drawn about the causes of these changes. For example, bare lands increased between 1988 and 2003 whereas Galool Forest decreased over the same period. Possible causes for these changes in land cover, based on qualitative data gathered, will be addressed in the following chapters.

The table also shows the herbaceous biomass, in each land cover type, for the year 2005. Sparse Vegetation had the lowest herbaceous biomass estimate (120 Kg/ha) while Shrubs Open had the highest, at 1400Kg/ha. Other herbaceous biomass estimates were 200Kg/ha.and 460Kg/ha.for Galool Forest and Grassland, respectively.


Hadaftimo
Badhan
Rad
Lako
Hubera
Mindigale
Ceel Dofa
Cawsane1
Cawsane2
Ceel buh
Harbar Sh
Buran
Mindihir
Goran
Balibusle
Qoyan
Bali Busl
Sibayo
Jingeda
Sherfi
Xingalool
Dahar
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Gebi Valley & Sool Plateau
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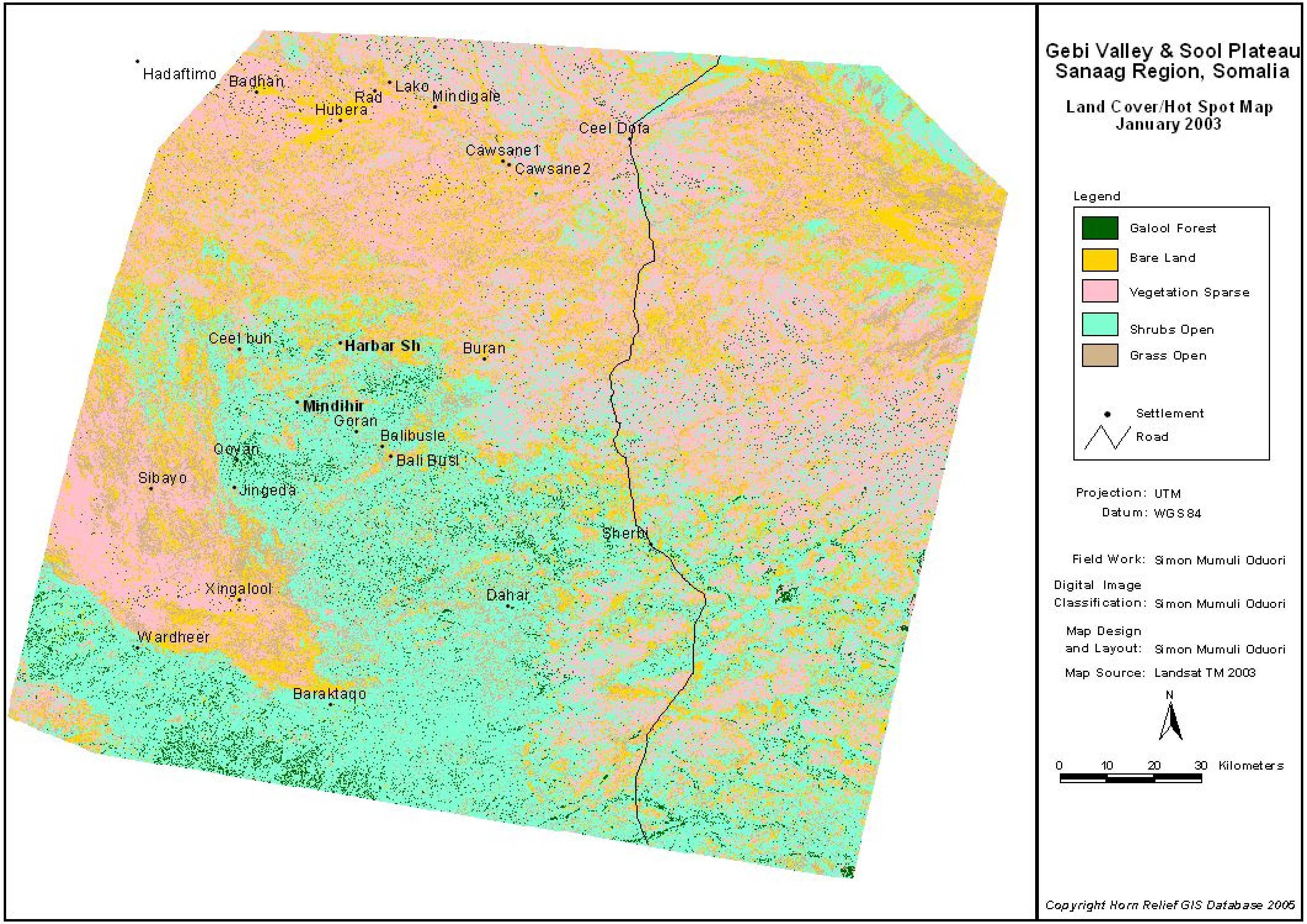
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Copyright Horn Relief GIS Database 2005
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Buran
Mindihir
Goran
Balibusle
Qoyan
Bali Busl
Sibayo
Jingeda
Sherbi
Xingalool
Dahar
Wardheer
Baraktaqo

Chapter 2: Drought

Drought has been identified as one of the major environmental problems in the Gebi Valley and Sool Plateau both by local communities and international agencies. This chapter will present a conceptual framework of drought, before analysing drought hazards and trends in the study areas using information from rainfall analysis and indigenous knowledge compiled during fieldwork. Lastly, this section will also capture the effects of the recent drought on the vegetation and on local livelihoods as revealed by NDVI analysis and interpretations of satellite imagery, supported by field observations and interviews with pastoralists.

1. Conceptual Framework

Camilla Toulmin (IIED, 1993) drew clear distinctions between drought and desiccation. Drought is defined as a period of one to two years in which rainfall is below average, and in which water shortages reduce growth and the final yield of staple crops or pasture. Humans and livestock are affected by drought in two ways. They endure food and water shortages. Desiccation, by contrast, is defined as a process of aridification resulting from a dry period lasting decades. The risk of drought is a product of both exposure to the hazard (climatology) and the vulnerability of livestock and people to drought conditions (Wilhite, 2000). Exposure to drought is assessed through monthly and annual climatic variations.

1.1 Typology of Droughts

Drought can be divided into four categories (Mathuva and Oduori, 2003):

- **Meteorological drought** is a condition in which precipitation is below the expected average. This presupposes that ecosystems and human activities are adapted to the average precipitation of an area, and less will induce moisture stress on the ecosystem. Such a situation may lead to a steady impoverishment of the quality and diversity of flora and fauna especially if frequent and persistent. The impact of sub-normal rainfall is reflected in reduced biomass, low levels of surface runoff in rivers and streams, scarcity of pasture and the drying up of small streams.

- **Hydrological drought i**s a condition in which aggregate runoff is less than average runoff. It refers to a period during which stream flows are inadequate to supply established uses under a given water management system. This type of drought has a direct impact on the operation of multipurpose dams, irrigation schemes, water-generated energy sources and water-driven industries such as water mills.

- **Socio-economic drought** refers to the effects of droughts on the supply and demand of goods. Drought, according to the socio-economic definition, occurs when supply falls below an established level of requirement demand due to rainfall shortages. The supply of agricultural, animal products, silvocultural products falls short of normal demand. The impact of drought in this case is frequently exaggerated, as there is a tendency to blame drought wrongly for all types of shortages that may be actually associated with other factors, such as hoarding.

- **Agricultural drought** refers to conditions in which the water needs of plants and animals are not met. This category is further divided into: incipient drought, permanent drought and seasonal drought. Incipient drought is considered drought only in instances in which the objective is to achieve the maximum possible yield from a given crop variety. It is important only at the experimental level and with respect to modern, large and specialised farms. Permanent drought occurs in arid areas where rain fed agriculture is impossible. In these areas, cultivation is only possible through irrigation. Seasonal droughts are droughts that occur every season. Seasonal droughts arise when the normal dry and wet seasons are disturbed and irregularity sets in.

1.2 Drought Characteristics and Severity

Droughts differ from one another in three special characteristics: intensity, duration and spatial coverage (Mathuva, 2003).

- **Intensity**: This refers to the degree of precipitation shortfall and/or the severity of impact associated with the shortfall. This is generally measured by the deviation of some climatic index from normal and is closely linked to the duration in the determination of the impact. The simplest index in use is the percent of normal precipitation, which compares actual precipitation to normal or average precipitation for time periods ranging from one to twelve or more months. Actual precipitation departures are normally compared to expected or average amounts on a monthly, seasonal or yearly basis.

- **Duration**: This refers to the length of the time interval in which the drought occurs. Droughts usually require a minimum of one to three years to become established but then can continue for several consecutive years. The magnitude of drought impact is closely related to the timing of the onset of the precipitation shortage, and its intensity and duration.

- **Spatial coverage**: Droughts also differ in terms of their spatial characteristics. Areas affected by severe drought evolve gradually and regions of maximum intensity shift from season to season.

The effects of drought vary according to the time of occurrence, frequency (probability), severity (persistence), and duration. Recurrence of droughts can be established in circumstances where long-term weather data is available. The severity of these droughts depends on the number of dry spells within a rainy season. Temporal fluctuations in seasonal and mean annual rainfall are indicative of the persistence of drought. A good definition of drought should be able to account for the variable susceptibility of tree crops and vegetation during different development stages.

1.3 Drought Preparedness

According to Mathuva and Oduori (2003), in the event of drought the objectives of intervention include the following:

- To reduce human suffering by providing water during the drought emergency
- To preserve asset stock in order to minimise household vulnerability to future droughts
- To build communities’ capacity to mitigate and withstand future droughts
- To facilitate a coordinated approach among relevant agencies in effectively targeting and providing relief assistance to affected population groups

Drought results in deterioration of natural resources and the livestock economy. An early warning system is an important component of drought monitoring programmes. Drought occurs when a significant water deficit takes place that is spread both in time and space. Drought is best defined by using properties of water deficit conceived or experienced in the difference between time supply of water and water demand. Therefore, a large water deficit of significant duration for a given water user or interest is defined as drought.

The process of planning for drought consists of three elements:

- Drought Monitoring, which involves identification of indicators of drought that can be tracked in the process. A drought forecast is part of drought monitoring and comprises four elements, namely: duration, severity, distribution, and occurrence. Thus in a drought forecast, it is important to study the duration and severity of critical droughts using annual and seasonal rainfall time series data. In Northern Somalia, it is possible to forecast droughts using spatially aggregated historic NDVI data. NDVI data can be used to predict drought severity and duration trends in the Gebi Valley and Sool Plateau livelihood zones. A time series of this NDVI analysis can be generated to provide long-term trends. It is however important to note that due to climatic change, it is no longer possible to forecast with certainty drought trends on the basis of time-series data.

- Risk assessment, which entails acquiring an understanding of the impact of drought severity, duration and spatial extent and community vulnerability to drought.

- Drought mitigation, which is to take action in advance of drought to reduce its long-term risk. This requires policies, activities, plans, and programmes aimed at reducing drought vulnerability.

2. Rainfall Patterns in the Gebi Valley and Sool Plateau

The Gebi Valley and Sool Plateau areas are characterised by low, highly variable rainfall and a landscape that undergoes a marked and abrupt change between wet and dry seasons within a year. The amount and duration of rainfall in the rainy season decreases southwards away from the hilly and mountainous areas. Average annual rainfall varies from 300 mm in the Golis Mountains to 100 mm south of the Sool Plateau. Average rainfall does not always provide sufficient moisture for green pastures for livestock and successful rain-fed crop production.

There are two rainy seasons (Gu and Deyr) bracketed by two dry seasons (Jilaal and Xagaa):

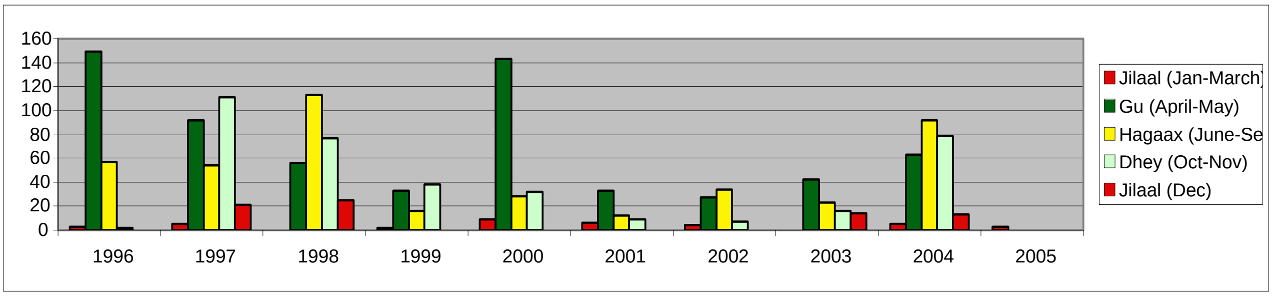
- Gu is a transition period between the monsoons in April and May that is relatively warm and humid, and which marks the main rainy season of the year
- Xagaa is the southwest monsoon from June to September, cloudy and windy with relatively cool and dry weather
- Deyr is another transition period from October to November, providing a second season of rain
- Jilaal is the Northeast monsoon from December to March, which is the longer dry and hot season

2.1 Rainfall Analysis

Accurate and reliable rainfall analysis requires 30 years of continuous rainfall time-series data acquired via the same methodology. Historical data on rainfall patterns for Sanaag and Sool is limited. Data available from before the outbreak of civil war consists of non-continuous rainfall time-series data recorded at local meteorological stations[2]. The records used in this study are stacked time-series analysis (1996-2005) using unmarked Meteosat images (interpolated and smoothed) provided by FEWS-NET. For unknown reasons, three different sets of data for the same period were made available and the third set is presented per season in the two tables below.

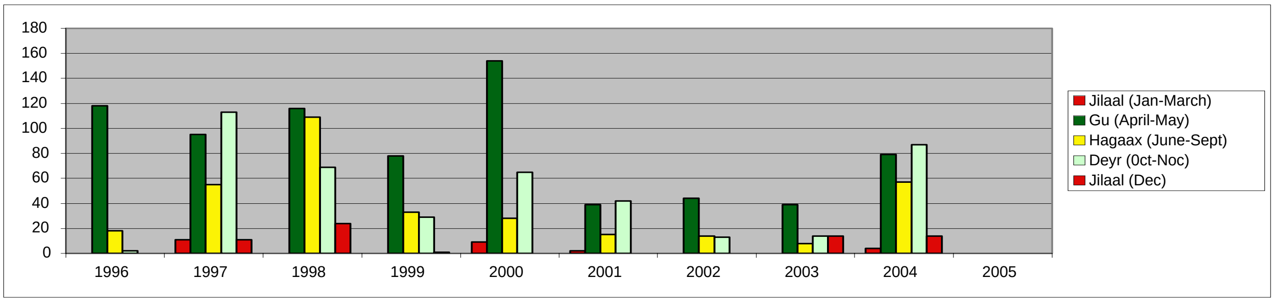
Seasonal Rainfall Patterns in Sanaag Region (1996-2005)

[2] Daily, monthly and annual rainfall for the Northeast Regions of Bari, Nugaal, Sanaag and Sool, Ministry of Agriculture, Flood early Warning System Department, Mogadishu (FEWS, January 1989) provided by SWALIM. In this data set, there are no data available for between 1961 and 1984 and from 1987 to 1995. The rainfall data on the agro-climatology of Somalia ends in 1988.



Source: FEWS-Net Meteosat, 2005

Seasonal Rainfall Patterns in Sool Region

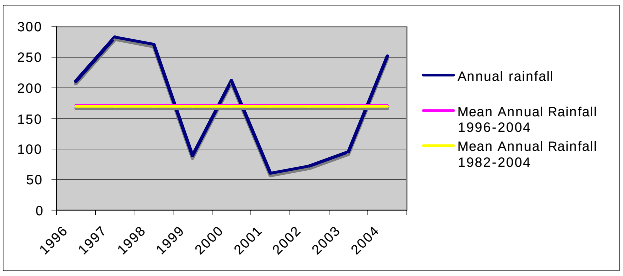


Source: FEWS-Net Meteosat, 2005 (1996-2005)

Rainfall in Sanaag region is strongly influenced by the hilly terrain of the Golis Mountains (Al Madow). Due to the mountainous and hilly masses, Sanaag region receives slightly higher rainfall than Sool region, which lies in a lower altitude. In general the rainfall of both regions is characterised by small total amounts having a bimodal distribution during most of the year, and by temporal and spatial distribution variations from year to year and season to season. Normally, both regions receive the highest rainfall amounts in Gu season (April-May). However, the charts clearly indicate a decrease in rainfall in both regions between Deyr 2000 and Gu 2004 (below 50mm in average). After the plentiful Gu of 2004, both regions also experienced an exceptional Deyr. The tables also show exceptional rainfall in Gu 1996 and Gu 2000.

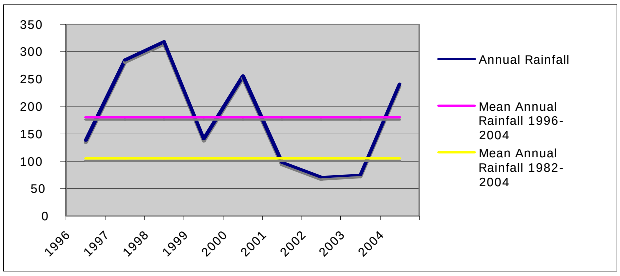
From the above rainfall data, two graphs were formulated for this present study to illustrate the recent drought events in the study area. The two graphs indicate an increase in dry spells both in magnitude and duration (1999 and 2001-2003 dry spell) for Sanaag region. Since 1996, the longest dry spells and correspondingly the largest deficit volume occurred during the last drought. The figures also show more deficits (dry spells) than surpluses (wet spells) in Sanaag region.

Annual Drought Events in Sanaag Region



Source: FEWS-Net, 2005

Annual Drought Events in Sool Region



Source: FEWS-Net, 2005

Drought events can be categorised as mild, moderate and severe using a standardised index (Gibbs, 1975; Rossi, *et al*., 1992; Sharma, 1997). According to Sharma (1997), a mild drought corresponds to 90 to 100% of the mean annual rainfall and may extend from 2 to 6 years over a time span of 10 to 200 years. A moderate drought corresponds to 80 to 90% of the mean annual rainfall and may persist for 2 to 4 years over the same time span. A severe drought corresponds with 60 to 80% of the mean annual rainfall and may persist for 1 to 3 years over the aforementioned time span. For Sanaag region, the more recent drought can be classified as a severe drought since the area received only 60% to 80% of mean annual rainfall (as measured from 1982 to 2004) for three consecutive years (2001-2003).

2.2 Local Oral Memory Since the 1950s

Oral memory can be a very rich source of information about drought trends (see annex 2). From the analysis of qualitative questions in the general questionnaire, it appears that several droughts have been widely experienced in the study area since the 1950s. For example Siiga-Casse (1950-1952), Cadhooley (1963-1964), Daba-Dheer (1973-1974 also called Gargaaraley), Gubungubley (1984-1986), Arbaca (1990-1992) and of course the last drought (2000-2004) which has different names, the most common being Talawaa and Tuur ku qaad (meaning confusion and bear the burden on the back) because of the high death toll of pack camels. Droughts are locally described as cyclical events, which strike on average once a decade.

However, the last drought has been described as the worst ever experienced in living memory, as well as the longest and most extensive (see annex 2). This is reflected in its name in some localities, such as *Lama Arag* (never seen before) in Hadaaftimo. In most of the settlements visited during this study, especially in the Sool Plateau, it began in 2000 and lasted until early 2004. However, in several other locations, especially in the Gebi Valley and Xadeed, it began even earlier, in 1999; in Cawsane, Badhan and Hadaaftimo, it began in 1998; in Mindigaale, Sherbi, Mindhicir and Baraagaha-qol, and even Ceel-Doofar, it began in 1997.

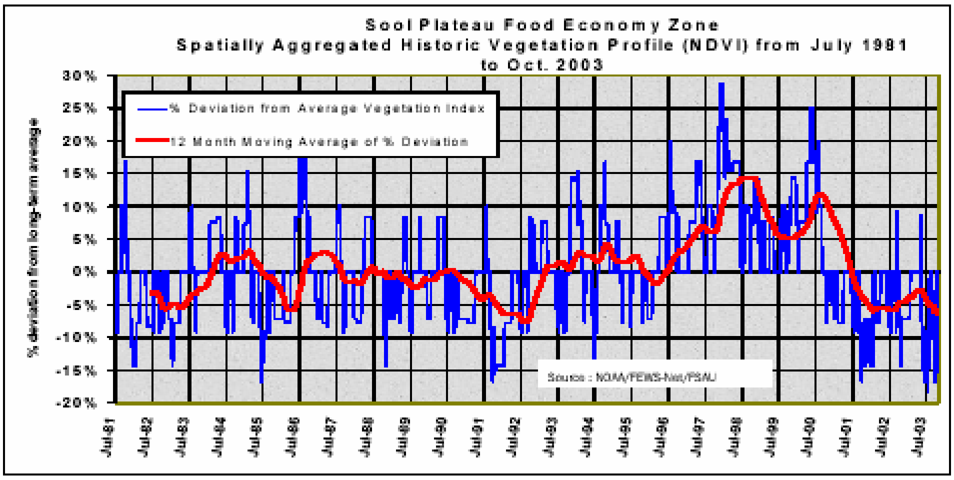
3. Drought and Vegetation Decline

A decrease in vegetation cover has been noted from NDVI analysis and satellite-imagery analysis supported by field observation and interviews with pastoralists. The main issues concern low levels of regeneration of palatable vegetation despite the last good rainy seasons (Deyr 2004, Gu 2005), and the appearance and proliferation of new non-palatable species.

3.1 Normalised Difference Vegetation Index (NDVI)

NDVI is a useful indicator of changes in vegetation cover. Using remotely sensed satellite imagery data sets of the Normalised Difference Vegetation Index (NDVI) going back to July 1981, FEWS-NET and FSAU conducted a historic average vegetation profile analysis for just the Sool Plateau

Food Economy Zone (FEZ). Low values of NDVI represent surfaces with less vegetation. NDVI values throughout the FEZ were spatially averaged for each 10-day period starting in 1981 to derive a single value, and this was then compared with the long-term average for the FEZ to determine the percentage deviation from normal.



In the graph above, four periods of sub-average NDVI are notable: 1981-1983, 1986, 1991-1992 and 2001–2004, which represent drought events characterised by low vegetation cover. The years 1997-1998 coincided with the *El Nino* rains, which were characterised by abnormally high rainfall. The result of this was manifested in high vegetative photosynthetic activity and hence high NDVI values.

3.2 Indigenous Knowledge and Field Observations

Pastoralists are well aware of the impact of drought on vegetation, especially on palatable vegetation, which is used as forage by the different categories of livestock (camels, cattle, shoats, donkeys and horses).

From the analysis of responses to the general questionnaire, it appears that drought has been one of the main causes of vegetation loss. Many trees and shrubs dried. The oldest pastoralists interviewed stated that ***Acacia bussei*** (Galool) declined by an average of 80% since the 1940s and 1950s. In 60% of settlements visited, many elders mentioned drought as one of the two major causes of decline of this species, the second cause being charcoal burning (see annex 3). Much of the perennial grasses also dried.

*Regeneration is a major concern and many species do not seem to have fully recovered from the recent drought despite good Gu and Deyr rains in 2004-2005. Non-regeneration of Duur grass (**Anthropogon spp.**) is particularly alarming due to its special properties: It is a useful wind and water break, stopping lines of grass seed from being blown or floating right away* (Hunt, 1951).

"*A lot of trees did not regenerate like Damal, Dhuur, Higlo, Meygaag; Qurac, Qalaanqal. Only 30% of Daran, Duur, Saddexo and Gubungub came back*" (Ceel-Doofar).

"*Duur and Gubungub grasses did not recover*" (Sherbi).

"*Higlo, Meygaag, Qalaanqal, Jiic, Dukay, Hiil, Qansax and Qurac trees did not regenerate well. Duur and Duxi grasses did not fully recover*" (Baraagaha-qol).

"*Only 60% of Duur, Dureemo, Sifaar, Duxi, and Gubungub regenerated. Geed Wacal (**Commiphora**) trees did not come back*" (Dhahar).

"*80% of Dhuur are dead*" (Mindhicir).

"*Duur plants did not come back. Duxi and Sifaar were also lost*" (Wardheer).

"*Higlo, Meygaag, Qalaanqal, did not come back as well as Dureemo, Duur, Sifaar and Duxi. Only 30% of the grasses returned*" (Sarmaanyo, Sool Plateau South).

"*Dureemo and Duur grasses did not come back*" (Sibaayo).

Strip of Duur/Galool near Sarmaanyo, with dead palatable Duur (***Anthropogon spp.***), Sool Plateau North

Nomadic settlement in the degraded perennial grassland of Xadeed between Xingalool and Sibaayo

On the other hand, many intruder species appeared. In Yuube, Halamash grass appeared after the 1950 locust invasion from Ethiopia. In Raad and Mindigaale, pastoralists mentioned the intrusion of another non-palatable grass species called Aftoxolle (***Zygophyllum Hildebrandtii)*** after the 2000-2004 drought.

Aftoxolle (**Zygophyllum Hildebrandti**i) intruder in Raad (Gebi Valley)

4. Quantity and Quality of Water from the Aquifer

Regional and local ground water conditions in the target areas were investigated by Faillace & Faillace (1986). The authors obtained most of their information from German and Chinese borehole-completion reports (Von Hoyer & Eckart, 1981; (CWDT, 1986). Sool Plateau groundwater is linked to physiographic, geology, and recharge processes.

4.1 Physiography

The study area can be divided into two physiographic provinces: (a) the plateaus and (b) the Valleys of the Gebi Valley (and part of Daroor Valley), on the one hand, and the Sool Plateau on the other. The geological formation of the plateaux belongs to the Eocene period and is widely exposed in these areas. On a regional scale, the movement of groundwater is better defined according to the two major physiographic provinces. The hydrology of Taleex Plateau and Sool Plateau is as follows: The Taleex Plateau rises gently towards the edge of the escarpment, which constitutes the uppermost part of the Togga Nugaal catchment areas. Most of the area is covered by gypsum and gypsiferous soils and to a lesser extent by limestone. The areas covered by gypsum are completely bare, with some pebble layers covering a few places.

Drainage is nearly absent in areas covered by gypsum; karstic depressions and sinkholes are widely spread in these zones. Sinkholes in the area of Cerigaabo and south of the town often coincide with Berda trees. Groundwater recharge by direct infiltration in these regions occurs mainly in the uppermost part of the Togga Nugaal catchment zone. Water infiltrates rapidly into fractures, fissures, sinkholes and karstic depressions in both the Auradu limestone, which constitutes the edges of the escarpment, and also in the overlying Taleex formation.

According to the knowledge obtained from nine water wells drilled by the Chinese government in 1985 in Sool Plateau for rural water supplies, depth ranged from 113.5m in Xingalool to 230m in Guud Cad, which lies within the Karkar Formation. Most of the Chinese wells were drilled in the vicinity of previous deep wells. The new wells were drilled in Ceel-Buh, Dhahar, Qardho and Adinsoone among others.

The water table in the Sool plateau in the floodable area of Xingalool occurs at depths of approximately 60 metres. The middle and the upper sections of the Karkar Formation consist of limestone with intercalations of marls, and are generally dry since aquifers are below 100 metres. The section is constituted mainly of marls and shales, with occasional intercalations of water-bearing limestone layers. These few, thin layers yield very little water.

In spite of the low rainfall in the Sool plateau and the great depths of water-bearing strata, the semi-confined water-bearing layers intercalated with marls and clay layers supply water with low mineralisation. The Chinese boreholes have a TDS ranging from 1250 mg/l in Awrculus to 1730mg/l in Ceel-Buh. The borehole in Xingalool has a TDS value of 3300mg/l and taps water from the gypsiferous alluvial sediments, which accounts for the high TDS value, and from the Karkar Formation.

The results of boreholes drilled in the Sool plateaus show that groundwater resources are somewhat scarce and limited to small water-bearing layers of limestone intercalated with marls and clay of the of Karkar Formation.

4.2 Water Quality

Water that falls as rain in the study area is very pure. As it runs off from and along the hills, plains and floodplains, it erodes soil and picks up a significant load of sediment. Water that seeps through soil and rock layers dissolves various materials. (Water containing more than 50 parts per million (ppm) of calcium and magnesium salts is considered hard and more than 100 ppm causes it to be classified as hard water because much soap is required for cleaning purposes).

Streams pick up more and more discharge water and dissolved salts as they flow into flatter areas and low elevations. The salt content increases more rapidly in arid regions because the dilution factor for water is smaller. Salt concentration increases as less water and more salt go to the water table or to the streams. The highest concentration of salts occur in the dry periods because the rock layers and sediments of these arid soils contains more leached salt, and in the lower parts of long small rivers the length permits several leaching cycles to occur and the low water volume in dry periods provides minimal dilution.

According to local communities, the last prolonged drought also decreased the quality of the water of the aquifer. Drilled in 1987 by the Italian Development Agency, the borehole of Baraagaha-qol was abandoned in 2002 just after its rehabilitation by Horn Relief[3]. A sudden and massive death of livestock occurred and was attributed by the local community to a deterioration of the water quality. The chemical analysis ordered by Horn Relief in Kenya in October 2003 shows high electro-conductivity (5.3mS) and high PH levels (8.2), high Calcium carbonate content (1550 mg/l), Chloride (1150mg/l) and Sulphate (1800 mg/l). All these recordings exceed international standards for human drinking water. Chloride concentrations of above 250 mg/l give water a salty taste. Sulphate content in excess of 250-500 mg/l gives the water a bitter taste. Above 300 mg/l of Calcium carbonate, water is said to be very hard. However, from the Faillace report, one of the old boreholes of Xingalool had higher figures (for example EC=6.7mS). Therefore, it is not clear whether high salinity; bitterness or hardness were direct cause of livestock deaths.

The quality of water from the 228-meter deep borehole of Yuube drilled in 1978 by the Italian Development Agency and rehabilitated by Horn Relief in 2004 is said to have deteriorated, albeit to a lesser extent, since the drought. The local population increasingly uses the permanent mechanised shallow well providing hard water that is located inside the settlement for domestic water use. No analysis is available.

4.3 Factors Affecting Recharge

Lack of rainfall diminishes the recharge rate of springs, boreholes and permanent wells. In Badhan, the manager of a spring reported that water levels had decreased by 10 meters. However, this is also due to high levels of water removal for trucking to settlements for filling berkeds or directly to grazing sites.

In the study area, primary recharge water only comes from rain, while secondary recharge may occur via seasonal rivers (toggas). The groundwater level coincides with the water table and its shape correlates closely to the surface topography of the region, reaching its highest elevations beneath the hills and descending towards valleys in response to gravity. The slope and the material through which the water drains determine its velocity and direction of movement. When rainfall decreases, the water table in the hills subsides and gradually approaches the level of the valleys. Also, in times of extended drought, the water table may drop enough to dry up shallow wells. So the variations in rainfall permeability of rocks and sediments from place to place are contributory factors to the unevenness of the water table.

Water that passes straight into an aquifer is known as direct recharge, whereas water that percolates laterally from higher elevations into aquifers at lower elevations, or that leaks from rivers is known as indirect recharge.

Direct recharge from rainwater is unconfined recharge to phreatic or water table aquifers and the indirect recharge is rainwater infiltrating directly into the surface on relatively high ground flows under gravity towards the lower plains. The rate of flow is determined by both gradient and geological material. Due to the limited storage volume, water levels may nevertheless be variable and seasonally controlled. This recharge mechanism (sub-surface flow) occurs along the fault/fracture zones and the toggas. Sub-surface flow eventually reaches the vast plains, where it indirectly replenishes the various types of aquifers underlying them. Indirect recharge also occurs where hydraulic continuity exists between the alluvial topsoil and the deeply seated weathered or fractured basement aquifers; there will also be recharge from infiltrating surface water (streams and flood areas).

[3] Horn Relief's rehabilitation of the various borholes involved only provision of new gensets and infrastructure sorrounding the exterior (e.g. water troughs, engine house, etc.) where appropriate and did not involve any work on the interior of the borehole.

Data on water quality from underground water sources in the study area[4]:

N.B: 1mmho/cm ≈ 750 ppm ≈ 0.075% ≈ 10 meq /litre ≈ 0.01 N

Zone	Location	Depth	PH	EC	Taste	Recharge rate
Gebi Valley	Ceel-Doofar borehole	70			Hard	NK
	Badhan spring	10	8	2.64 ms	Hard	NK
	Ceelaayo	18			Hard	Poor
	Mindigaale wells	5			Hard	Good
	Body Cadet well	14			Hard	Poor
	Yuube borehole	228			Turned Hard	15 minutes
	Qoraley well	27			Hard	Poor
Karkar	Buraan borehole	36	7	2.5 ms	Sweet	15 minutes
	Buraan spring	5			Sweet	NK
Sool Plateau North	Carmaale	160			Sweet	immediate
	Ceel-Buh old borehole	194	7.4	2.7 ms	Sweet	1 hour
	Ceel-Buh new borehole	250	7.3	1.3 ms	Sweet	4 hours
	Baraagaha-qol abandoned borehole	160	8.2	5.3 ms	Turned very hard in 2002	immediate
	Dhahar borehole	NK			Sweet	NK
Xadeed	Xingalool old borehole	120			Hard	immediate
	Xingalool new borehole	110			Hard	immediate
	Sibaayo well	16.5			Very Hard	NK

4 All measurements were taken during fieldwork, except for Baraagaha-qol borehole. For this borehole, chemical water analysis was done in Kenya by the Government Chemists Department in October 2003 at the request of Horn Relief.

5. Drought's Impact on Pastoralist Livelihoods

The last prolonged drought, particularly during the last two years, (2003-2004) had severe impacts on pastoralism, which is the main economic activity in the study area. Drought dried up all the palatable vegetation used as forage by the different categories of livestock (cattle, camels and shoats), which died from starvation and a decrease in water, as reported by pastoralists and Horn Relief. The *main causes of camel death are malnutrition and related diseases. Large camel deaths are a result of the lack of quality pastures for three consecutive years*. (Horn Relief, op cit, June-July 2003). In Buraan, elders reported that camels ate the denuded branches of trees and died from gum infection.

Migration, which is the usual coping strategy, was not practical due to a coincidence of several factors: the extent of the drought in the affected area; the dearth of pack camels and donkeys and the high cost of hiring truck to transport livestock to grazing sites; and also restriction of movement following the civil war, when each clan returned to its own territory. The main coping strategy of pastoralists, many of which essentially faced destitution, has been to turn to alternative sources of livelihood using local natural resources: charcoal burning and grass harvesting.

5.1 Loss of Livestock

A multi-agency team (FSAU/FAO, UNICEF, WFP, UNOCHA, FEWS NET, Horn Relief and VSF) conducted an emergency humanitarian assessment in Sool Plateau October 9-13, 2004. The objective was to ascertain the severity and extent of the humanitarian problem and make recommendations concerning appropriate responses.

The principle findings showed that cumulative livestock losses (mortalities and distress sales) over the past four drought years decimated herds and altered herd composition. Most critically, camels were particularly affected, with losses of 60-70%, and even higher mortality rates among pack camels (over 80%), which increased vulnerability of pastoralist households by reducing their mobility. Nearly half (40-50%) of shoats died. Even more alarming was the drop in livestock reproduction, on which hopes rest for future viability and recovery (FSAU, 2003).

From the study, the uniqueness of the last drought is that it eradicated the majority of the livestock and not only killed drought- vulnerable categories of livestock such as cattle, but also camels. The drought was nicknamed Xoola Dhamays meaning "eradication of all animals" in Sibaayo; Mariso or "it emptied everything," in Badhan, and Geel Baabi'iso in Mindhicir, meaning "Camel Killer." These losses induced considerable trauma; many wealthy camel owners who have lost their beloved animals suffer from psychological harm, for example, drawing camels on rocks (Xingalool).

In the study area, pastoralists provided us with the following information on livestock losses (see annex 4):

- Pastoralists lost on average 97% of cattle, 95% of camels, including pack camels, 82% of shoats and 71% of donkeys
- The average size of camel herds before the drought was 79; afterward it fell to 4. Settlements with higher mean camel herd sizes were: Baraagaha-qol (300); and Dhahar, Mindhicir and Ceel-Doofar (all 100)
- Settlements most affected by camel losses were Baraagaha-qol (99.3%), Wardheer (98.7%), Cawsane and Dhahar (98%), Ceel-Buh (97.7%), Sarmaanyo (97.5%) and Carmaale (97.1%). All these settlements are located in Sool Plateau North and South, except Cawsane, which is in the Gebi Valley
- The settlements least affected by camel losses were Badhan (83.3%) and Sherbi (85.5%)

Loss of pack or burden camels is a major issue, as reflected by a nickname of the last drought in Sarmaanyo (Tuur rarato, meaning: carry everything on your back)

"The pack camels died because they carried water back and forth. They could not find enough forage with the drought, not enough forage" (Ceel-Buh).

To date, the only category of livestock that has recovered is shoats (estimated at 50% of pre-drought levels).

5.2 Famine and Malnutrition

Loss of livestock affected the diet of pastoralists. A 60-70% drop in income from livestock sales drastically reduced the purchasing power of producers (FSAU, 2003). The lack of livestock products, which are the main source of food and income, especially milk, considerably increased malnutrition rates, which remained high in some surveillance sites as of early 2005.

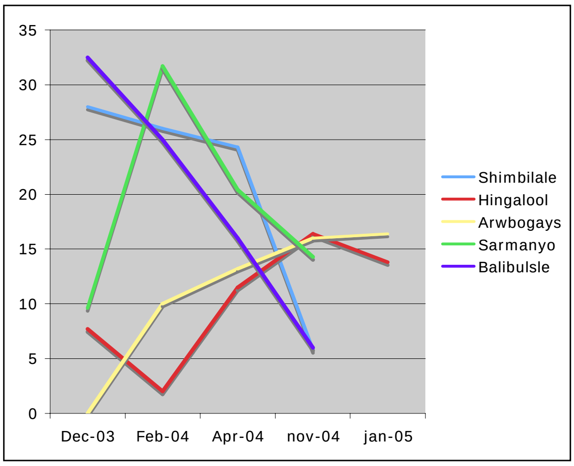
Approximately 15,500 households in the Sool Plateau of Sool, Sanaag and Bari Regions, Gebi Valley and Lower Nugaal livelihood zones have experienced food insecurity (FSAU).
In November 2004, all sites in the Sool plateau reported global malnutrition rates below 16.5%. Compared to the last rounds of sentinel sites surveillance, malnutrition levels within the Sool plateau were gradually decreasing with the exception of Xingalool and Awrboogays; *5.4% of the women were malnourished, a significant decline from April- 2004 levels*. (FSAU Nutrition update, January 2005).

The under-five mortality and crude mortality rates were 0.9/10000/day and 0.2/10000/day respectively, lower than those observed in previous surveys (FSAU, Nutrition Update, January 2005). In May/June 2003, there were respectively 1.9 deaths per 100,000 children under five and 0.88 deaths per person per day. Both mortality rates were indicative of a situation approaching the classification alert. (IIA, 2003).

In Cawsane, women cooked a tree of a type known as Carmo. In Mindhicir, pastoralists resorted to consuming hyenas. In Ceel-Buh, before the provision of food aid, women were forced to feed young children a diet of black tea, exclusively.

However, it is interesting to observe that Global Acute Malnutrition trends vary greatly among the FSAU-monitored sites as shown in the table below. Staff who have been involved in FSAU's monitoring of malnutrition provided several explanations.

Firstly, the drought did not affect all the settlements at the same time and with the same severity. Xingalool, Awrboogays and Sarmaanyo began to feel the effects of lack of rain in Jiilaal 2004 while other localities, such as Bali-Busle and Shimbiraale were already affected in Jiilaal 2003. On the other hand, these two locations benefited from small rains in Deyr 2003 and Gu 2004. Some settlements received food aid and had more opportunities to turn immediately to an alternative source of livelihood. For example, charcoal burning was used as a source of livelihood in Bali-Busle on the Sool Plateau North from 1991 until February 2004.



Global Acute Malnutrition levels in sites within the Sool Plateau Livelihood zone (2004), Source: FSAU, 2005

5.3 Scarcity and High Cost of Water

Most of the pastoralists facing water shortages moved to permanent water sources, especially springs and boreholes: "*The area of Buraan was overcrowded not only with the Warsangeli but also the Cisman Maxamuud (Majeerteen) and Dhulbahante gathered here because of permanent water. Some boreholes were broken down; others could not provide enough yields like Ceel-Buh. The area of Badhan was dry and the spring of Badhan could not give enough water.*" (Badhan)

However, some pastoralists decided to remain in their home areas because of poor livestock condition or owing to the assumption that Buraan would be overgrazed. In villages without permanent water (berkeds or broken boreholes like in Carmaale in 2003), water prices for both human and animal consumption increased considerably with water tankering. Water tankering had to be introduced in grazing sites and pastoral settlements.

In 2003, during the drought, villagers of Sool dependant on water trucking spent 60% of their income on water (Horn Relief, Sanaag Drought Assessment Report, July 2003). Aggravated by the long distance between pasture and water points, households remaining on the plateau had to rely on water trucking, an expensive undertaking that costs 30,000-50,000 Somali shillings per drum of water. This has gone up from 10,000 Somali shillings in a normal year *(FSAU food security report, July 2003)*. The typical price of one drum of water ranged from 10,000 to 70,000 Somali shillings depending on distance from the source of tankered water. This price increase forced pastoralists to divert their financial resources away from other requirements such as food purchases and animal-health services to water. Ninety percent of pastoralists were purchasing water on credit and carrying debts (FSAU, 2003). In Sanaag region, in dry seasons and during the droughts, much of the sweet water for domestic use is tankered from the spring of Buraan because it is free of charge.
To date, households with small herds remain in serious distress due to a lack of pack camels and donkeys (more expensive than camels today), which are used to carry household items to grazing areas, and for water transportation. Water trucking was still needed to supply pastoralist settlements in grazing lands at the end of this short dry season (Xagaa).

Drums in front of a nomadic settlement near Carmaale ready to receive water trucked from the berkeds of Carmaale, ahead of the next Deyr short rains

Water being trucked from Buraan spring to Mindhicir berked

6. Coping Strategies and their Limitations

During previous droughts especially Dhaba-Dheer (1973-1974), pastoralists received considerable assistance from the Somali government, which resettled a large number of destitute people in Government irrigation schemes built in the fertile riverine areas of Juba and Shabeelle regions (Kurtun-Waarey, Sablaale, Dujuuma and the coastal town of Baraawe). During the last drought, in the absence of a strong government, and before humanitarian assistance was provided (after 3 years of drought), pastoralists were forced to be self-reliant: "*We are between Somaliland and Puntland, in the middle, we are abandoned by the two administrations and only Horn Relief came to assist us with limited capacities.*" (Mindigaale)

6.1 Inward and Outward Migration

Normally, the main coping strategy during drought is migration. From 2000 to 2002, pastoralists tried to migrate outside Sanaag region but due to the extent and severity of the drought, a majority returned, and most of their livestock died in their home areas. In 2002, some pastoralists from Ceel-Buh decided to migrate to the Hawd in Ethiopia but due to the extent of the drought, many of them did not survive. Some camels from Cawsane were left in Guban but these were also lost. Elders reported that the pastoralist movements were later restricted by the loss of pack camels and the high cost of truck hiring for livestock transportation.

Some pastoralists from Garoowe came to Sanaag region hoping to find Gubungub (***Eragrostis haraensis***) for their livestock; consequently this grass species declined due to overgrazing. It is interesting to note that the drought that affected the study areas between 1984 and 1987 was nicknamed Gubungubley because of overgrazing of Gubungub by migrants.

Gubungub (**Eragrostis Haraensis**) between Badhan and Ceel-Buh.

Pastoralists also mentioned political restrictions imposed following the civil war, when many Somalis returned to clan territory. In Yuube and Xingalool, elders stressed that migration was only possible within Warsangeli territory since the civil war.

6.2 Displacement of the Destitute to Settlements and Urban Centers

In all the permanent settlements visited, correspondents emphasised the migration of destitute pastoralists to urban centres. In Buraan, the representative of the Buraan Women's Union (BWU) explained that: "*Most of the destitute pastoralists run to the settlements to seek assistance from their relatives or find work. Many were left especially old men, women and children who are difficult to transport.* They also emphasised that pastoralists are still paying debts for water and food bought on credit during the drought. In Badhan, elders estimated that 70% of pastoralists moved to towns and other settlements to stay with relatives, or got help from outside*.*

According to many correspondents from urban areas, this trend put pressure on urban centres (Buraan, Ceel-Buh, and Dhahar). The destitute have been blamed for increases in theft and deterioration of hygiene. In Dhahar, women reported that water and housing facilities are insufficient for the increased population.

6.3 External support

In several locations, a number of destitute pastoralists received help from the Diaspora (Wardheer, Xingalool, Ceel-Buh, Damala-Xagarre, and Badhan). Buraan, Wardheer, Ceel-Buh, Cawsane, Baraagaha-qol, received food relief from WFP.

6.4 Alternative Livelihoods

Many destitute people move to towns to seek employment such as stone collection (Yuube) for the men and house-help work (Xingalool) for women. Some destitute women managed to open businesses (tea kiosks, shops). However, all settlements visited named charcoal burning and grass harvesting in open, legally and illegally enclosed rangelands, as the main drought coping strategies:

"*When we lost our livestock, everybody tried to survive. Before we had free grazing, now a lot of enclosures are established for grass harvesting and sales. There is also charcoal burning. As there is no government and few NGOs to help us, we became aggressive to the environment*" (Raad).

"People who lost their animals became like beasts and started eating the land: they cut trees to burn charcoal and sell it." (Ceel-Doofar)

According to Buraan, Xingalool and Mindhicir elders, berkeds were also used as a source of income; many of them have been built for commercial purposes. Average profit for a berked owner is 10,000 Somali shillings per 200-litre drum sold.

Conclusions

Despite the lack of data for a proper drought analysis, it can be concluded that the last drought that occurred in the study area was devastating because the water deficit was extensive in terms of both time and space. It was destructive to the environment and also to pastoralism, the local main source of livelihood. Alternative livelihoods that were adopted as drought-coping strategies, such as charcoal burning further destroyed the fragile environment and spurred conflict over scarce natural resources (communal vs. private land use). Drought preparedness was very limited.

Many efforts to date have focused on understanding drought hazard rather than drought vulnerability (Downing and Baker, 2000, (Wilhemi and Wilhite, 2002). Drought vulnerability factors are developed in the following chapters.

Although the community claims that the quality of borehole water has significantly decreased, particularly after the drought, this study could not conclude the reasons for these claims and recommends that this be addressed through a hydro-geological survey.

Chapter 3: Soil Erosion

Soils constitute a small fraction of the earth's material, yet they are a vital resource for the growth of plants and are very fundamental for humans' life-support system. Soils are damaged or destroyed by human carelessness, which can cause the loss of fertile topsoil and disturb more and more of the earth's surface. The soils in the study area are under stress from considerable erosive forces, especially water and wind, which move soil components from one place to another.

1. Conceptual Framework

Erosion by water occurs wherever rainfall drops strike bare soil or runoff water flows over erosive and insufficiently protected soil. There are four main forms of water erosion:

- **Splash erosion** is the detachment of soil particles by the striking force of rain drops on an unprotected ground surface
- **Sheet erosion** is the removal of thin layers of soil by flowing water on the soil surface. Rain drops splash and surface water flow cause sheet erosion, with splashes acting to provide most of the detaching energy to soil particles and the ensuing water providing most of the transporting capacity
- **Rill erosion** occurs when rills begin to form when water flows as a thin, unconfined sheet for a relatively short distance before developing into threads and tiny channels
- **Gully erosion** occurs when rills enlarge and cut deeper into the soil until they are too large to be erased by ordinary tillage

Water erosion causes damage in many ways. Soil is lost; plant nutrients are removed; texture is changed; structure deteriorates; productive capacity is reduced; and fields are dissected. The sediments produced polluted streams and lakes and pile up on bottomlands, in stream channels, and in reservoirs

Wind erosion is a process of detachment, transportation, and deposition of soil material by wind action. It causes serious soil deterioration and is a major problem in dry-land regions like the Gebi Valley and Sool plateau. Serious and widespread wind erosion occurs periodically in this area, most often during Jiilaal season of the year (when winds from the northeast blow in the country) between the months of December and February and sometimes even in September. Soils are moved by wind in one of three ways: soil particles and aggregates of silt size and smaller are kept suspended by the turbulence of air currents and travel great distances in this way; Intermediate grain sizes of fine to medium sand are moved in the wind by a motion called saltation, which consists of a series of leaps, in which grain rise into the air and fall again after a relative short flight; larger grains of soil and sand cannot be lifted into the wind stream, but they may be bumped along the soil surface or move on the surface by creeping. Wind erosion causes a great deal of damage each year. This damage takes different forms such as loss of soil, texture changes, nutrient and productivity losses, abrasion, air pollution, and sedimentation.

2. Soils of the Gebi Valley and Sool Plateau

2.1 History of Soil Erosion in the Gebi Valley and Sool Plateau

The history of soil erosion in the study area was constructed by compiling data, descriptions, and studies available. The occurrence of soil erosion in northern Somalia was reported by Hunt in a 1944-1950 study on the Somaliland Protectorate. It was shown that such erosion is associated with the southern Golis Mountains (Al-Madow) which begin in the northern and hinterland rugged surface and gradually slope towards the Indian Ocean inside the study area. This section of the terrain is dissected by an extensive network of intermittent seasonal streams. The soils are being severely eroded because the considerable rainfall in the watershed is irregular and sporadic and there are significant areas of bare rock with only pockets of soil among them (Hunt, 1944-50). Since that time, various reports have noted that erosion of grazing land is a particularly difficult problem to deal with (Hemming 1972, IUCN 1977).

Early incidences of erosion were attributed to increased livestock populations on the rangelands, which are characterised by patchy perennial grasses, and which, when grazed, expose the intermittent bare soil to erosion and compaction by rain drops. Erosion removes the fertile topsoil, and compaction impedes the infiltration of rain water and the germination or growth of grasses and herbs (KNA: Cowley, 1947/8).

Hunt concluded that in the last century there was a naturally adjusted balance maintained to preserve the soil on which pastoralists grazed their stock. This balance is being broken down by development and settlement, and protecting the soil is a factor in every development programme, and this has disturbed the fine balance of soil productivity in a semi-desert area inhabited by nomadic stock-holders.

Recently SEPADO noted the danger of increased charcoal burning and cutting of grass and other pasture for export, at the same leaving behind little food for livestock, humans or wildlife. In this way, hundreds of square kilometres of burned land no longer host any life and undergo alarming rates of desertification and other environmental catastrophes that are occurring in the country (Tiempo, undated).

2.2 Field Observations on Soil Degradation

During the fieldwork it was noted that the soils of the study area are under relative risk of degradation. Soil degradation is defined as a process which lowers the current and the potential capability of soil to produce (quantitatively and qualitatively) goods or services (FAO 1979; UNEP 1982). A variety of environmental factors contribute to soil degradation, among these:

- Accelerated runoff due to local bare, steep and sloping hills and ridges
- Increased aridity, which leads to reduced vegetation cover
- Occurrence of heavy cyclones characterised by high-intensity erosive rainfall and long duration, causing floods in the study area. Examples include the cyclone of 1971-1972, *El Nino* in1997-1998 and heavy rainfall in December 2004
- Unhindered surface water runoff and flash floods
- Poor vegetation cover on exposed gypsum and limestone rocks and denuded lands through severe tree cutting and overgrazing
- Destruction of soil aggregation of various particle sizes and structure by soil salinity/sodicity, livestock trampling along the paths to water points and increasing vehicle traffic on innumerable unpaved roads
- Formation of soil surface crusting and sealing in large areas
- Reduction of soil surface porosity, poor water infiltration and permeability
- Extremely shallow to deep erosion of soils
- High winds that blow dust storms in dry seasons

In the vicinity of all settlements in the Gebi Valley and some in the Sool Plateau area, signs of all types of water and wind erosion were evident. The settlement areas particularly damaged by the different types of soil erosion are:

- Ceel-Doofaar, Cawsane, Mindigaale, Raad-Laako, Badhan, Hadaaftimo and Yuube in the Gebi Valley
- Carmaale, Ceel-Buh, Buraan, Dhahar and Sherbi and Waaciye in the Sool Plateau

The extent and severity of erosion is not uniform across this large study area. The most eroded spots are usually easily detected by the colour of the subsoil and by the sparseness of vegetation. The damaging effect is sometimes increased by the lost soil becoming sediment that destroys the land surface in low areas, diverting the course of seasonal rivers, and consequently affecting the landscape.

The types of water erosion identified on the ground include: sheet, rill and gully, and at the initial stages of the rains, splash erosion. The splash first changes the upper physical composition of the topsoil by detaching the aggregated soil particles and setting them in motion.

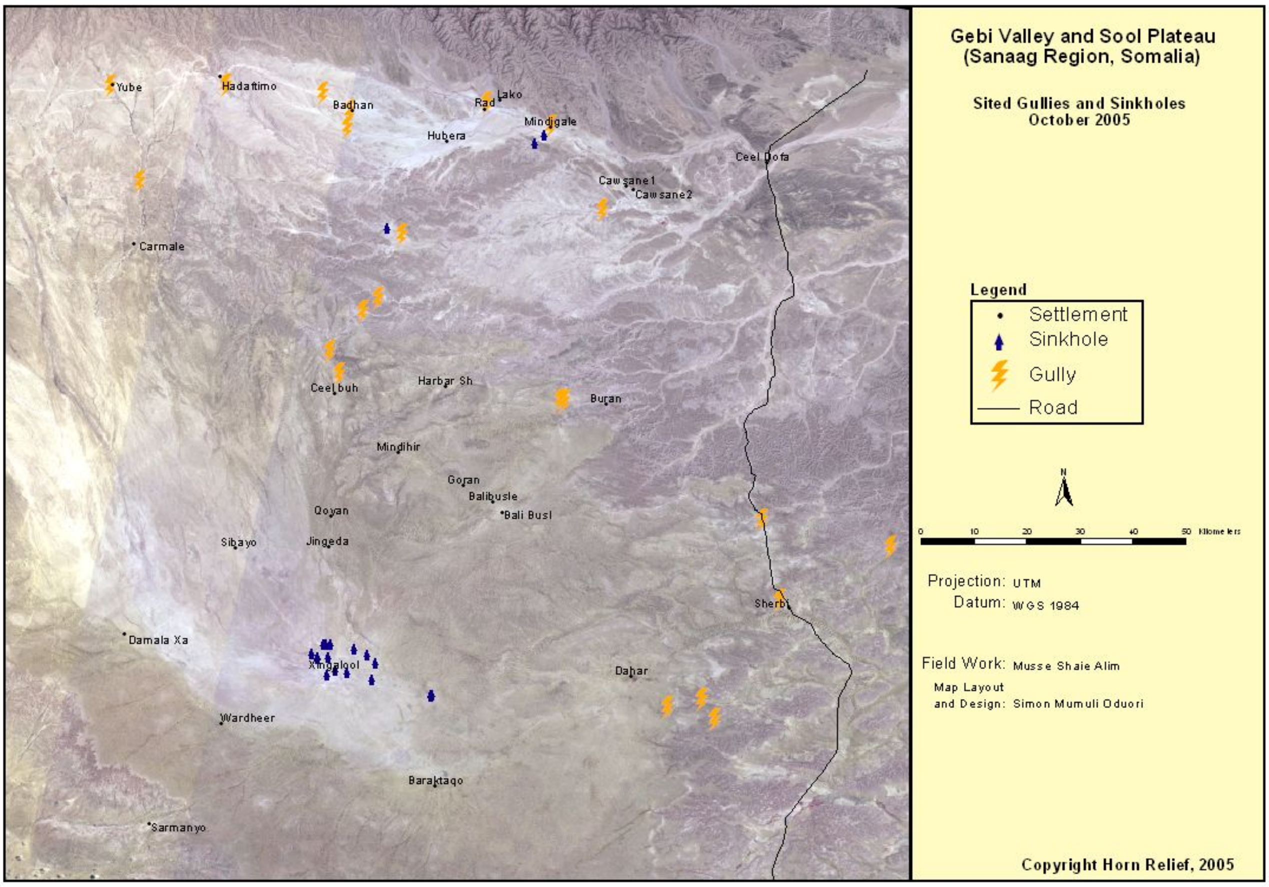
The other types of water erosion, sheet, rill and gully are immensely advanced in the region. During the survey, a reduced rate of erosion was observed on the plains, where a surface layer of mainly limestone and gypsum is on the surface. In these places stones intercept raindrop energy and runoff scour forces. This action of retarding runoff allows more time for water infiltration and facilitates establishment and survival of herbaceous and other plants.

Sheet erosion was observed to be widespread all over the study area with the indicator in most cases being remnants of dry herbaceous plants rolled up by water movement on flat gently sloping ground facing a downward direction; surface crusting and sealing were also observed to be common indicators of sheet erosion in the study area.

Rill erosion is more likely to occur wherever a certain roughness of surface terrain is evident, and threads of water tend to concentrate to form tiny channels, which become bigger channels. Rill erosion is more pronounced on the plains, where soft, pinkish gypsum outcrops occur. Rill erosion also occurs where there are deep fissures, fractures and cracks on the ground, the existence of which may be due to the collapse of sub-surface soluble rocks, like limestone, which is very susceptible to chemical weathering through the action of the rainwater. The degree of rill formations in the region varies from slight shallow (20-50 cm apart and more than 35cm deep) to severe very dense rills.

Many gullies have been identified in various places in the Gebi Valley and Sool Plateau, but only a total of 30 gully sites of different sizes and densities were visited. The gullies visited are in all 10 villages where Horn Relief has been involved in conducting intensive operations of gully rehabilitation. The sites visited in each village were identified by the community elders, women and youth groups during interviews. The sites are perceived as among the most damaged by gullies and are rapidly expanding into the rangeland floodplain environment, an area previously believed to be among the most productive in the region before it was destroyed.

Simple measurements of depth, width and ground slope were taken. Additional information about the gullies was obtained from the people living in the vicinity, and from a Horn Relief expert supervising the rehabilitation of gullies, water-runoff harvesting and soil- erosion prevention. To know more about the characteristics of the soils in the working area, soil samples were taken for soil analysis of the physical and chemical properties from 20 localities.



By simply examining the cross-sectional views of gullies from their starting head to their mouths there is a constantly decreasing gradient, deepening and widening part of the gully below. The rate of gully expansion in the various places in this region is very much relative to the intensity and duration of the rainfalls, the degree of land slope, the land surface roughness, the erosion susceptibility of the soil or debris, and the vegetation cover.

Many gullies were started by insignificant water flow in a footpath, stock track and vehicle tracks, which are particularly noticeable around watering points. However, once the gully has started it can grow rapidly by head ward extension, digging deeper and deeper in the bed and causing collapse of the walls in the floodplains where there is more erosive soil material or debris both sideways and upstream of the channels. The degree of gully formations seen in the floodplain can be ranked according to their depths. Commonly the gullies observed are slight to severe degree types from deep (100cm) to very deep (10m), and with widths of 100m to 4km and lengths between 1 and 10 kilometres in a dendritic formation. Extreme gully development (forming badlands) is seen only in few places such as Hadaaftimo. Gullies occur all over the Gebi Valley (from Cawsane to Yuube) and in some areas of Sool plateau, particularly Ceel-Buh, Carmaale, Buraan and Dhahar, mostly are at an advanced stage of development. So far, these gullies have destroyed nearly half of the floodplains of the visited areas and expand their total area during every event of heavy rainfall.

Hadaaftimo gully

Cawsane gully

The local community, the previous regime and the current regional administrations are aware of the problems posed by gully formation but tend to neglect it. As a result, gullies have become big enough to affect the rangeland as well as various urban settlements like Waaciye, Ceel-Doofar, Mindigaale, Raad-Laako, Hadaaftimo, Yuube and Ceel-Buh.

2.3 Physical and Chemical Properties of Soil Samples Taken from the Gebi Valley and Sool Plateau

The table in Annex 6 describes some of the physical and chemical properties of the typical soils in the area. The properties are less variable.

Physical Properties

The most obvious physical properties of the soil surface of the Gebi Valley and Sool Plateau are the crumbly, powdery or granular textures which are present on most of the bare grounds replaced by crusting and sealing. Surface crusts are generally well developed in all the areas where the texture is silty clay loam and therefore soft and friable. The presence of this crusting on sloping areas (gradient of more than 1%) is a sign of increased runoff water and erosion susceptibility.

Surface sealing is also noticeable, as fine silt grains plug the pores, making it difficult for seeds to germinate, root penetration and water infiltration.

The soils in the Gebi Valley areas of Cawsane, Mindigaale, Raad-Laako, Badhan-Gungumaale, Hadaaftimo and Yuube are deep to very deep, and vary greatly in texture from surface to depth, being often silt loam at the surface and changing to silty clay loam or clay with depth. In colour, these range from pink to pinkish white or reddish yellow. The structure of the surface soil (a horizon) consists of loose, powdery or fine-crumb soil. In soil profiles at crack and gully sites respectively in Xubeera and Mindigaale, the structure was massive throughout its depth and very friable. Owing to the silt loam texture on the surface and finer texture (having much smaller pores) at depth, they are infiltrated and permeated more slowly and moderately. Therefore a moderate storm often produces more runoff and these soils are liable to erosion because of being on gently sloping surfaces.

In a larger part of Sool Plateau, in and around Carmaale, Ceel-Buh (Habar-Humbulle and Ceel-Haqay), Baraagaha-qol, Damala-Xagarre, Bali-Busle and Dhahar (Geed-Cilmi and Kalxileed), soil texture is finer and varies with depth often from silty clay loam to claylike, while in other parts it is claylike all through the depth. Soil colour is often reddish brown to reddish yellow. Water infiltration and permeability is slow, and it is more resistant to erosion; consequently there is rarely gully development.

Chemical Properties

Emphasis, during the chemical analysis, was placed on assessment of salinity through Electrical Conductivity Measurement and exchangeable Sodium and other cations associated with the soil. Most of the soils in the region are calcareous or gypseous.

Soil pH was measured in a suspension of ratio 1:2.5 soil to water, in the field and also in a laboratory (ICRAF). Nearly all the soils in the Gebi Valley have a mild to alkaline pH ranging from 7.6 to 8.5. All the soils are non-saline (<1.2 mS) with no sodicity problems. However, in small pockets around Mindigaale, Gungumaale (near Badhan), Xubeera and Hadaaftimo areas, salinity varies with depth from slight to moderately saline (1.5-3.9 mS). In Sool Plateau, soils are alkaline and have no salinity or sodicity problems.

Concentrations of individual cations varied widely among different sites. The overall trends of the exchangeable cation contents, though, are worth noting: the dominant cations are calcium (ranging from between 16.20- 4.35 me/100g soil), followed by magnesium (1.3-7.6 me/100g) and do not regularly increase with depth. Exchangeable sodium is almost zero, giving low ESP readings. Levels of organic carbon in all the soils are high, meaning that much of the carbon is derived from inorganic materials. Total nitrogen is fairly low (0.02-0.09%), whereas the total phosphorous levels are fairly high. However, only little amounts of phosphorous are readily available, because at moderately high pH values, phosphate fixation is common due to the formation of highly insoluble calcium phosphates.

Hence, the soils in the study areas are characterised by low soil fertility (low in organic matter content and deficient in macro nutrients such as nitrogen, phosphorus and potassium), high susceptibility to crusting and compaction, high soil-moisture deficits and a tendency to severe wind and water erosion.

The soils of the Gebi Valley and Sool Plateau are suitable for grazing and must be preserved as rangeland. Introduction of crop irrigation is possible, in the form of flood water from seasonal intermittent streams (toggas), where soils are deep and well drained, until such time as an acceptable system is used to maintain soil fertility and impede land and environmental degradation.

3. Major Causes of Environmental Degradation and their Impact

The available rainfall data shows that three heavy rainfall events have unleashed immensely powerful floods, causing some extensive damage including: settlement destruction (for example, Xubeera's population was relocated to Badhan town by the Siyad Barre government); removal of vegetation; and soil erosion, which formed huge gullies in places, and covered others in sediment.

"*Hadaaftimo was a very rich flood plain before the cyclone. The cyclone destroyed the vegetation and the soils. The gullies transformed the area into a desert. All the water is lost with the gullies and the togga. Soil cannot produce vegetation because the water cannot stay anymore"* (Hadaaftimo).

3.1 De-vegetation of Prime Grasslands in the Gebi Valley

The oral memory of elders interviewed corroborates that the floods of 1971 and 1972 overflowed all riverbanks and submerged floodplains until water reached the margins of the surrounding hills. According to local oral memory, several palatable species of grasses were uprooted and swept away, consequently disappearing from many areas (Sifaar from Ceel-Doofar, Dureemo from Raad-Laako, Gargaro from Raad-Laako, Doomar from Ceel-Doofar and Mindigaale; Xul from Mindigaale).

3.2. Decreased Soil-Water Retention

The greatest resource constraint in the Gebi Valley and Sool Plateau is water and its retention in the soil. Throughout the year, rainfall is the sole source of water necessary for human domestic use, watering livestock and pasture and crop production. Rainfall is characterised by temporal and spatial variability from season to season and year to year. Often rainfall occurs in short periods of high intensity and, because of the rugged local topography, a large amount of rainfall is lost as runoff into the Indian Ocean through rivers carrying a heavy sediment load from the fertile soils. No less common is the loss of huge amounts of water through tunnels or sinkholes located in the depressions.

Apart from the negative aspects of the sloping and over-steep topography that promotes increased water runoff through surface drainage and subterranean cavities, the major cumulative impact of reduced water retention is very much attributed to the long-lasting droughts, aggravated loss of vegetative cover, water and wind erosion of soil, animal overgrazing and trampling, illegal rangeland use and poor resource management.

The landform of the Gebi Valley region is in evolution as it is dissected by many ephemeral streams, which cause a combined effect of mass wasting and soil erosion by running water following occurrences of abundant rainfall. Such streams flow for only a few days or perhaps just a few hours during the year. In some dry years, these channels might carry no water at all.

In recent history, the first cyclone event hit the study area in 1971-72 and was followed by several others. These cyclones supplied the streams in the area with runoff and underground water and eventually changed the physical features of the landscape, causing soil erosion over large areas to varying degrees, by dissecting new stream channels and gullies. The heavy rains caused some streams to broaden their channels or divert from their original courses as riverbed deposits obstruct the water flow and produce new stream valleys, as in areas of Xubeera, Bocooda, and Ceel-Doofaar. At Xubeera a new channel was formed that joins two sections of the togga Gebi (Gebi stream), which flows to the Daroor Valley downstream. "*Before the cyclone, the togga Gebi ended 10 km from Hadaaftimo, now it reaches Xubeera*" (Hadaaftimo). "*The cyclone destroyed a lot of land and increased erosion. The streams which were formed drain all the water with no water going to the lowlands*" (Badhan).

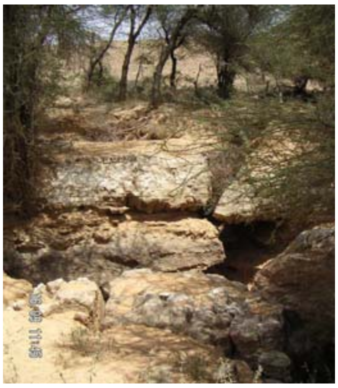
The Durdur river, created by the 1971/72 cyclone flows towards Ceel-Doofaar and many toggas have formed new small tributary channels. "*The flood plain of Cawsane is destroyed by floods from uplands. Many streams are expanding*" (Cawsane). *Every year, the grazing valleys are destroyed by the floods. There are new rivers and gullies and the water doesn't stay. It goes to the ocean*" (Ceel-Doofar).

Degraded prime grassland in Bocooda;
The new river Durdur, which was created by the
cyclone of 1971/72

The saturation of river-bank material with water and the steepening of slopes beyond the angle of repose create sufficient gravity to overcome inertia and triggers downward movement in various forms: slump, rockslide, debris flow and soil overwashing.

Another problem of water retention is manifested by the presence of sinkholes. Sinkholes are depressions formed in areas where soluble rocks have been removed by ground water. The dissolving action of ground water at surface depressions slowly removes rocks at sinkholes and also creates subterranean caverns. Limestone is most susceptible to this chemical weathering, because of its high calcium carbonate content. The rain water, which dissolves some carbon dioxide as it falls through the atmosphere (more is released by decaying organic matter), is a naturally weak carbonic acid that ionises to form the very reactive hydrogen (H^+) and produces soluble bicarbonate (HCO_3^-) of lime, which is then carried away.

Much of the water infiltrates rapidly into fractures, fissures, sinkholes and karstic depressions and then moves slowly underground into stream channels. Such sinkholes are found in both Auradu limestone and in the overlying Taleex formation. The formation of sinkholes occurs in different locations of the study area such as Mindigaale, Badhan and Xingalool.


Sinkhole in Mindigaale, the Gebi Valley


Xingdixiri sinkhole near Xingalool

3.3 Rate of Formation and Expansion of Gullies

"Land degradation began with the 1971-1972 cyclone. It destroyed the land and formed gullies on both sides of the settlements" (Mindigaale).

The 1971-1972 cyclone and other recent flood events created gullies with their great gravitational force. The gullies formed in these areas are reported to have been expanding since 1972 and were exacerbated by *El Nino* in 1997/1998 and then heavy rainfall in 2004. In most cases, soils examined in the most gully-afflicted areas have a low organic-matter content, low clay content, and a weak structure with consistency varying from very friable to friable; consequently when moist, they are more susceptible to being washed away.

3.4 Wind Erosion

In the study area, strong winds blow from the southwest to the northeast during the Xagaa dry season (Jun-Aug) and in Jiilaal (Dec-Feb) every year. Dust devils also frequently occur at this time. The average wind velocity (from measurements taken by Hunt in the 1950s and Agroclimatology, 1988) in the study area ranges from 40 to 75 km/h and thus the wind-erosion hazard is considerable. The moving air picks up loose debris and fine soil particles, mainly silt fractions, which remain in suspension, and transports them to other locations. These winds spread sediments over large areas, as well as high into the atmosphere and can often be seen from as far away as 70 miles (112.7km); perhaps further if they form a thick cloud of dust. Wind removes about 190-300 mt/ha of soil annually from denuded bare surfaces. Fine soil particles are commonly removed from the bare and overgrazed soil softened and pulverised by livestock trampling and from the numerous dry, unpaved country roads overrun by vehicles.

Signs of wind erosion's effects are observable in the Gebi Valley where drifting sands accumulate around shrubs and dry wood lying on the ground. As wind velocity falls, sand mounds are formed due to the obstruction posed by vegetation in its path. Sand mounds are very common in Xubeera. Dust also encrusts the plant leaves and reduces transpiration, causing them to dry out rapidly and thus reducing their palatability for animals.


Sand dunes covering Higlo trees in Hubera

Also, those interviewed reported that during the last prolonged drought, dust storms made it very difficult to see anything even at a short distance. Dust blown from the study area is believed to have reached and obscured the atmosphere as far away as Bosaso. This occurred because the major vegetation cover of the region, grasses and forbs, perished as a consequence of the drought making soils more prone to wind erosion.

Conclusions

All over the Gebi Valley and Sool Plateau there is extensive active gully erosion, although it is more pronounced in the recent alluvial plains of areas within the constituencies of Ceel-Doofaar, Sherbi, and Waaciye villages in the east along the tarmac road to Bosaso and all through the area stretching south of the Golis mountain escarpment from east to west Cawsane, Mindigaale, Raad-Laako, Badhan, Hadaaftimo to Yuube village and other parts of the central and southern part of Sool Plateau, around Ceel-Buh, Buraan, Carmaale, Wardheer (Dooxada Qol), and Dhahar.

The majority of active gullies are reported to have been formed following the 1971/72 cyclone, and since then many others have emerged after subsequent occurrences of heavy rain storms. Gully erosion is ongoing and has intensified over the years. By checking the source of runoff for each gully, it was observed that all of the gullies had been caused by excessive runoff from hills and undulating surfaces and over flooding rivers.

Erosion causes tremendous damage in the region. Every year, soils of the grazing valleys with prime grassland like Bocooda, Cawsane, Hadaaftimo, Yuube, Carmaale and Mindigaale are destroyed by floods; vegetation is devastated; plant nutrients are removed; soil texture is changed; structure deteriorates; the productive capacity of pasture is reduced; and land surface is dissected; valuable water resources flow away into the ocean and the sediments produced mostly end up in stream channels and in the Indian Ocean.

To date, large areas of the most fertile soils have been damaged by expanding gullies, relative to the total area of potentially productive alluvial plain rangelands, and despite wide dispersal throughout the region. These gullies have already sharply changed the landscape and damaged the local environment in terms of accessibility and land use for rangelands, farming and settlements.

Consequently, it is necessary to plan water-diversion drains and culvert outlets that can funnel water at non-erosive velocities to grazing lands.

Chapter 4: The Breakdown of Governance

Drought vulnerability has increased considerably in the Gebi Valley and Sool Plateau in part due to anthropogenic factors, especially overgrazing and commercial deforestation. After the presentation of a conceptual framework, this chapter will, based on interviews with pastoralists and field observations, analyse the effects of sedentarisation of pastoralists on land use and tenure, especially following the overthrow of the Siyad Barre government.

1. Conceptual Framework

Perspectives critical of the mainstream paradigms of modernisation can be termed "alternative development thinking." This study addresses the debate on one of these perspectives: pastoralists' management of their natural resources.

1.1. The Tragedy of the Commons

For many years, a vast body of literature depicted pastoralist production as economically irrational, and nomadic livestock management systems as environmentally destructive. The old orthodoxy (Lane and Swift, 1989) and the dominant approach in terms of pastoral development (Standford, 1983) described herders as individuals without economic rationale using harmful land-tenure methods. They were inspired by the famous "tragedy of the commons" theory developed by Hardin in 1968. The main principles of this theory, which greatly influenced policy-makers in Africa can be summarised thus:

- In pastoralist areas, herds are owned individually and trekking routes (parlours) belong to everybody and thus nobody
- The pastoralists suffer from "the cattle complex" (Herkovits, 1926) and irrationally accumulate herds for social and religious purposes rather than for economic purposes. Benefits accrue to the individual but all users assume the cost of over-grazing
- Pastoralists are not able to create their own management institutions
- Resource privatisation is necessary and should be imposed from the outside

Hardin's assumptions about free access land tenure regimes in pastoral areas were drawn from the "Theory of Games" and more specifically "The Prisoner Dilemma." According to these: *If two users in competition for the same common good have the choice between two strategies: conserve or degrade the resource, each of them will choose the latter assuming that if one of them conserves the resource, the other will cheat and use the caution of the other to maximise his own profits. In his study, he qualifies the second type of user as free riders* (Morehead and Lane, 1994).

In fact, Hardin confused the common-property regime, defined as a collective property, with a free-access regime in which common property is a *rest nullius* (a thing that does belong to anyone, a public property) and which he characterised, in the pastoral context, by the absence of rules regarding the use of the resource and the absence of institutions to enact sanctions and enforce them (Lane, 1996). This confusion legitimated the imposition of modern range management systems such as grazing blocks among the Somali of North-eastern Province in Kenya and in Northern Somalia (Helland, 1980, Unruh, 1996) and even privatisation of rangelands amongst the Maasai of Kajiado district of Kenya (Rutten, 1992).

This paradigm has been seriously questioned and is now recognised as an erroneous base on which to establish future development for pastoral areas (Moorehead and Lane, 1995, p 421). New approaches, the school of property rights (Benkhe, 1988) or the approach of the insurance problem (Bromley, Cernea, 1989), insist on building on customary resource-management institutions.

1.2 Customary Pastoral Land Use and Tenure

Since this shift, many recent studies have tried to understand pastoralists' customary land use and tenure systems, defined as collective rules governing land occupation and land distribution. In fact, these rules usually apply to a vast range of resources beyond the soil and the land alone, including surface water and systems of access to underground water (shallow wells, hand-dug wells and modern deep water points), fauna and herbaceous or ligneous vegetation, crops, minerals, and wild-gathered products (Thébault, 1995a).

Yet, few studies have pinpointed the crucial role of access to water in pastoral natural-resource management. For Danièle Kintz, any study of pastoralist land tenure should *consider water as much as land, as an important issue in the thought and the practice of the pastoralists* (Kintz, 1991). In fact, dry season herds can only access pastures located within a radius of permanent water points and thus the water point is not a wealth in itself but a means to access the true wealth that is pasture. This also means that water access management can regulate the influx of animals and control the rate of pasture depletion (Thébault, 1995b). This network of permanent water sources used in dry seasons represents a clear "land-tenure web" (*trame foncière*). Amongst transhumant pastoralists, Bourgeot identified specific transhumance patterns ("space economy") with seasonal movements of herds and flocks accompanied by herdsmen along more or less fixed trekking routes to wet-season grazing before returning to their sedentary base, where families live permanently in the dry seasons (Bourgeot, 1994).

The territories of pastoral communities are closely associated with their permanent water points. Thébault makes a distinction between the large "territories of transhumance" (wet grazing areas) and the more restricted "territories of anchorage" (dry grazing areas), which enclose strategic resources such as permanent wells and riverside grazing, and specific areas bearing palatable salty species. The resources found in dry grazing areas represent secure areas of withdrawal, and are subject to more defined access rights, which give priority to a restricted community and can even evolve toward individual appropriation (Thébault, 1995a). These dual pastoral territories are constituted by different types of groupings depending on the social organisation of each pastoral community. For example, Somalis practice patrilineal descent. However, the physical and social boundaries of these territorial groupings are flexible enough to adapt to climatic aridity as well as natural disasters such as droughts or floods.

1.3 Disruptive Factors

Even if these new analyses can be considered a step in the right direction, they often underestimate the adverse effects of modern water development on customary pastoral-resource management: Thébault observed that the *maitrises foncières*[5] of the herders was affected by the lack of recognition of the indigenous access rights and by the adverse effects of the modern pastoral hydraulic systems. In fact, the implementation of new water-tenure practices disrupted customary forms of grazing management: "*Because of their public access, cemented wells and fuel-driven boreholes have contributed to dismantlement of the space management tools of the pastoral communities*" (Thébault, 1995a and 1990). Daniele Kintz explains in more detail the changes brought about by modern water-tenure practices: *The appropriation (by drilling, sale or allocation of ground water is individual, for a family or for the use of a restricted group, especially in dry areas. Only the wells and boreholes drilled by outsiders (administrative services, NGOs for example) are not subject to any explicit allocation. However, this trend is changing. These wells and boreholes are now distributed by name to specific groups, in order to limit the influx of herds and over-grazing at the vicinity of these water sources* (Kintz, 1991).

[5] The concept of "maitrises foncières" has been developed within Le Roy's model of tenure relations. It is used in anthropology in an all-embracing sense, to describe all forms of appropriation, powers of management and social control over land, including customary or contractual forms and not only private ownership as recognised under the official laws (IIED Land Tenure Lexicon, 2000)

On the other hand, diversification into agriculture around new water infrastructure has also been associated with the physical enclosure of agricultural land and rangelands by a wealthy minority. When the self-perpetuating logic of enclosure gains momentum, even individuals who do not want to enclose are forced to do so to prevent others from expropriating all the communal land. The pastoralists also start to fence rangelands as reserved grazing areas to prevent agricultural encroachment and rangeland clearing (Behnke, 1988). The sharp increase in charcoal production due to urbanisation, overseas demand, and as a drought-coping strategy also contributes to palatable-tree deforestation and shrinking of rangelands (native grasses, forbs, shrubs and trees used for forage).

2. The Collapse of Range-management Systems

From the literature review it is clear that anthropogenic range degradation is linked to changes in settlement, grazing patterns and land use promoted by the introduction of new permanent water sources (boreholes, permanent wells) and water storage technologies (houses and underground berkeds).

*Historically, the plateau was used as a wet-season grazing area due to its low water table and lack of permanent water sources. However, the increasing number of livestock and people over the last decades has led to the proliferation of berkeds and an increase in water availability. The increasing population has clustered into villages where public agencies have drilled new boreholes to support additional people and animals. These developments and the proliferation of berkeds have converted the Sool Plateau into a year- round grazing area and attracted a relatively higher concentration of livestock, mainly camels and shoats (*FSAU Food Security Report, September 2002).

*Historically, the lack of permanent water on the Sool Plateau meant that it could only be used as a wet-season pasture area and pastoralists spent the dry seasons near the permanent water sources on the edge of the plateau, particularly in the Gebi, Daroor, and Nugaal valleys. Consequently, the regular migratory patterns tended to restrict grazing pressure on the plateau and allow pasture near to permanent water to recover during the rains to be utilised later in the dry seasons. The advent of permanent water in the form of boreholes and berkeds changed the use pattern of the plateau dramatically. Instead of regular migration off and on the plateau, pastoralists were now able to stay throughout the year, and people were able to settle and create villages around water sources. The result of this, in combination with increased human and livestock population generally, has been the typical overgrazing pattern seen throughout Somali*a. (IAA, 2003).

2.1. Water Development and Settlements

In Sanaag region, the areas of influence of the three main Warsangeli communities encompassed different ecological zones used as seasonal grazing areas: Guban coastal areas; the Al Madow (Golis) and Karkar Mountains; and the Gebi Valley and the Sool Plateau (including Xadeed). Guban and Al-Madow/Karkar were used for dry-season grazing and the Gebi Valley and the Sool Plateau for wet-season grazing. However, according to local communities, prior to colonialism, the Gebi Valley used to be a reserved grazing area:

"*We had a traditional technique for range conservation. For centuries, the sultans of the Warsangeli used to protect the grasslands of the Gebi Valley. They were reserved grazing (seere) to preserve grazing for dry seasons and droughts. In Gu, when the rains came, we used to go and graze in Sool Plateau (Ogo and Xadeed) first to allow the grass of the Gebi Valley to grow and then come to the plains in the Gebi Valley. The British and the Somali governments maintained the system, which collapsed after the fall of Siyad Barre*" (Hadaaftimo).

"*In the old days, we had law and order. We, the Warsangeli, used to go far away from the Gebi Valley and from the permanent water sources (springs*[6]*, permanent wells and Laaso in riverbeds*[7]*) in rainy seasons and come back in dry seasons. The rule changed. The government of Somalia reduced the power of the Sultan, allowed permanent settlement for political reasons and drilled boreholes in the Sool Plateau*" (Ceel-Buh).

"*The Sool Plateau near Sarmaanyo was a thick waterless woodland, good for grazing and drought resistant. There were a lot of antelopes. Dhulbahante people use to migrate here from their permanent water points in the Nugaal Valley*"[8] (Sarmaanyo).

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[6] Badhan (Gebi Valley), Buran (Karkar), Qarajele (Karkar)

[7] Warat, Got Rabobe, Bihin, Magebakarcho, Gabargeli, Labax Hadile, Buuk, Ceel Haralay, Ceel Cad,, Dudimo, Lasso Ingiye, Qohable, Buglore, Mingifa, Yalomaha, Rubadle, Afyer, Mindigale, Dudur, Domo, Lasso Edad, Togo Ror, Biyo Arare, Ebafure, Ceel Lahaley, Gardabaris, Sibayo for Warsangeli

[8] Kalacat, Haran, Lasso Urban, Lasso daworo, Talex and Dobogley springs in the Nugal Valley

Old spring in Badhan

Laaso in Dudh River, Mindigaale equipped by Johanitor in 1994 and rehabilitated by Horn Relief (2002).

Even though the British and the Somali governments both tried to maintain the traditional seere system, they also promoted permanent settlement both in the Gebi Valley (Yuube) and in the Sool Plateau (Carmaale, Ceel-Buh, Dhahar, Baraagaha-qol), mainly by providing engine-driven boreholes (100-250m) and permanent wells**.**

During the colonial period, four main settlements existed in the study area: Buraan in Sool Plateau; and Ceel-Doofaar, Xubeera, and Hadaaftimo in the Gebi Valley. The Somali government created four settlements in the Gebi Valley: Badhan[9], Mindigaale, Raad-Laako and Yuube; and at least 12 settlements in the Sool Plateau and Xadeed: Carmaale, Ceel-Buh, Alxamdulillah, Waaciye, Sherbi, Baraagaha-qol, Sarmaanyo, Shimbiraale, Sibaayo, Damala-Xagarre and Xingalool.

After independence, many boreholes were drilled by the central government to ensure political support from the local communities. In order to minimise overgrazing around the new settlements, the national authorities enforced new range-management systems. For example in Ceel-Buh, pastoralists were instructed to follow a new rotational grazing system: "W*e used to supervise and control rangeland. We had a rotational grazing system. The road from Ceel-Buh to Xingalool was divided into two grazing areas. The pastoralists used to graze on one side and, after the rains they moved to the other side*" (Ceel-Buh).

Since the collapse of the government in 1991, settlement construction has been proceeding in a haphazard manner in the study area. Before the most-recent drought (2000-2004), at least six new villages were created in Sool Plateau North and South, Bali Busle 1 (1992-1993) and Bali Busle 2 (1995), Qoyan (1994), Gooran (1997), Jiingadda (1999), Awrboogays (1995), Mindhicir (1997) and Habar Shire (1999). In the Gebi Valley, there are at least three new settlements: Carmo, (1995), Raad (1998) and Cawsane 1 (1998). Pastoralists clearly wish to remain near the pastures. Some communities such as the Warlable established Mindhicir to have a separate permanent anchorage on the Sool Plateau. However, the major reason for the establishment of these settlements is that they offer new opportunities for charcoal burning as a source of income. The elders of Bali Busle told us that the settlement was created in 1992-1993 specifically for charcoal export.

This pattern of uncontrolled settlement continued during the drought as a coping strategy. For example, the village of Wardheer was established in 2002 by destitute people and pastoralists who remained with small herds and wished to stay close to the pastures. They rely on nine underground berkeds; another 15 are under construction. Sweet water is trucked from Xingalool, Baraagaha-qol and Damala-Xagarre berkeds. Hard water is trucked from Xingalool borehole. (see annex 5**).**

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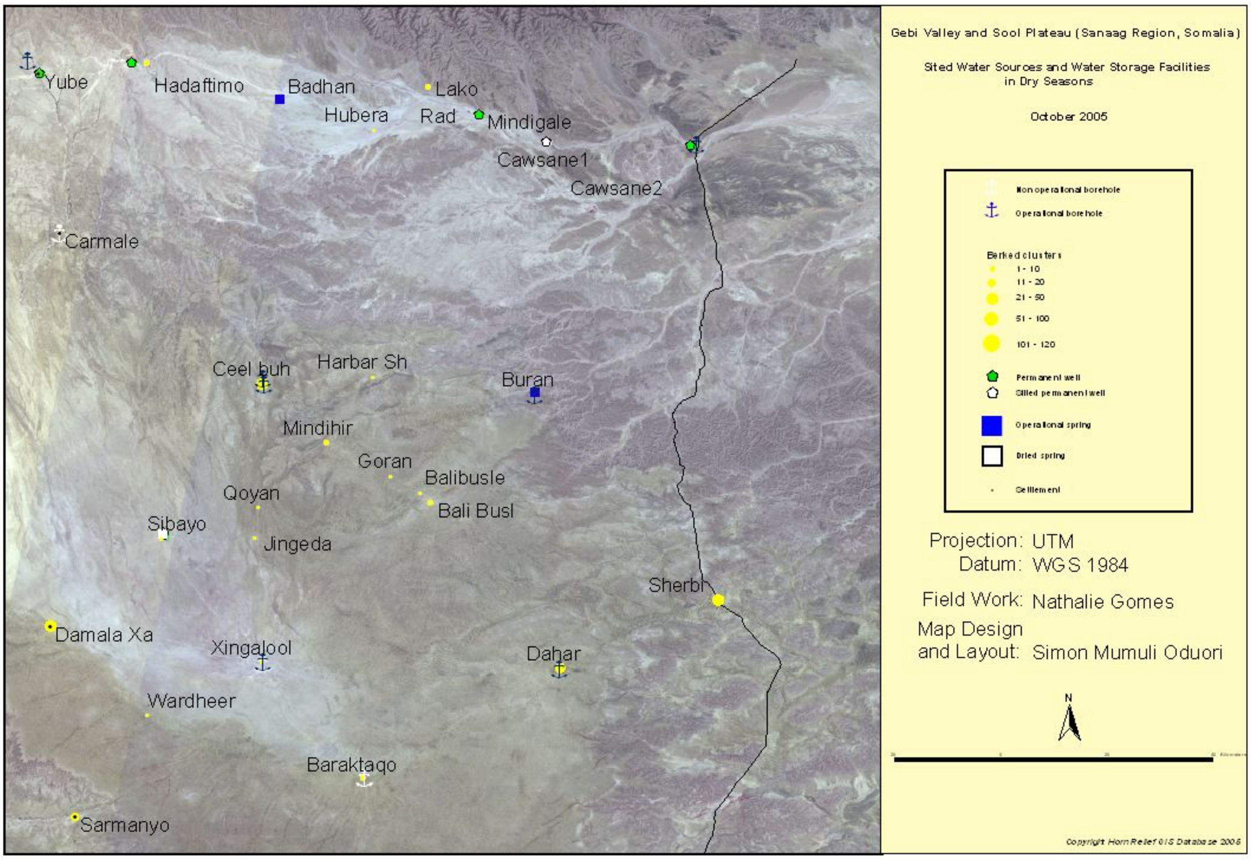
[9] Badhan was created after the 1971-1972 cyclones destroyed the settlement of Xubeera. Xubeera was the residence of sultan Mohamud Ali Shire from 1925 to 1971.

Carmaale: created in 1962 following the drilling of a borehole (Sool Plateau North)

Wardheer: created in 2002 by destitutes (Sool Plateau South)

All post-1991 permanent settlements on the Sool Plateau, except Awrboogays, rely entirely on private underground or house berkeds and/or direct water trucking both for domestic and livestock consumption. Reservoirs, generally lined with waterproof masonry walls, and berkeds have been constructed to harvest runoff and rain water. The average capacity of underground berkeds assessed in the study area is 320 m^3. Meant as a seasonal water supply, berkeds have been converted into permanent water storage tanks earmarked both for human and animal consumption. This development is associated with the introduction of water trucking. Filled with water from permanent water sources (springs and boreholes), the berked can now function almost perennially and allows permanent settlement in waterless areas such as the Sool Plateau (see annex 5).



In the study area, underground private berkeds appeared in the 1960s in Sherbi, Baraagaha-qol, Dhahar and Ceel-Buh. They are very expensive to build and only a small minority can afford them.

Survey results indicate that on the Sool Plateau, an average of only 2.2% of households are equipped with underground berkeds. The pastoralists typically build berkeds themselves with income from livestock sales. Newer ones, with a capacity of 216m^3, and which cost $4500, have been constructed with loans or funds from the diaspora. International NGOS such as COOPI and MPA have also provided berkeds in Sibaayo, Damala-Xagarre (Xadeed) and Sarmaanyo (Sool Plateau).

Oldest berked in the study area, located in Sherbi; dug in 1961 and covered with grass thatching

New-model berked with iron roof, constructed by COOPI in Sibaayo

House berkeds began to appear in the 1980s and are only used for domestic consumption of sweet water. However, an average of only 5.4% of households in the Sool Plateau are equipped with house berkeds, which are also expensive: a 64m^3 house berked costs $1000.

Oldest house berked in Carmaale, constructed in 1983

In all the settlements visited, a large number of berkeds were under construction and the current number of berkeds is expected to double in a few years. However, in some locations, berkeds are unfeasible. Due to the soil composition (soft gypsum) in many locations, a large number of berkeds suffer from cracks (Sherbi, Xingalool, Sarmaanyo, and Bali-Busle).

2.2. Overgrazing and Waste Pollution

Due to the disruption of traditional grazing patterns and range-management institutions, the vicinities of all permanent settlements suffer from overgrazing, especially those equipped with boreholes (Carmaale, Ceel-Buh, Xingalool, and Dhahar) or numerous wells (Sibaayo).

"*The nomads come in dry seasons around the borehole and it affects the grassland*" (Xingalool).

"*Since the borehole failed (2003), the pastures are better. Carmaale does not attract the pastoralists anymore*" (Carmaale).

"The borehole and also the berkeds have attracted a lot of pastoralists and damaged pastures around Dhahar. We are afraid of massive migrations because of the recent good rains but we can't avoid them. It is our culture. If our area had drought, we would go to their area" (Dhahar).

"*The proliferation of berkeds increases livestock and population and destroys the surrounding vegetation. But thirst comes first because you can die in a short time*" (Damala-Xagarre).

At the same time, all the permanent settlements suffer from waste pollution, which affects livestock and water quality of the surface water sources. During the last prolonged drought, livestock deaths were linked to ingestion of plastic bags disposed around villages. Waste pollution also affected the water quality of the berkeds located inside the settlements. Women's groups are theoretically in charge of waste disposal but enforcement capacity is low: "*We know that many animals died ingesting plastic bags during the last drought. Our group URMUD was involved in garbage collection but it is difficult to force peopl*e" (Ceel-Buh).

"I *dug the first berked in Damala-Xagarre. Now, there is a lot of pollution with the garbage and it even affects the water quality of the berkeds located near the settlement*" (Damala-Xagarre).

Berked in Damala-Xagarre showing pollution with garbage.

3. The Spread of Range Enclosures

The other major change in land use came as a result of communal land appropriation. In Hadaaftimo, Yuube and Carmaale, the British allocated farmland with certificates. In the district of Cerigaabo, the Somali government also encouraged pastoralists to settle and practice rain-fed farming after the 1974 drought. In 1975, the Ministry of Agriculture gave every household a registered concession of 0.4 ha of land. Sorghum and maize were produced but this strategy foundered when the rains started to fail: "*One rain in 10 years only gives enough water for farming"* (Yuube). These farms are mainly used by extended family as reserved grazing, for commercial grass harvesting or cultivation.

Observation revealed recent illegal enclosures on communal rangeland for:

- Grass harvesting: "*Range enclosures for grass harvesting on communal land started after the long drought, when people started to look for alternatives. There are 30 in Raad and around 20 in Laako of variable size*" (Raad-Laako).

- Small-scale farming in Hadaaftimo, Yuube, Mindigaale, Ceel-Doofaar, Damala-Xagarre and Dhahar: "*We had 47 farms from the British and now there are 93. Forty-six have been appropriated since the collapse of the government"* (Hadaaftimo).
  "*We have 100 wells irrigating 100 farms. People just took the land in 1997*" (Ceel-Doofaar).
  "*We have small farms. Land is communal, we divided the land but it is experimental. It is not really individual property. So far, the areas we planted are small and there is no conflict*" (Damala-Xagarre).

Grassland concession near Yuube

Harvested grassland in an illegal private enclosure in Laako

4. Anthropogenic Deforestation and De-vegetation

Forage shortages during the last prolonged drought have been attributed to the high concentration of herds in reduced rangelands due to deforestation of palatable trees for charcoal production: *The death rate among camels is on average 75%. The main cause has been shortage of fodder due to large-scale commercial production of charcoal, requiring cutting of Galool trees (**Acacia bussei**) (IAA, October 2003).*

*The effect of the mass clear cutting of trees and bushes for charcoal is rapid deforestation, soil erosion and encroachment of desert in areas that were traditionally vital rangelands. Due to charcoal burning, trees that camels normally feed on have been greatly reduced. 70% of **Acacia bussei,** the species of Acacia camels prefer and depend on for fodder have already been lost (*Horn Relief, Sanaag Drought Assessment Report, June / July 2003).

Grass harvesting is also a major environmental issue, especially in the Gebi Valley: "We *used to live in two very productive flood plains: Xubeera and Raad. The flood plains are damaged by tree cutting and grass harvesting. We are responsible. Beside natural factors, we are not sparing anything. We have destroyed everything*" (Raad).

4.1. Deforestation

*Until the late 1950s, it appears that the production of wood fuel and charcoal had little noted impact on the environment. This changed in the 1960s when the increasing growth of populations in urban areas such as Mogadishu and the accompanying demand for energy, combined with charcoal exports**,** meant deforestation was occurring at an alarming rate (FSAU, monthly report, June 2003).*

Between 1969 and 1991, the Somali government banned charcoal exportation. During this regime, power chain saws were prohibited in Somalia (IRIN News, October, 2000).

With the collapse of the government, charcoal production and burning recommenced at ever more alarming rates (FSAU, monthly report, June 2003).

"Since the collapse of the Siyad Barre government, intense charcoal production has taken place, in particular in Eastern Sanaag, due to lack of employment opportunities, and as a coping mechanism during times of drought and hardship. 85% of the available acacia forests may have been cleared for charcoal exportation. After wiping out the acacia forests in the Sool Plateau and Gebi Valley, charcoal producers are now clearing forests in the coastal and mountain areas [Al Madow] (IIA, 2003).

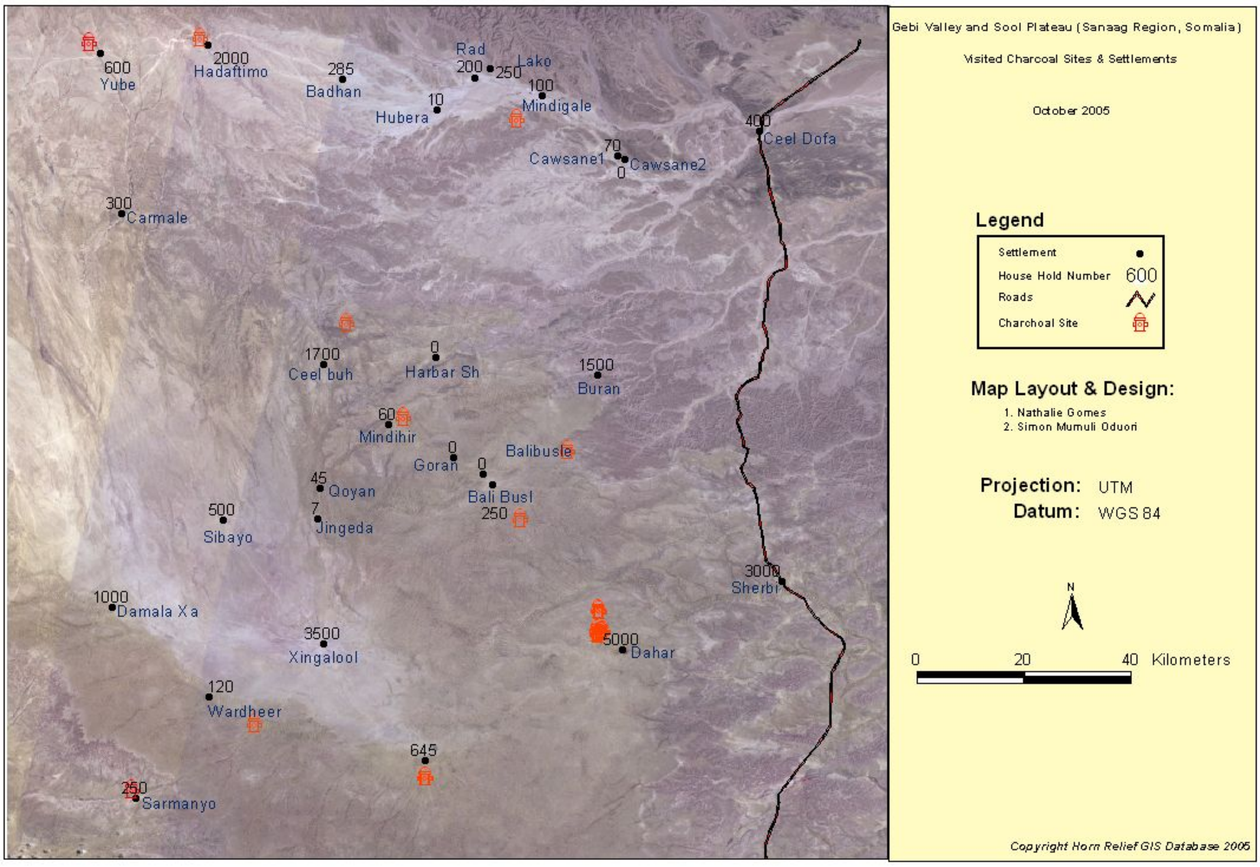
Pastoralists interviewed confirmed that local communities formerly never cut or burned live trees: *Large tracts of Galool were found dead in some areas and it was suggested that these trees had died of old age* (Hunt, 1951).

Galool (***Acacia bussei***) were debarked to make woven mats, water vessels and ropes. Gob (***Ziziphus Mauritania***) were debarked for animal feed. Dead Jiic (***Acacia seya/baccarini***) wood was used for hut construction; Meygaag (***Boscia Miniimifolia***) were used to make livestock enclosures; and Qurac (***Acacia tortillas***) was used as firewood and in making charcoal. Following concessioning of rangeland in Hadaaftimo and Yuube, people began to build huts and enclosures with stones.

Meygaag, used in Gooran for hut construction

Damal debarked in Yuube for animal feed

During the colonial and post-independence periods, charcoal production was limited and controlled by the National Range Management office. Licences were only available to cooperatives under the *Noolay Charcoal Association (*NCA) and producers were only permitted to burn dead trees.



In the majority of the settlements visited, the charcoal industry began to spread among local communities in 1991, after the fall of the government, due to the lack of law and order, and as a new and lucrative source of livelihood fed by the demand for exports to Gulf States via the newly created port of Bosaso. According to Linkenback, 80% of post-1991 charcoal production in Somalia was exported (Linkenback, 2001). In Buraan, elders spoke of greedy traders and truck-owners that sell items to locals and then load their empty trucks to ferry charcoal away from the settlements.

*The Sool Plateau used to be densely covered in **Acacia bussei**; which is, significantly, the best tree species for charcoal production. Consequently large-scale commercial exploitation of charcoal took place on the Sool Plateau with businessmen bringing gangs of youths from other areas to cut and burn trees for export out of Bosaso. The port authority banned charcoal exports in 1998 and has continued to implement the ban in all areas of production. Charcoal production, however, continues to supply local markets in Bosaso, Cerigaabo, Garoowe and Gaalkacyo, and some informants suggest that the supply goes even further south. What is clear is that the original dense cover has been severely depleted and the port and local community bans have to some extent slowed down the process. The fact remains, however, that for households who are currently without other income sources, charcoal production is their only means of survival. There have been no programmes for reforestation of the area to replenish the tree cove*r (IIA, 2003).

In the study area, charcoal burning decreased considerably after the 1998 export ban initiated by the Puntland administration but rose again during the drought as an alternative source of livelihood for destitute pastoralists and unemployed youth. Between 1992 and 2000, the village of Bali Busle exported 100 trucks of charcoal per day; since 2000 this has fallen to ten a day. In Mindhicir charcoal production began with the drought. Previously, the village exported ten trucks a day and now this is only one. It has been estimated that wood fuel provides 92% of domestic energy in Somalia (Inglis, 2002). In Buraan, elders mentioned that current charcoal production does not meet the demand of the main regional urban centres where it is sold: Bosaso, Gaalkacyo, Laascaanood, Garoowe, Cerigaabo, Qardho, Ceelaayo and Galdogob**.**

Elders estimated that more than 1200 trucks of charcoal are still produced in the study area and exported every month to feed the local market, which is equivalent to approximately 400,000 trees cut a month. A truck contains on average 200 bags; one 50kg bag of charcoal is equivalent to 1.6 live trees (NOVIB, 2004). The villages that currently export massive quantities of charcoal for national consumption are: Dhahar, Baraagaha-qol and Wardheer located on the Sool Plateau. Dhahar exports 20 trucks a day and Baraagaha-qol exports 10. In fact, in Sarmaanyo, elders reported 50 active charcoal sites around the settlement. If the average production per site is 50 bags, then by the team's calculation: 20 settlements x 50 sites per settlement area x 50 bags per month x 1.6 live trees = 80,000 trees cut every month, a slightly more credible figure.

Charcoal prices

Region	Area	Export centre	Selling Price/ 50kg	Reselling price/ 50kg
Sool Plateau	Dhahar	Qardho	40 000SShs ($2.70)	NA
	Xingalool	Bosaso and Laascaanood	40 000SShs ($2.70)	NA
	Ceel-Buh	Laascaanood, Bosaso	$ 2.67USD/50 kg	$ 6 USD/50 Kg
	B-Qol	Bosaso, Garoowe, Qardho and Laascaanood	$ 2.67 USD/50 kg	$ 6.67 USD/50kg
	Carmaale	Bosaso	$ 2.67 USD/50 Kg	$ 6.67 USD/50 kg

Source: Horn Relief, 2005

The tree species most affected by charcoal production is Galool (***Acacia bussei***), which is also the prime source of forage for camels. With the ongoing depletion of Galool, charcoal burners turned to other species (Qurac, Bilcil, Meygaag in Sarmaanyo), Damal (Mindigaale, Raad), Gob (Raad) Sosog/Yuube (Buraan, Wardheer, Hadaaftimo, Yuube), Mara (Hadaaftimo), Higlo (Sherbi, Sarmaanyo). Duur grass (***Anthropogon Kelleri***), known for its water-retention properties, is also affected because it is used to cover charcoal kilns. In the grasslands of Xadeed, due to tree shortages, women began to cut prime palatable perennial forage such as Baskalax shrub for firewood.

Charcoal site near Ceel-Buh 80mx80m of Galool forest cleared, 29/09/2005 (Sool Plateau)

Baskalax (Xadeed)

The common tree-harvesting techniques observed during fieldwork do not differ much from the ones described below:

*Typical charcoal production techniques follow a monthly rotational cycle of approximately ten days cutting and drying of trees, five days tending the kiln, and five days cooling and bagging of charcoal. A typical producer will make 45 bags of charcoal (25 kg per bag). Approximately 16 mid-sized Acacia trees of between three to four metres produce 30 bags of charcoal. One truck carries a load of 200 bags and the price is much higher during the rainy season than in the dry season. A bag of charcoal in 2000 cost about 35,000 Somali Shillings (about $3-$4) and sold for $10 in the Gulf States. One ship holds about 70,000 to 100,000 bags and takes about two months to fill. It is estimated that one shipload of 100,000 bags is equivalent to more than 100,000 trees cut. (*Biemah, 2005)

Another report offers further detail:

"*The common harvesting methods observed were either to set fire at the base of the tree or cut it 40 cm above ground level. This method of harvesting trees for charcoal makes it impossible for trees to regenerate in clusters, as a large part of the tree is unutilised. We witnessed about 2km south-west of Bali-Ahmed Village, one charcoal burner digging up and producing charcoal using the remnants of stumps left over from previous charcoal production. In areas where most of trees have been depleted (Caraweelo, Jab-dhurwaa and, Masaajidka), charcoal producers frequently reuse the stumps for charcoal production. When 13 charcoal producers were asked whether they prefer live trees in relation to quantity or quality of its charcoal, they responded that if dry wood were available, they would never burn live trees because dry wood is more productive.* (NOVIB, 2004)

With regard to charcoal production techniques, two types of kilns were observed in the study area:

- Pit/trench kilns
- surface mound kilns

Pit kilns are typically used in montane areas whereas surface mound kilns are used where there is enough soil to cover them.

Despite variations in the size of pit kilns, they are generally 1.30m deep, 1.70m wide and 2.60m long. Before wood is placed in the pit, it is cut into stumps of about 1m in length to minimise air penetration. Wood is arranged horizontally with open space left at the centre of the pit. This space is filled with a combustible material such as Duur grass so that fire spreads effectively through the pit during burning. Afterward, three or four iron bars or another strong metal a little longer than the pit are laid across it so that sheets can be arranged on top.

The output of a medium pit kiln is 10 sacks per production. Two to three days are needed to dig the pit, another day to place the wood in the pit, one day to burn and one day to cool.

Surface mound kilns are designed to resemble traditional Somali houses, with a strong pole erected at the centre and other poles of 1m in length positioned around the centre pole, covered by soil and sheets on top.

Both types of kilns need to be closely supervised during the carbonation process to prevent charcoal being burned to ash. With pit kilns, it is necessary to reduce air access during strong winds, and the reverse when there is little wind. With surface mound kilns it is important to open air inlets when the upper part collapses.

During the study, an analysis was made to determine the number of live and dead trees respectively, of equal diameter required to produce 200 sacks of charcoal. The result: 20-donkey cartloads of dead trees or 100 trees, and 25 donkey cartloads of live trees or 125 trees, are needed to produce this amount. Dry wood is also more quickly processed into charcoal than live trees.

	HARVESTING PERIOD	***COLLECTION***	***BURNING***	***COOLING***	***PREPARATION***	***PERIOD TO PRODUCE 200 SACKS***
LIVE TREES	***30 DAYS***	***6 DAYS***	***6 DAYS***	***12 DAYS***	***1 DAY***	***55 DAYS***
DEAD TREES WHERE ABUNDANT	***15 DAYS***	***2 DAYS***	***2 DAYS***	***2 DAYS***	***2 DAYS***	***23 DAYS***
DEAD TREES WHERE SCARCE	***30 DAYS***	***15 DAYS***	***6 DAYS***	***6 DAYS***	***3 DAYS***	***60 DAYS***

Other than the type of tree used (i.e. live or dead) for charcoal production, other factors that influence the amount of time needed for charcoal production are: labour, tools, mode of transportation, quantity and diameter of trees accessible.

4.2. Grass Harvesting

In the majority of settlements visited, grass harvesting began in 1991 as a result of the increased demand for livestock forage to be exported from the port of Bosaso. Before the last drought, in the Gebi Valley, the main producing villages were Hadaaftimo and Badhan. On the Sool Plateau, production was centred in Carmaale, Ceel-Buh, Mindhicir, Bali Busle, Sarmaanyo and Sherbi. In Sarmaanyo, grass harvesting was only practiced from 1993-1995. In Mindhicir, grass harvesting was only practiced in 1996-1997. In Bali Busle, between 1990 and 2000, 30 to 40 trucks of grass (Dureemo and Sifaar) were exported per month to Bosaso and Ceelaayo. In Badhan, a 6-tonne truckload of grass sold for two million Somali shillings.

Grass harvesting sharply increased after the last prolonged drought due to two exceptionally good rainy seasons (Deyr 2004 and Gu 2005), and actually spread to new locations, such as Raad-Lako and Buraan. In Buraan the destitute targeted ***Chrysopogon aucheri*** (Dureemo) and *Sporobolus spp* (Sifaar) for export to Bosaso. However, the market soon collapsed on the Sool Plateau, especially in Ceel-Buh and Bali Busle, due to traders' preference for ***Cynodon Dactylon*** (Domar) and Siidal grass species, which are more widely available in the Gebi Valley.

Grass harvesting is practiced in open rangeland but also in both legal enclosures (Hadaaftimo, Yuube, Carmaale, and Badhan) and illegal enclosures (Hadaaftimo, Yuube, Carmaale, Raad-Lako and Badhan).

In Hadaaftimo, Yuube and Carmaale, grass harvesting is practiced on land concessions: "My *farm was given to my grandfather by the British. In dry seasons, I let the animals graze inside but not all the people are like this. I grow Xul and Domar. I have 6 hectares; I inherited four hectares and added two. I harvest at the end of Gu and at the end of Deyr. I produced 12 trucks of grass last Gu. Each truckload was sold for $500. They sent them from Bosaso or we rent them from Hadaaftimo. We have to share the benefits among eight families"* (Hadaaftimo).

The most widely used species for grass harvesting are ***Echinocholoa colona*** (Doomaar Madow), **Digitaria Scalarum** (Doomaar Cad/Xul), ***Paspalidium desertorum*** (Gargaro), ***Sporobolus Arabicus*** (Sifaar) and Siidal

Grass harvesting in Raad-Lako (Gebi Valley)

5. Damage Caused by the Proliferation of Road Networks

In Ceel-Buh, Hadaaftimo, Bali-Busle and Sarmaanyo environmental degradation has been linked to increased road traffic, especially for water trucking and charcoal transportation: "Hundreds *of trucks pass through Bali Busle every night. They created roads, which destroy the vegetation and increase wind erosion. They also create rills that capture water from the run-off*" (Bali Busle).

Conclusions

The ongoing build up of settlements disrupts range management systems and induces overgrazing and waste pollution, which in turn affects livestock and surface water sources. Enclosures are shrinking communal rangeland to the benefit of only a minority. Deforestation and grass harvesting have reduced vegetation cover, especially of palatable plants.

Chapter 5: Conservation and Rehabilitation Initiatives

Following the collapse of Somali traditional authority (sultans and councils of elders) and in the absence of a national government, environmental conservation and rehabilitation initiatives in the study area have been limited. However, recent initiatives, both by local communities and Horn Relief, have had a positive impact.

1. Community Initiatives

The main focus of initiatives undertaken by local communities, especially elders, is stopping charcoal burning and grass harvesting within their own localities. In many settlements, villagers have also carried out small-scale reforestation. Some villages also are engaged in small water-conservation activities.

Community Policing of Deforestation

Local communities are well aware of the adverse effects of deforestation (lack of shade, lack of forage, lack of firewood, reduced land cover, formation of gullies and wind erosion). Elders have discouraged villagers from destroying common property for commercial purposes and have tried, with very limited success, to organise patrols.

Policing and Regulating Charcoal Burning

In almost all the settlements visited, the elders tried to stop charcoal burning and export by the local residents. In some villages, especially in the Gebi Valley, these efforts seem to have been quite successful: "*We started charcoal burning in 1991 but we stopped after the drought, in May 2004. We had a meeting between the different communities and we decided to stop cutting trees for export*" (Cawsane).

"*We started producing with the drought but we reduced charcoal burning. Now it is only for domestic consumption and not for export" (Badhan).*

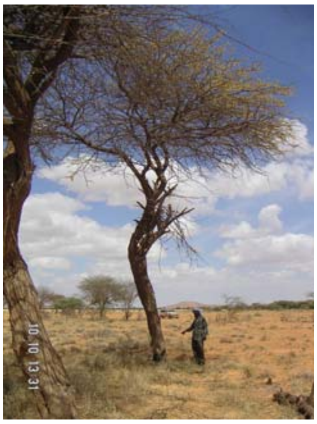
"*Since we established the settlement, we, the elders, prohibited charcoal burning*" (Damala-Xagarre).

In several villages, the elders organised patrols, made arrests and meted out punishments: "*The Puntland government banned charcoal export, but in our area —we are between Puntland and Somaliland—nobody has control. We, the civilians, rule our places with customary law. Charcoal burning started in 1991 but we decided to punish those found cutting or burning trees*" (Raad-Laako).

"*Since 1991, taxes are collected from the villagers for the payment of a local patrol. In 2001, an attempt to burn our protected Galool forest, near the town, was stopped. This Galool forest has been protected since 1991*" (Sherbi).

"*Charcoal burning was banned by the elders in 2003. In 2003, people were caught burning trees and arrested. Their animals were seized. Since then nobody has tried"* (Ceel-Doofar).

Since the last rains (Gu 2005), anyone found cutting trees is arrested and punished" (Mindhicir)



Protected Galool tree targeted by burners in 2001 in Sherbi (Sool Plateau)

Destroyed kiln near Sherbi (Sool Plateau)

However, in many villages, the coercive powers of elders and patrols with respect to the destitute, especially youth, is limited:
"*Whenever, we contact the destitute, they say, that is OK, we realised that trees are important but we have children to sustain, can you provide us with an alternative source of livelihood*?" (Ceel-Buh).

In Buraan, elders tried to prevent 150 unemployed young men from burning charcoal. However, they could not find an alternative livelihood for them and so some returned to charcoal burning. Elders led a regionwide effort to stop charcoal burning on several settlements of the Sool Plateau. Buraan, Mindhicir, Bali-Busle and Habra-Shire agreed to stop both charcoal burning and grass harvesting but Mindhicir contravened the pact. A delegation was sent from Buraan to Dhahar because Buraan truckers participated in charcoal transportation from Dhahar. However, the truckers were not receptive. The people of Baraagaha-qol also continue to burn charcoal; they have cleared their area of trees and moved on to Bali-Busle.

"*We try to intervene but we have no resources. We stop them and they come back. Some villages refused to honour the agreement we made in 2003 (Dhahar, Baraagaha-qol and Kaladhaca) and when they cleared their area of trees, they came here*" (Bali-Busle).

"*We have 600 young men involved in charcoal burning. They don't have jobs. We had an agreement with Buraan to stop burning charcoal but we could not honour it. We have no alternative, no project, and no assistance*" (Baraagaha-qol).

"*There are conflicts when the elders go and talk to the young charcoal burners. Trucks are destroyed and people die. They tell you give me an alternative. There are no farms, nothing except livestock production and many destitute people*" (Dhahar).

"*There are conflicts between the charcoal burners and the pastoralists*" (Mindhicir).

Galool logs ready for charcoal burning near Dhahar (Sool Plateau North)

Active charcoal burning site in Mindigaale (Gebi Valley)

Additionally, elders and local patrols are frequently powerless in the face of organised and armed groups of outsiders.

"*In 2002, we had a meeting to reduce charcoal burning but they burn in hiding. Sometimes you have to drive for 10 km to find them, but it's not possible"* (Mindigaale).

"*We managed to stop local residents from burning charcoal in 2004 but outsiders come with armed guards and we do not have any resources to keep organised patrols*" (Wardheer)

"*Before the government collapsed, we had patrols to control illegal tree cuttings. Community policing is difficult. They do it at night, in the bush and sometimes it is very dangerous. For example, four years ago, some people tried to burn charcoal. They were stopped by force and one truck driver was killed between Mindhicir and Ceel-Buh*" (Ceel-Buh).

"*There are more than 50 charcoal sites guarded by armed guards in the area and it is not possible to intervene (Sarmaanyo).*

"Before 2003, we tried to stop charcoal production but Puntland officers have guns but no cars and no fuel to patrol and no salary" (Sarmaanyo).

Control and regulation of charcoal transportation on the main roads is non-existent. In Sherbi, while the team discussed charcoal burning, deforestation and community initiatives, a charcoal truck was seen parked in the middle of the village.

Controlling Grass Harvesting

In several locations, elders managed to stop grass harvesting as soon as it started: with the good rains of November 2004 (Buraan, Sibaayo, Ceel-Doofar, and Mindhicir). In Cawsane, over the last five years, attempts have been made to enclose rangeland for grass harvesting but elders consistently opposed such efforts: They are captured and given a warning. In many areas, such as Hadaaftimo, grass harvesting is a source of conflict with pastoralists.

Burning heap of harvested grass in Hadaaftimo

1.1 Small-scale Homestead Tree-planting

In several settlements (Mindigaale and Bali-Busle), villagers began planting trees at the main roads, mainly fruit and Somali gum trees, which are a new source of income.

Lime tree In Bali-Busle (Sool Plateau North)

Also noted was an increase in oasis farming, with irrigation from different water sources: springs in Buraan; wells in Ceel-Doofar and Mindigaale: and berkeds in Hadaaftimo, Damala-Xagarre, Dhahar and Sherbi.

Buraan spring irrigates 150 small plots with palm trees (Timir) imported by the British from Saudi Arabia, lime trees and vegetables (Sool Plateau North)

One of the 100 private mechanised wells in Ceel-Doofar irrigating one of 100 private farms growing palm trees (Timir), Somali gum trees (Moxor), lime trees, guava trees, cotton trees and vegetables. It was dug in 1993 on communal rangeland in the Gebi Valley by a returnee from Jowhar (1973-1974 drought)

Berked irrigating a farm with lime trees, cotton trees, guava trees and Somali gum trees (Moxor) in Hadaaftimo (the Gebi Valley)

However, concerns have been raised about the use of water for irrigation when available drinking water is scarce, and because it is well known that irrigation significantly reduces the water levels of aquifers. Therefore it is important to mitigate this with water retention and detention structures to recharge aquifers.

In some villages of the Sool Plateau, enclosures for farming on communal rangelands are either prohibited (Cawsane, Xingalool) or constitute a source of conflict between pastoralists: "*In 2002, camels belonging to a pastoralist entered a private enclosure in Hadaaftimo and two persons were killed. Blood price of 240 camels was paid*" (Hadaaftimo).

Lastly, in several settlements of the Gebi Valley and the Sool Plateau, large quantities of grasshoppers and crickets were observed destroying both trees and grassland (Ceel-Buh, Bali-Busle, Xingalool and Wardheer, Mindigaale): *"The number of Jiriqaa (crickets) and Kabajaan (grasshoppers) is increasing. I planted two trees recently and they were eaten" (Wardheer).*

"We have a problem with grasshoppers breeding in Qumbucul, Qoolo and Dawli. They damage farms and pastures" (Mindigaale).

1.2 Soil Conservation

In Yuube, and Bali-Busle, elders mentioned that formerly, rock, stone, and sand embankments were used to divert water and these allowed the regeneration of vegetation in the flood plains. However, the only settlement that has recently tried to undertake some form of soil conservation and water harvesting is Sibaayo in Xadeed. The community plugged a sinkhole located near the wells with stones.

2. Horn Relief's Commitment to Environmental Health

In an effort to promote sustainable livelihoods in the Sanaag region, Horn Relief has closely monitored long-term factors related to food security and pastoral livelihoods throughout more than ten years of operation in the area. This has included monitoring indicators such as the state of the environment (particularly coastal areas and rangelands), water supply, animal health, access to markets, and the level of purchasing power among pastoralists.

2.1 The Emergency Relief and Drought Vulnerability Reduction Programme (ERDVR)

Horn Relief's close relationship with pastoralist communities enabled the agency to sound the alarm about an impending humanitarian emergency. FSAU has also, over the years, been highlighting the region's deteriorating food and livelihood security conditions. Horn Relief called for an assessment to gauge the level of humanitarian need in the Sanaag and Sool regions of northern Somalia. An OCHA-led interagency assessment was subsequently undertaken in October 2003, and it documented a humanitarian situation of crisis proportions. The assessment teams identified Sanaag as the most affected region, with a vulnerable population of 190,455 people.

OCHA recommended an immediate, concerted and coordinated response from the international community in order to avert a full-scale disaster. Following on these recommendations, international organisations and UN agencies including WFP, UNICEF, Horn Relief and VSF extended and increased interventions in Sanaag through distribution of food, water and provision of non-food items. Horn Relief chose a cash-based response due to the specific nature of the emergency, and in recognition of the need to empower the beneficiaries and enable them to meet their prioritised needs.

The Emergency Relief and Drought Vulnerability Reduction (ERDVR) Programme in Sanaag implemented by Horn Relief utilised a cash component, namely a cash-for-work initiative to meet the humanitarian needs of the target population and to encourage them to undertake longer-term environmental rehabilitation activities as part of a solution to the emergency.

Summary of Micro-Projects

The following table summarises the micro-projects undertaken by Horn Relief and its partners during the first phase of the Emergency Relief Drought and Vulnerability Reduction Programme.

Site	Intervention/Activity	Cumulative Length/Meters	Impacts
Wardheer	Circular soil bund Straight soil and stone bunds (diversion from road) Protected soil bunds/alternating	6600 2756 6880	Water diverted/detained/retained, improved infiltration/water conserved, vegetation regenerated, soil sediment deposition
Baragaha Qol	Soil bunds across old roads Stone protected soil bunds. Protected soil bunds	4870 1028 16860	Water diverted/detained/retained, improved infiltration/water conserved, vegetation regenerated, soil sediment

	alternating/rock dams Planting of tree seedlings	1009 2504	deposition, Improved drainage (sanitation)
Dhahar	Soil bunds Rock dams Drop structures/gabion Stone protected soil bunds Planting of tree seedlings	350 2400 4 1000 2518	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture; Improved drainage of village
Xingalool	Soil bunds Protected soil bunds Planting of tree seedlings	100 10681 2230	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture; Improved drainage/road network in the village
Ceel-Buh	Soil bunds Rock dams Check dams Protected soil bunds Stone protected soil bunds alternating with spillway rock dams Planting of tree seedlings	2280 3500 410 2254 260 2000	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture
Awsane	Rock dams Check dams	3500 825	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture
Mindigale	Soil bunds Rock dams Check dams Protected soil bunds Planting of tree seedlings	106 2140 294 66 1700	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture
Badhan	Soil bunds Soil/Rock dams Rock dams Protected soil bunds Stone protected soil bunds alternating with spillway rock dams circular soil bunds Planting of tree seedlings seedling pits	4764 5773 2790 2670 950 100 3000 2490 2005	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of soil/sediments/plant/grass seeds; regeneration of vegetation/pasture
Hadaaftimo	Rock dams Check dams Protected soil bunds Gabion Diversion canal Planting of tree seedlings	546 83 1065 64 90 1700	Water diversion/detention/retention, improved infiltration/water conserved, vegetation regenerated
Carmaale	Soil bunds Rock dams Check dams	3000 1500 100	Reduced erosion/advance of gully head; prevention of further gully, rill and sheet erosion; evidence of gully healing; Deposition of

			soil/sediments/plant/grass seeds; regeneration of vegetation/pasture

Where gullies have not formed, land degradation and further erosion was prevented by protective measures such as increasing the absorption capacity of the soil, protecting the land surface with vegetative cover and by diverting excess surface runoff from the watershed at a lower velocity through properly designed and maintained waterways. Focus was placed on diverting water away from the eroded area to adjacent rangelands as well as on safely disposing of excess water.

ERDVR was implemented over an eight-month period, and thus was not intended to deliver a full-scale solution to the problem. However, it is has achieved valuable and concrete results in terms of soil-erosion control and water conservation. Nonetheless, it is strongly recommended that similar programmes be undertaken and expanded in scale due to the vast and ongoing nature of the problem.

During the survey undertaken in late 2005 in the Gebi Valley and Sool Plateau, the team observed numerous structures that had been constructed in the ten aforementioned villages as part of ERDVR for the conservation and rehabilitation of rangelands.

Horn Relief also supports two tree nurseries run by community-based organisations in Ceel Buh and Badhan. The organisation has, additionally, introduced highly efficient solar cookers to Sanaag and Bari regions, which, once scaled up, hold great promise in curbing demand for charcoal, particularly in urban areas where charcoal demand is highest.

Check dam with gabion wire being put in place (Hadaftimo Gully)

Rock dam after the rains detaining rain water and improving vegetation regeneration (Awsane Valley)

Circular soil bunds near Damala-Xagarre (Xadeed denuded grassland)

Soil embankment around Xingdixiri sinkhole, near Xingalool, (Xadeed)

Sanaag Student Association Tree Nursery in Ceel-Buh
(Sool Plateau, 29/09/2005)

Conclusions

Local communities are attempting to control the charcoal trade and grass harvesting with limited resources and success. Settlers are also initiating small-scale homestead reforestation with potentially lucrative tree species (lime, guava, cotton, Somali gum). However, the associated need to build range enclosures is a source of conflict. Also, invasion by crickets and grasshoppers poses a real threat to new livelihoods.

At the same time, Horn Relief has successfully implemented rangeland rehabilitation/restoration solutions. The simple technology and techniques utilised by the ERDVR have shown great success and should be replicated in more areas. CARE and a local partner have have also done some small scale envieronmental works, including enclosures around sinkholes in Hingalool. However, some of these, along with a few structures from the ERDVR, have already been destroyed or damaged from the heavy rains. There is a need for improvement of the construction of some structures through use of external material, such as gabion wires, to strengthen the structures. Furthermore, there remains a demand for similar construction over a more extensive area, including Yuube, Bocooda, and Carmaale.

Overall Conclusions

Major Environmental Issues

From the current assessment, it is evident that the main environmental problem of the Gebi Valley and Sool Plateau is the recent drought, which affected the prime livelihood of the local communities: transhumant pastoralism. The consequences of the drought have been devastating. Lack of rainfall reduced vegetation cover and biodiversity of the land. Interpretation of satellite images confirms the loss of land and vegetation cover. As a consequence there has been great loss of livestock from starvation or water stress (more than 80%), migration to urban centres or camps, and tremendous suffering and loss of human life from starvation and malnutrition. Many palatable vegetation species that dried out during the prolonged drought have not fully regenerated despite the two good rainy seasons (Gu 2005 and Deyr 2004) that followed.

However, other factors both natural and anthropogenic have exacerbated drought vulnerability in recent decades. Firstly, In the Gebi Valley and Sool Plateau, the flood events (1971-1972 cyclones, *El Niño* and cyclone floods in 1997-1998 and heavy rains in 2004) have had tremendous impact on the landform, structure, soil and vegetation. The most serious consequence of this has been gully damage, but also soils and vegetation has been destroyed; plant nutrients have been removed; soil texture has been negatively changed, resulting in reduced capacity of the land to produce pasture. In some floodplains there is a proliferation of unpalatable plant species (e.g. Aftoxolle), or of plants with little economic value (Keligii noole) in areas where nutritious pasture once grew. Further, de-vegetation is conducive to wind erosion.

Simultaneously, a breakdown in both customary and modern governance induced drastic changes in land uses, which affected the environment. The range-management systems of the past collapsed with the progressive creation of numerous, scattered permanent settlements, especially in the Sool Plateau and Xadeed. This process was exacerbated by the creation of permanent water sources (boreholes) and by the local construction of new water storage facilities (berkeds), water trucking and increased transport routes. This in turn contributed to overgrazing and led to waste pollution, which affects livestock by degrading the quality of surface water sources. The concessioning of land and land-grabbing processes have also contributed to the shrinking of communal rangeland and overgrazing, especially in the Gebi Valley.

Since the collapse of the government and the advent of the last prolonged drought, pastoralists have engaged in alternative economic activities, the charcoal trade and grass harvesting, which endanger the environment and their traditional source of livelihood (pastoralism). In the study area, anecdotal evidence suggests that more than 1200 trucks of charcoal are produced and exported every month to feed the local market, equivalent to approximately 400,000 trees cut a month, but research indicates the number to be nearer 80,000 a month, which is still of tremendous concern.

The use of palatable Duur grass to cover charcoal kilns is an attendant problem that reduces forage, decreases water retention and diminishes soil protection from erosion on the Sool Plateau. Grass harvesting is associated with illegal enclosure of rangelands, which comes at the expense of the majority of the pastoralists.

The proliferation of crickets and grasshoppers (***Gryllidae*** and ***Acrididae***) and the ensuing damage to pasture is another threat on the Sool Plateau and Xadeed, following two consecutive seasons of good rainfall (Deyr 2004 and Gu 2005).

There is also a lack of village and settlement planning. Consequently, little or no protection measures are incorporated to separate areas for building houses from areas for the water reservoirs. Increasing waste pollution affects the water quality of the spring, wells and berkeds, which is also a major concern.

Environmental Awareness and Community Initiatives

In all settlements visited, the level of local environmental awareness was found to be extremely high, especially regarding anthropogenic factors such as the collapse of range-management systems and institutions, the rise of charcoal burning and grass harvesting. In the Gebi Valley and the Sool Plateau, charcoal burning is cited as the major environmental issue by 80% of villagers, more damaging even than natural disasters. The main environmental conservation and rehabilitation initiatives being undertaken by communities relate to controlling or preventing charcoal burning and grass harvesting, typically through community policing. Due to a variety of constraints these efforts enjoy mixed results at best, and require considerable support.

Natural disasters, such as drought and flood and particularly the impact of these on livelihoods have been classified as the second most serious environmental issue and threat. Preparedness, however, is very low and initiatives to minimise the consequences of these are financially or practicably unfeasible for local communities.

Government and NGO Initiatives

The two governments that claim jurisdiction over the studied area have sought to implement limited environmental conservation and rehabilitation initiatives, the best known and most efficient being Puntland's 1998 ban on charcoal export. In September 2001, the Transitional National Government (TNG), through its Ministry of Livestock issued a directive banning all charcoal export from Somalia. Foreign ships coming to Somalia to take on charcoal were warned that "they risk arrest, fire or both if they are caught." Enforcement of a complete charcoal ban would depend on the ability of various Somali authorities to cooperate and set up an effective justice system. The TNG's ban was ignored by charcoal traders. One Mogadishu charcoal buyer observed: "*The government isn't creating jobs. I am not listening to them*" (IRIN News, May, 2003). Similar initiatives have been launched in Puntland: *Recognising the negative impacts on the environment, the Puntland administration has recently banned the export of charcoal to the Gulf Sates and the Somaliland administration is considering new regulations to put an end to charcoal production in the North West (FSAU, Monthly report, June 2003).*

Horn Relief is the only development agency involved in long-term practical environmental conservation and rehabilitation activities in the study area, although there have been small scale activities initiated by the local community and other agencies such as CARE. Horn Relief undertook the ERDVR micro-projects initiative in 2003 to repair gullies and restore denuded land, at the same time providing pay and work to local communities hard hit economically by the drought. Horn Relief has also undertaken anti-charcoal campaigns and has introduced solar cooker technology to the areas.

Recommendations

Reducing Drought Vulnerability

1. Restock pastoralists with pack camels to allow them to recover economically and to allow migration to areas with good pasture and adequate water

2. Restore the practice of reserved grazing lands and/or apply modern rotational grazing systems to allow regeneration of vegetation

3. Support initiatives to increase water retention and soil conservation:

    - Engage qualified environmental experts and extension workers to lead community workers to design and plan soil-conservation structures so as to avoid sub-standard activities being carried out in the future

    - Emphasise maintenance and re-enforcement of old structures, especially the rebuilding of broken rock dams, check dams, cut off drains, soil bunds and gabions buried by sediment

    - Build new rock dams and sand embankments on the flood plains, around gullies and sinkholes

    - Rehabilitate both big and small gullies. Rehabilitating the latter is cheaper and easier

    - Efforts should be made to increase water harvesting to improve production and protection of the rangelands, and not vice versa.

4. Combat commercial deforestation and illegal de-vegetation and promote reforestation.

    - Develop campaigns to ban the trade in charcoal both internationllay and locally

    - Provide sustainable alternative livelihoods to the destitute and others involved in the charcoal trade

    - Provide alternative sources of energy to charcoal (e.g. solar) in major towns, where there is high fuel demand for cooking, which in fact motivates many unemployed young men to enter the charcoal burning trade for income generation

    - Establish range patrols and road checkpoints through community policing

    - Create more tree nurseries and distribute seedlings to villages and encourage planting around homesteads, berkeds and grazing land for shade, wind break, fruit and forage

5. Monitor water availability and quality for human and livestock use

6. Monitor and evaluate the durability of soil-conservation structures

Drought Preparedness

1. Strengthen mechanisms for forecasting drought and floods

- Rehabilitate rainfall stations, and install rain gauges with support from FEWS-NET and SWALIM
- Redefine FSAU livelihood zones according to landforms and indigenous environmental classifications and improve indicators (e.g. rainfall data analysis and baseline data on range conditions)
- Establish frequent and more regular drought surveillance mechanisms to monitor changes and trends, using this study as a baseline

2. Promote consensus on interregional migration

Further Studies to be Undertaken

1. Undertake land-cover mapping using most current data as land-cover changes can occur rapidly

2. Undertake a more detailed assessment of gullies, particularly to measure rate and size of expansion

3. Undertake a hydro-geological survey to assess the sustainability of oasis farming as an alternative livelihood and to expand current rehabilitation initiatives

4. Research work should be integrated into future field studies to provide more comprehensive understanding about the nature of the soil environment in order to strengthen present efforts and stabilise the environment over the next 30 years

5. Conduct a study of grasshoppers and crickets and their long term implications for the environment

6. Conduct a study on fishing in coastal areas as an alternative livelihood

7. Undertake more-detailed baseline studies on vegetation to facilitate monitoring of change over time

Annexes

Annex 1: Questionnaire

HORN RELIEF'S ENVIRONMENTAL DEGRADATION AND REHABILITATION ASSESSMENT STUDY IN THE GEBI VALLEY AND SOOL PLATEAU AREAS OF NORTHERN SOMALIA

This instrument will be used to gather data on environmental change in Gebi Valley, Sool Plateau in Bari, Sool and Sanaag regions of Northern Somalia.

Instructions
Before administering the questionnaire, please complete the screener below.

SCREENER

Date………………………………………………………………..................

Interviewer's name…………………………………………

Region………………………………………………………………...............

District………………………………………………………………

Livelihood zone……………………………………………

Village/Site…………………………………………………………...

Date of permanent settlement (Village) ………………

Reason for settlement……………………………………

Estimated population (Village):

Number of persons……………………………
Number households…………………………

Clan, lineage……………………………………

Key informant / focus group……………………………

Location coordinates:

Y……………………………………………………………

X……………………………………………………………

Part 1: Environmental Degradation and Resource Conservation: Qualitative questions

Environmental Degradation/drought/desertification – Issues, threats, effects, coping strategies	Indicative Evidence/Source
1. What are the major environmental degradation problems in this area? 2. Are these problems stratified according to slope, aridity zones, soil types, and elevation? 3. What are the major causes of environmental degradation in this area? Droughts 4. Are drought events predictable? 5. If yes, what are the strategies adopted before the drought to minimise the impact of the expected drought? 6. When were severe droughts experienced in these areas and over what periods? 7. What has been the recent impact of drought on the environment and the people? 8. What are the main coping strategies currently used by pastoralists from the various wealth groups? 9. What are the other steps taken after the drought to reduce its effects? Charcoal production 10. Is charcoal harvesting practiced in the area? 11. When did charcoal production start in the area? 12. Which are the main species harvested? Are dead or live trees cut? 13. Where are the main sites? 14. What is the impact of charcoal production on the environment? 15. What are the expected future trends in charcoal production and marketing? Grass harvesting 16. Is grass harvesting practiced in the area? 17. When did grass harvesting start in the area? 18. Which are the main species harvested? 19. Which are the main markets? Rangeland degradation	Focus groups with local village leaders Focus groups with pastoralists, especially around boreholes and trading centres Focus groups with local authorities Secondary data Key informant interviews with livestock traders

20. Where do herds move in dry seasons? Where are they watered? 21. Where do herds move in wet seasons? 22. What is the condition of the surrounding main grazing areas? 23. What are the causes of range degradation? (Droughts, overstocking, congestion around water points, deforestation, land enclosures?) 24. What permanent watering points are used in the area? 25. How are these points distributed in the area? 26. Could these points have contributed to range degradation? 27. Is range enclosure practiced? Since when? By who? Why? Awareness 28. Is the community aware about the effects of climatic changes (especially rainfall variability and distribution) on your environment and livelihoods? 29. Is the community aware of the effects of deforestation on their environment? 30. What are the emerging threats to pastoralism in Northern Somalia? 31. If the community was challenged to propose alternatives to pastoralism, what would you recommend? Are these alternatives sustainable? Rehabilitation initiatives 32. What are some of the common traditional resource-conservation techniques in northern Somalia? Have these techniques been effectively sustained in the area? 33. What resource-conservation techniques have been introduced in the areas of Northern Somalia? Who is supporting these activities? 34. Are these techniques appropriate, effective and sustainable? Have these techniques improved soil and vegetation productivity in affected areas? Conflicts 35. What conflicts occur over natural-resource management and use in the area? 36. What are the processes in place for conflict resolution?	

PART 2: Environmental information: Quantitative questions

Palatable trees

		Palatability (high, medium, low)								
Botanical name	Local name	Camels		Goats		Cattle		Sheep		Species decline since 1940-1950 (0-10)
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	

Palatable shrubs

		Palatability (high, medium, low)								
Botanical name	Local name	Camels		Goats		Cattle		Sheep		Species decline since 1940-1950 (0-10)
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	

Palatable grasses

		Palatability (high, medium, low)								
Botanical name	Local name	Camels		Goats		Cattle		Sheep		Species decline since 1940-1950 (0-10)
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	

PART 3: Socio-economic information: quantitative questions

Camels in Household
Tick only one item

	2000		2005	
High (+70)	3			
Medium (40-70)	2			
Low (-40)	1			
None	0			

Cattle in Household
Tick only one item

	2000		2005	
High (+20)	3			
Medium (10-20)	2			
Low (-10)	1			
None	0			

Shoats in Household
Tick only one item

	2000		2005	
High (+200)	3			
Medium (70-200)	2			
Low (-70)	1			
None	0			

Donkeys in Household
Tick only one item

	2000		2005	
High (+5)	3			
Medium (2-5)	2			
Low (-2)	1			
None	0			

Charcoal production
Tick only one item

High (+10 truck a month)	3	
Medium (5-10 trucks a month)	2	
Low (_5 trucks a month)	1	
None	0	

Grass harvesting production
Tick only one item

High (+10 truck a month)	3	
Medium (5-10 trucks a month)	2	
Low (_5 trucks a month)	1	
None	0	

Annex 2: Drought Trends in Local Memory

Drought (orange) ***Rainfall*** (green)

[redacted]

Zone	village	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
	Ced Dafar	Sign Case								Durba										
	Caware																			
	Miligale																			
	Ral Lako																			
	Balhal Ibera	Sign Case																		
Gebi Valley	Hadftim															Adde				
	Yule						Daba Dheyr													
	Sherti	Augst																		
	Buan																			
	Dlair	Sign Case													Adde					
	Babusle	Sign Case						Daysare								GariGari Sar				
	Ced Buh																			
sool 1	Midhir																			
	Camale	Adde						Daba Dheyr												
	Xnglool	Sign Case																		
	Sbayo															Adde				
Xadeed	Danala Xagere																			
	Badtaq	Sign Case			Wajixum											Adde				
	Wadleer	Sign Case																		
sool 2	Samayo																			

[redacted]

Zone	Village	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Ced Dafar		Dufan			Gari Gari Sar											Glungud			
	Caware		Dufan								QoraMabbe							Glungud		
	Miligale					DabalDeyr					QoraMabbe				Adde		Glungud			
	Ral Lako																			
	Balhal Ibera		Dufan			DabalDeyr										Glungud				
	Hadftim		Dufan																	
Gebi Valley	Yule					DabalDeyr										Caab Sare				
	Sherti	Gaarale																		
	Buan					DabalDeyr														
	Dlair				DabalDeyr											Glungud				
	Babusle	Watqaso				DabalDeyr		Matan				Glunguld			Adde					
	Ced Buh					Gagarale											Glungud			Adde
	Midhir					Geger					Qormaddabe									
sool 1	Camale					Caga							Adle					Glungud		
	Xnglool				Gazale									Glunguld						
	Sbayo					Gagarale														
Xadeed	Danale Xagere													Cari Gai Sar						
	Badtaq																			
	Wadleer				DabalDeyr															
Sool 2	Samayo					DabalDeyr														

	Village	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005			
	Ced Dafar								Jaweyn							Tsunami				
	Caware		Arbaca								Kala Ayto				Dulklat	Tsunami				
	Miligale									Kala Ayto						Tsunami				
	Ral Lako											Tur Aurto				Tsunami				
	Balhal Ibera					Difanley														
	Hadftim											Tur Aurto				Tsunami				
	Yule															Tsunami				
	Sherti															Tsunami				
	Buan											Tur Aurto								
	Dlair	Arbaca										Tukwaiyo Tukuat				Tsunami				
Tsunami	Babusle		Haba Cadi			Gogale						Tukwaiyo Tukuat								
	Ced Buh											Sansnti								
	Midhir	Abarca																		
	Camale													Shitarra						
	Xnglool																			
	Sbayo											Heriro								
	Danala Xagere		Abarca					Ghara Dher				Cla Damaa								
	Badtaq							Ditle				Cisma								
	Wadleer									Tukwaiyo Tukuat						Tsunami				
	Samayo											Tukwaiyo Tukuat								
	Hadftim														Tur Aurto					

Annex 3: Vegetation Decline Estimates

Botanical name	Local name	Camels		Goats		Cattle		Sheep		Location	Species decline (1940/50-2005)	Cause of decline
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet			
Trees												
Acacia Bussei	<u>Galool</u>	H Flower	H Leaves	H	H	H	H	H	H	Mindigale	10-0	1971 cyclone, drought Charcoal since 1991
										Cawsane		
										Hubera		
										Raad-Lako		
										Hadaaftimo	10-3	Drought and charcoal
										Yuube	10-2	Charcoal
										Bali Busle	10-1	Drought and charcoal
										Buran	10-1	Charcoal
										Carmale	10-4	Drought, charcoal
										Ceel-Buh	10-2	Drought, charcoal
										Mindihir	10-0.5	Charcoal
										Sherbi	10-2.5	Drought, charcoal
										Wardheer	10-1	Drought, charcoal
										Sarmanyo	10-1	Charcoal
										Damala-Xagare	10-5	Charcoal
Acacia Tortillis or Acacia Raaddiana	<u>Qurac</u>	M Fruit	M Leaves	M	M Leave	M Fruit	M Leave	M Fruit	M Leave	Ceel Dofar	10-3	Drought
										Mindigale	10-7	Fencing
										Cawsane	10-2	
										Hubera	10-1	
										Hadaaftimo	10-1	Cyclone and lack of water diverted by new river Gebi
										Yuube	10-100	Before used for fencing but now burning
										Bali Busle	10-9	
										Buran	10-30	Drought, used for fencing
										Carmale	10-5	
										Ceel-Buh	10-5	Drought
										Mindihir	10-6	
										Sherbi	10-10	Drought, charcoal
										Wardheer	10-2	Charcoal
										Sarmanyo	10-1	Fencing
										Sibayo	10-1	Not cut for charcoal
										Damala Xagare	increased	
Acacia Mellifera	<u>Bilcil</u>	H	H	H	H					Bali Busle	10-8	Drought
										Buran	10-20	
										Ceel-Buh	10-2	Cut for wood
										Sarmanyo	10-5	Charcoal burning
										Damala Xagare	10-9	
Acacia Seya/baccarini	Jiic	H	H	H	H					Bali Busle	10-4	Construction
										Buran	10-1	Construction
										Ceel-Buh	10-1	Construction
										Sherbi	10-5	Construction
										Wardheer	10-2	Construction
										Sarmanyo	10-10	
										Damala Xagare	10-1	Construction
Moringa Oleifera	<u>Damal</u>	H Fruit	H Leaves	H Fruit	H Leaves					Ceel Dofar	10-3	Drought
										Mindigale	10-50	Increase in number after Galool depletion
										Causane	10-3	
										Hubera	10-2	Lack water, only remains near river
										Raad-Lako	10-100	
										Yuube	10-10	
										Bali Busle	10-10	
										Sherbi	10-10	
										Wardheer	10-3	
												Drought and animal fencing
Boscia Minimifolia	Meygaag <u>Picture cut for construction Goran</u>	H	H	H	H					Mindigale	10-8	Use building nomadic house
										Cawsane	10-1	
										Raad-Lako	10-15	
										Bali Busle	10-8	Construction
										Carmale	10-2	Construction
										Sherbi	10-1	Construction
										Wardheer	Reduced	Construction
										Sarmanyo	Reduced	Charcoal burning
										Damala Xagare	10-2	Construction
	Sarmaan		H		H					Cawsane	10-4	
Salvadora persica	Cadey	H	H			H				Ceel Dofar	10-7	Sold Bosaso, tooth brush
										Cawsane	10-0	
Ziziphus Mauritania or spinachristi	<u>Gob</u>	H		H		H		H		Ceel Dofar	10-7	Uprooted by floods
										Cawsane	10-1	Human consumption
										Raad-Laako	10-1	Washed away by cyclone
										Hadaaftimo	10-1	Cut for animal, destroyed by
										Buran	10-4	cyclone
										Sherbi	10-5	Cut for animals
												Floods, cut to feed animals
Cadaba Herterotricha	<u>Higlo</u>	H	H	H						Ceel Dofar	10-0	Drought, water diversion,
										Mindigale	10-5	overgrazing
										Cawsane	10-4	
										Hubera	10-3	
										Raad-Lako	10-10	Lack of water Cyclone?
										Carmale	10-2	
												Drought, overgrazing, only
										Sherbi	10-4	green plant during dry seasons
										Sarmanyo	Reduced	Charcoal cover and
										Sibayo	10-1	overgrazing
										Damala Xagare		Charcoal burning
												Drought, wind, overgrazing
												Drought, overgrazed and covered with sand dunes
Juniperus Procera	Dayib									Al-Madow	10-3	Timber since 1991
	Duke	H		H						Raad-Lako	10-12	
Acacia Ebtaica	Sosog/yuube	H		H						Hadaaftimo	10-4	Charcoal and fencing
										Yuube	10-10	Just start burning
										Buran	10-5	Charcoal
										Wardheer	10-2	Charcoal
Acacia Nilotica	Maraa	H	H	H						Hadaaftimo	10-5	Charcoal
										Wardheer	10-4	Drought
										Sarmnyo	10-10	
										Damala Xagare	10-10	
Tamarix Aphylla	Dhuur	H								Ceel Dofar	10-8	Construction of Huts
	Awo			H						Ceel Dofar	10-1	Construction huts, drought and floods
Phoenix Dactilifera	Timir									Buran	2-200	Imported by British from Saudi Arabia
Acacia edgeworthii	*Qansax*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*Sherbi*	*10-1*	*Cut to fence berked*

	Xamur		*H*		*H*					*Sherbi* *Sibayo*	*10-10* *1.1*	
	Daray									Sibayo	1.5	
	Dharkkayn									Sarmanyo		

Botanical name	**Somali Name**	**Camels**		**Goats**		**Cattle**		**Sheep**		**Location**	**Decline**	**Cause of Decline**
		Dry	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**			
Shrubs												
Cadaba Somalensis	Qalaangal	H		H				H	H	Ceel Dofar Mindigale Cawsame Hubera Hadaftimo Bali Busle Wardheer Sarmanyo Damala Xagare	10-1 10-8 10-0 10-4 10-1 10-10 10-3 10-1	Drought Cyclone, floods and drought Drought, overgrazing Charcoal burning Drought and overgrazing
	Baskalax	H	H	H	H	H	H	H	H	Carmale Sibayo Damala Hubera	10-1 10-1 Reduced 10-5	Drought, overgrazing **Drought and firewood** **Drought**
Grewia Tenax	Dhafaruur		H		H					Ceel Dofar	10-1	Drought
	Jafle		H		M					Raad-Lako Damala	10-20 10-6	 Drought
Chascanum Africana	Yubluluc		H		M					Cawsane Raad-Lako	10-7 10-30	
	Larlajis		H		M					Raad-Lako	10-20	
	Hiblola		H		H					Hadaftimo	10-1	
Cadaba Barbigera	Caanamacays	H	H	H	H					Hadaftimo Yuube	10-1 10-10	 Reduced by drought but regenerating
	Halamash		H		M					Raad-Lako	0-100	Intruder: Came after the cyclone1972 Dangerous for camels
	Surat		H		H					Yuube Bali Busle	10-10 10-10	Reduced by drought but regenerating
	Mirow		H		H					Yuube	10-10	
	Dhirindhir		H		H					Ceel Dofar Ceel-Buh Sherbi Wardheer Sarmanyp	10-5 10-3 10-7 10-4 10-2	Drought Drought Drought
	Gawllalo									Ceel Dofar Wardheer Sibayo Damala Xagare	10-1 10-4 10-2 10-1	Drought Drought Drought **Drought, and** **sand dunes**
	Garoon/Karoon		H		H					Ceel Dofar Bali Busle Carmale Sherbi Sarmanyo Damala Xagare	10-1 10-6 10-5 10-5 10-5 10-5	Drought Drought Drought, overgrazing Drought Drought Drought and overgrazing
Commiphora elenbechii	Didin		H		H					Ceel Dofar Sherbi Wardheer Damala Xagare	10-1 10-10 ? 10-1	Drought Drought, gum collection Drought and overgrazing
	Hamhama		H		H					Bali Busle Sarmanyo	10-6 10-5	Insect Charcoal
	Ilca Cade		H		H					Bali Busle	10-10	
	Lamayolo	H	H	H	H					Bali Busle	10-4	Construction
	Miro		H		H					Bali Busle	10-10	
	Hill		H		H					Carmale	10-4	Drought, overgrazing
Balanites orbicularis	Kulan	H								Carmale	10-3	Drought, overgrazing
	Balanti		H		H					Carmale	10-4	Drought, overgrazing
Lantana Microfilla	Ged xamar		H		H				H	Carmale Sibayo Damala	10-8 10-1 10-9	Drought, overgrazing Drought
Commiphera spp	Hagar-Cad		H		H					Sherbi Wardheer	10-4 10-3	Drought Drought
	Kabraro		H		H					Sherbi	10-2	Drought
Grewia Erytherea	Murcaanyo		H		H					Ceel Dofar Sherbi Wardheer Sibayo	10-1 10-5 10-6 10-1	Drought Drought
Grewia Tanix	Dhafaruur		H		H					Sherbi	10-3	Drought
Grewia Villose	Gomoshaa		H		H					Sherbi	10-1	Drought
	Muhude		H		H					Sherbi	10-2	Drought
	Madoya		H		H					Sherbi	10-4	Drought
	Muroho		H		H					Sherbi	10-1	Drought
Acacia	Cadaad		H		H					Sherbi	10-2	Drought
	Tabok									Wardheer Sarmanyo Damala Xagare	10-4 10-2 10-9	Drought
	Muqlo									Wardheer Sarmanyo	10-4 10-8	Drought
Pistacia Lentisucs	Xamur									Wardheer	10-2	Drought
Commphora Spp	Xagar									Sarmanyo Damala Xagare	10-8 10-9	
	Mirafur									Sarmanyo	10-8	Charcoal
	Guure									Sarmanyo	10-5	
	Jimbac									Sarmanyo	10-5	
	Bulumbirle									Sarmanyo	10-5	
Pistacia Lentisucs	*Xamur*									*Sarmanyo*	*10-5*	
Acacia Edgeworthii	*Qansax*									*Sarmanyo*	*10-5*	
	Dawa Haure	L		L		L		L		Sibayo	10-0	
	Dalol		H		H		H		H	Sibayo	10-1	
	Cali Bowye									Damala Xagare	10-10	

Botanical Name	Somali Name	Camels		Goats		Cattle		Sheep		Location	Decline	Cause of Decline
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet			
Grasses												
Limorum Spp	Daran	H		H		H		H		Cawsane	10-1	
										Raad-Lako	10-5	Eaten by outside migrants at end of rains Overgrazing/Drought
Anthropogon Kelleri	Duur	H	H	H	H	H	H	H	H	Cawsane	10-0	
										Bali Busle	10-6	Drought, overgrazing and charcoal
										Buran	10-10	
										Carmale	10-3	Drought, charcoal to cover kiln
										Mindihir	10.1	Drought, charcoal
										Sherbi	10-1	Drought, cover charcoal
										Wardheer	10-3	
										Sarmanyo	10-3	Drought and charcoal cover
										Sibayo	10-1	
										Damala	10-4	Drought and charcoal cover
Eragrostis Haraensis	Gubungub	H		H		H		H		Cawsane	10-0	
										Yuube	10-10	
										Bali Busle	10-3	Drought, overgrazing
										Buran	10-10	
										Carmale	10-0	Resistant to drought but finished by herds Last to survive drought but overgrazed
										Sherbi	10-1	
	Weyrax	H		H		H		H		Cawsane	10-0	
	Taaxug	H		H		H		H		Cawsane	10-0	
										Bali Busle	10-10	
										Sherbi	10-10	
Sporobolus spp	Duxi	H	H	H	H	H	H	H	H	Ceel Dofar	10-2	Drought
										Cawsane	10-0	
										Hubera	10-0	Drought
										Raad-Lako	10-10	
										Hadaftimo	10-9	
										Yuube	10-1	Drought
										Buran	10-10	
										Ceel-Buh	10-1	
										Sherbi	10-1	Drought
										Wardheer	10-0	
										Sarmanyo	10-2	Drought
										Damala	10-1	Drought
Chrysopogon Aucheri or melenis grandiflora	Dureemo	H	H	H	H	H	H	H	H	Ceel Dofar	10-2	Drought
										Mindigale	10-6	
										Cawsane	10-1	
										Raad-Lako	10-5	Cyclone and drought
										Hadaftimo	10-2	Drought, over-cutting, car tracks, cant grow with Qurac tree, which multiplied after cyclone 1971
										Yuube	10-10	
										Bali Busle	10-7	Drought
										Buran	10-10	
										Carmale	10-5	Drought, overgrazing
										Ceel-Buh	10-2	
										Mindihir	10-2	Drought
										Sherbi	10-3	Drought, cover charcoal
										Wardheer	10-3	
										Sarmanyo	10-3	Drought
										Siabyo	10-1	Drought
										Damala	10-1	
Paspalidium desertorum	Gargoro/ Cagagaro	H	H	H	H	H	H	H	H	Ceel Dofar	10-1	Drought
										Mindigale	10-2	
										Cawsane	10-7	Gulley
										Raad-Lako	10-2	Cyclone and overgrazing during drought Grass harvesting
										Sherbi	10-2	Drought, taken by gulley
										Sarmanyo	10-2	Drought
										Damala	10-5	Drought, overgrazing
Echinocholoa colona	Doomaar Madow									Ceel Dofar	10-2	Drought/floods
										Mindigale	10-6	Taken by floods, drought gullies Gully
										Cawsane	10-0	
										Raad-Lako	10-10	Harvested
										Hadaftimo	10-1	Destroyed by Gully, lack of soil Ok with land adjudication
										Yuube	10-10	Drought, overgrazing
										Carmale	10-4	
	Ul or Doomaar Cad	H	H	H	H	H	H	H	H	Mindigale	10-3	Taken by floods, drought, gullies Gully
										Cawsane	10-0	
										Hubera	10-0	Drought
										Raad-Lako	10-10	Harvested
										Hadaftimo	0-7	Came in 1987
										Yuube	10-10	
										Buran	10-10	
	Sifaar	H	H	H	H	H	H	H	H	Ceel Dofar	10-5	Drought and floods, also reduced in size
										Mindigale	10-5	Before tall grass now short
										Hubera	10-0	Drought
										Cawsane	10-0	
										HaHadaftimo	10-9	Increased with land adjudication
										Yuube	10-20	
										Bali Busle	10-7	Drought
										Buran	10-10	
										Ceel-Buh	10-2	
										Sherbi	10-1	Drought
										Wardheer	10-1	
										Sarmanyo	10-2	Drought
										Sibayo	10-1	
										Damala	10-1	Drought
	Siidal	H	H	H	H	H	H	H	H	Cawsane	10-0	
										Raad-Lako	10-5	Covered by sand dunes or encroached on by Gully since 1972 cyclone , Harvested

	Ramaas		H		H		H		H	Mindigale Hubera Hadaftimo Sarmanyo	10-3 10-0 10-10 10-9	Drought
	Aftoxolle									Mindigale Raad	0-?	Intruder non palatable
	Alamash									Yuble		Intruder from Ethiopia; came with locusts in 1950
	Cayo		H		H					Yuube	10-10	
	Hiil		H		H					Yuube Sibayo	10-10 10-1	Drought
	Badhanti	H	H				H	H	H	Yuube	10-30	
Dactylotenium Species	Saddexo	H		H		H		H		Hadaftimo Bali Busle	10-8 10-50	
	Xarfo									Bali Busle Buran Sherbi Sarmanyo	10-10 10-20 10-10 10-30	
	Sarin									Wardheer Damala	10-2 10-5	Drought
Dactylocetinium Scindicum	Saddexo									Sarmanyo	10-0	Drought
	Yamaarug									Damala	10-0	Drought
	Waniiq									Damala	10-1	Drought
Sericocomopsis	Food Cade									Damala	10-5	Drought
	Urxaad									Damala	10-5	Drought
	Geed Labeen									Damala	10-5	Drought
	Qoraya-Xaaris									Damala	10-5	Drought
	Dansaca Ure									Damala	10-5	Drought

Annex 4: Estimates of Livestock Losses

				Average size camels herd		Average size cattle herd		Average size shoat herd		Average size donkey herd	
ID	X	Y	Town/village	Before drought	After drought	Before drought	After drought	Before drought	After drought	Before drought	After drought
1	226134	1179256	Badhan-Hubera	60	10	40	0	300	60	3	1
2	260043	1170707	Cawsane1	50	1	40	1	200	45	0	0
3	245810	1181990	Mindigale	30	2	10	2	100	15	2	0
4	233295	1185338	Raad-Lako	70	6	50	2	500	35	2	0
5	183441	1191499	Hadaftimo	70	6	40	1	300	60	2	1
6	819596	1189649	Yuube	50	3	30	2	250	50	8	1
7	205026	1131536	Ceel-Buh	90	2	18	0	300	50	7	1
8	217083	1120425	Mindihir	100	6	15	0	400	50	0	1
9	256206	1129640	Buran	50	3	20	0	250	80	0	1
10	236565	1109102	Bali Busle2	55	3	20	1	200	75	5	0
11	824062	1159844	Carmale	70	2	30	0	200	50	5	1
12	204997	1079387	Xingalool								
13	186317	1102456	Sibayo	90	5	20	0	200	50	10	2
14	183631	1069370	Wardheer	80	1	20	0	200	30	20	2
15	823705	1086113	Damala Xagare	60	2	30	0	300	30	4	2
16	828859	1050364	Sarmanyo	80	2	20	0	200	40	5	2
17	224034	1057455	Baraktaqol	300	2	170	0	330	60	60	20
18	260920	1078158	Dahar	100	2	100	0	200	50	2	2
19	290756	1091000	Sherbi	75	11	60	0	200	40	3	0
20	286553	1175315	Ceel Dofar	100	5	0	0	200	60	3	1
			Average loss	79	4	37	1	242	44	7	2
				94.7% loss		**97.7% loss**		**81.8% loss**		**71.4% loss**	

Annex 5: Berked information

ID	X	Y	Village	House berkeds	Underground berkeds	Operational Underground berked	underground berked under construction	First constructed	Average capacity of underground berked in m^3
1	260043	1170707	Cawsane1	0	0	0	0	0	
2	245810	1181990	Mindigale	2	0	0	0	0	
3	233295	1185338	Raad	16	0	0	0		
4	236214	1187068	Lako	NA	14	14		1996	427,4
5	183441	1191499	Hadaftimo	300	12	11	NA	1975	540
6	819596	1189649	Yuube	NA	2	2	NA	1999	450
7	208500	1185043	Badhan	NA	0	0	0	0	
8	205026	1131536	Ceel-Buh	300	55	55	55	1968	345
9	217083	1120425	Mindihir	3	26	11	15	1997	81,4
10	256206	1129640	Buran	NA	0	0	0	0	
11	234800	1111150	Bali Busle 1	NA	3	1	2	1992	
12	236565	1109102	Bali Busle2	6	20	20	17	1996	186,6
13	824062	1159844	Carmale	30	5	5	30	1971	183
14	204997	1079387	Xingalool	60	11	9	20	1978 broken since 1995	342
15	186317	1102456	Sibayo 5COOPI)	NA	2	2	0	2004	84
16	183631	1069370	Wardheer	0	9	9	15	2000	191,7
17	823705	1086113	Damala Xagare (7 COOPI)	20	70	70	40	1981	259
18	828859	1050364	Sarmanyo (1 MPA)	50	70	40	0	1970	333
19	224034	1057455	Baraktaqol	NA	60	20	50	1967	680
20	260920	1078158	Dahar	350	38	35	20	1969	357
21	290756	1091000	Sherbi		145	120	20	1961	327,5
22	286553	1175315	Ceel Dofar	10	0	0	0	NA	NA
23	225992	1132938	Harbar Shiro		10	10	20	NA	NA
24	204436	1108404	Qoyan		10	4	10	NA	NA
25	229285	1114259	Goran		3	3	10	NA	NA
26	203841	1102786	Jingeda		4	4	14	NA	NA

Average UG capacity : 320 m^3

ID	X	Y	Village	number of house berkeds	number of households	Coverage	Operational Underground berked	number of households	Coverage
20	286553	1175315	Ceel-Dofar	10	400		0	400	0
1	260043	1170707	Cawsane1	0	70	0	0	70	0
2	245810	1181990	Mindigale	2	100		0	100	0
3	233295	1185338	Raad -Lako	16	450		14	450	3,1
4	183441	1191499	Hadaftimo	300	2000		11	2000	0,5
5	819596	1189649	Yuube	NA			2	600	0,3
6	208500	1185043	Badhan	NA			0	286	0
7	205026	1131536	Ceel-Buh	300	1700		55	1700	3,2
8	217083	1120425	Mindihir	3	60		11	60	18,3
9	256206	1129640	Buran	NA			0	1500	0
10	236565	1109102	Bali-Busle	6	250		21	250	8,4
11	824062	1159844	Carmale	30	300		5	300	1,6
12	204997	1079387	Xingalool	60	3500		9	3500	0,2
13	186317	1102456	Sibayo 5 (COOPI)	NA			2	500	0,4
14	183631	1069370	Wardheer	0	120		9	120	7,5
15	823705	1086113	Damala Xagare (7 CO)	20	1000		70	1000	7
16	828859	1050364	Sarmanyo (1 MPA)	50	250		40	250	16
17	224034	1057455	Baraktaqol	NA			20	645	3,1
18	260920	1078158	Dahar	350	5000		35	5000	0,7
19	290756	1091000	Sherbi		3000		120	3000	4

ID	X	Y	Name	Year of construction	Note	Price 200l rain	Price 200l from WT
1	824171	1160199	Carmale B1	1971		15000	30000
2	824512	1160144	Carmale B2	2003		15000	30000
3	216479	1120402	Mindihir B1	1997		10000-15000	40000
4	216784	1120323	Mindihir B2	2005		10000-15000	40000
5	183972	1069653	Wardheer B1	2000		10000-15000	60000-70000
6	183300	1069566	Wardheer B2	2003		10000-15000	50000-60000
7	204534	1079837	Xingqlool B1	1978		20000	
8	204169	1078859	Xingalool B2	1995		20000	
9	224168	1057383	Baraktaqol B1	1967		10000	70000
10	224280	1057330	Baraktaqol B2	1996		10000	70000
11	236952	1108272	Balibusle B1	1996		10000	35000
12	236155	1107694	Balibusle B2	2005		10000	35000
13	205163	1131897	Ceel-Buh B1	1968		10000-15000	60000
14	204898	1132644	Ceel-Buh B2	2005		10000-15000	60000
15	828797	1050499	Sarmanyo B1	1970		10000	50000
16	829150	1050302	Sarmanyo B2	2000		10000	50000
17	825307	1191850	Qoralay	1999		NS	NS
18	183960	1193019	Hadaftimo B1	1975	Irrigate plot		
19	236214	1187068	Lako B1	1996		15000	30000
20	234610	1186705	Lako B2	2001		15000	30000
21	186164	1102744	Sibayo B1	2004		5000	30000
22	290568	1091143	Sherbi B1	1961		10000	20000
23	291461	1090984	Sherbi B2	2005		10000	20000
24	260437	1078358	Dahar B1	1969		10000	10000
25	260691	1077462	Dahar B2	2005	Planned for irrigation	NS	NS
26	260007	1077899	Dahar B3	In construction	Irrigate plot	NS	NS
27	823806	1086067	Damala-Xagarre B1	1981		10000-15000	50000
28	823877	1085997	Damala-Xagarre B2	2004		10000-15000	50000
29	823185	1086342	Damala-Xagarre B3	1991	Irrigate plot	NS	NS

Annex 6: Soil analysis

Latitude longitude Elev.	Site	Depth	CLAY (%)	SAND (%)	SILT (%)	Texture class	pH:H2O	pH classes	EC1:2.5	Salinity class	Exchangeable calcium (me/100g soil)
10◦34'57.7" N 47◦58' 13" E 1309	Carmaale	0 to 15	39.0	17.0	44.0	SiCL	8.4	moderately alkaline	0.2	non saline	8.80
	Carmaale	15 to 60	51.0	13.0	36.0	C	8.3	moderately alkaline	0.2	non saline	8.75
	Carmaale	65 to 115	53.0	15.0	32.0	C	8.2	moderately alkaline	0.4	non saline	8.40
10◦34'58" N 48◦48' 21" E	Cawsane1	0 to 20	21.0	17.0	62.0	SiL	8.1	moderately alkaline	2.1	slightly saline	11.05
	Cawsane1	20 to 40	35.0	19.0	46.0	CL	8.2	moderately alkaline	2.2	slightly saline	13.90
	Cawsane1	40 to 60	27.0	21.0	52.0	SiL	8.2	moderately alkaline	2.1	slightly saline	14.20
	Cawsane1	60 to 80	43.0	13.0	44.0	SiL	8.2	moderately alkaline	2.2	slightly saline	9.80
10◦01' 01" N 48◦36' 01" E	Balli-busle	0 to 22					8.2	moderately alkaline	0.5	non saline	10.23
	Baraagaha-qol/ Ceelka	0 to 26					8.2	moderately alkaline	0.2	non saline	9.51
	Baraagaha-qol/ Ceelka	26 to 40					8.2	Moderately alkaline	0.2	non saline	6.44
	Baraagaha-qol/ Ceelka	40 to 50					8	moderately alkaline	0.5	non saline	9.64
9◦ 48' 43" N 47◦57' 00" E	Beerta-gobley/ Damalaxagarre	0 to 15					7.7	mildly alkaline	1.1	non saline	9.81
	Beerta-gobley/ Damalaxagarre	0 to 15					7.9	moderately alkaline	0.6	non saline	9.64
10◦ 18' 53" N 48◦ 17' 24" E	Ceel Hakay/ Ceel-buh	0 to 25					7.9	moderately alkaline	0.6	non saline	10.62
	Ceel Hakay/ Ceel-buh	25 to 40					7.9	moderately alkaline	0.2	non saline	8.17
	Ceel Haqay/ Ceel-buh	40 to 55					8.1	moderately alkaline	0.7	non saline	7.22
	Geed-Cilmil	0 to 16					8.1	moderately alkaline	0.2	non saline	8.47
Latitude longitude Elev.	Site	Depth	CLAY (%)	SAND (%)	SILT (%)	Texture class	pH:H2O	pH classes	EC1:2.5	Salinity class	Exchangeable calcium (me/100g soil)
9◦ 42' 29" N 48◦56' 57" E	Geed-Cilmil	16 to 42					8.2	moderately alkaline	0.2	non saline	11.88
	Geed-Cilmil	42 to 86					8	moderately alkaline	0.4	non saline	7.71
10◦41'41" N 48◦17' 48" E 1156	Gungumaale	0 to 20	7.0	59.0	34.0	SL	8.1	moderately alkaline	2.3	slightly saline	9.80
	Gungumaale	20 to 35	5.0	49.0	46.0	SL	8.2	moderately alkaline	2.6	moderately saline	9.20
	Gungumaale	35 to 50	5.0	45.0	50.0	SiL	8.2	moderately alkaline	2.7	moderately saline	9.25
	Habar/humbule	0 to 20					8	moderately alkaline	0.6	non saline	10.15

	Habar/humbule	20 to 35					8.1	moderately alkaline	0.6	non saline	10.23
10◦39'28" N 48◦29' 48" E	Xubeera 1	0 to 5	7.0	35.0	58.0	SiL	8.1	moderately alkaline	3	moderately saline	11.10
	Xubeera 1	5 to 33	5.0	31.0	64.0	SiL	8	moderately alkaline	2.7	strongly saline	16.20

Latitude longitude Elev.	Site	exchangeable sodium (me/100g soil	Extractable phosphorus (mg P/kg)	Carbon (%)	Nitrogen (%)
1034'57.7" N 47◦58' 13" E 1309	Carmaale	0.1	7.30	7.30	0.10
	Carmaale	0	22.70	22.70	0.07
	Carmaale	0.1	5.80	5.80	0.07
10◦34'58" N 48◦48' 21" E	Cawsane 1	0.1	3.50	6.35	0.05
	Cawsane 1	0.1	1.90	5.89	0.01
	Cawsane 1	0.1	2.00	5.77	0.15
	Cawsane 1	0.2	4.50	7.23	0.04
10^{o}01' 01" N 48^{o} 36' 01" E	Balli-busle		7.6		
	Baraagaha-qol/Ceelka		5.62		
	Baraagaha-qol/Ceelka		4.27		
	Baraagaha-qol/Ceelka		2.85		
9◦ 48' 43" N 47◦57' 00" E	Beerta-gobley/Damalaxagarre		1.97		
	Beerta-gobley/Damalaxagarre		1.49		
10◦ 18' 53" N 48◦ 17' 24" E	Ceel Hakay/Ceel-buh		3.02		
	Ceel Hakay/Ceel-buh		4.88		
	Ceel Haqay/Ceel-buh		4.85		
	Geed-Cilmil		3.77		
9◦ 42' 29" N 48◦56' 57" E	Geed-Cilmil		3.56		
	Geed-Cilmil		2.61		
10◦41'41" N 48◦17' 48" E 1156	Gungumaale	0.00	2.70	2.71	0.05
	Gungumaale	0.10	5.30	2.81	0.05
	Gungumaale	0.2	3.80		
Latitude longitude Elev.	Site	exchangeable sodium (me/100g soil	Extractable phosphorus (mg P/kg)	Carbon (%)	Nitrogen (%)
	Habar/humbule		1.73		
	Habar/humbule		3.16		
10◦39'28" N 48◦29' 48" E	Xubeera 1	0.10	1.30	5.52	0.08
	Xubeera 1	0.40	0.20	3.97	0.06

Latitude/ Longitude/ Elevation	Site	Depth	CLAY (%)	SAND (%)	SILT (%)	Texture class	pH:H2O	pH classes	EC1: 2.5	Salinity class	Exchang eable calcium (me/100g soil)
	Xubeera 1	33 to 56	7.0	59.0	34.0	SL	8	moderately alkaline	2.7	strongly saline	12.60
	Xubeera 1	56 plus	7.0	87.0	6.0	S	8.2	moderately alkaline	2.6	strongly saline	10.90
10◦44'54" N 48◦06' 57.7" E 1287	Hadaaftimo	0 to 28	27.0	19.0	54.0	L	8.2	moderately alkaline	1.5	slightly saline	9.80
	Hadaaftimo	28 to 78	7.0	43.0	50.0	SiL	8.1	moderately alkaline	2.4	slightly saline	8.50
	Hadaaftimo	78 to 120	27.0	19.0	54.0	L	8	moderately alkaline	2.6	moderately saline	8.50
	Hiil-Buraan	0 to 25					7.9	moderately alkaline	0.7	non saline	8.55
9◦47'23" N 48◦20' 40" E 915	Xin-Qori	0 to 30					7.9	moderately alkaline	0.419	non saline	10.90
	Xin-Qori	30 to 47					8.1	moderately alkaline	0.468	non saline	10.70
	Xin-Qori	47 to 66					7.9	moderately alkaline	1.11	non saline	10.14
9◦41' 33" N 48◦53' 02" E	Kalxileed	0 to 10					7.7	Mildly alkaline	0.2	non saline	10.05
	Kalxileed	10 to 20					8.1	moderately alkaline	0.2	non saline	8.52
	Kalxileed	20 to 80					8.2	moderately alkaline	0.2	non saline	9.78
	Kuri-kuris/Cawasane	0 to 50					8.1	moderately alkaline	0.8	non saline	11.24
9◦58' 04" N 49◦15' 55" E	Lucda/Sherbi	0 to 26					8.2	moderately alkaline	0.2	non saline	7.95
	Lucda/Sherbi	26 to 165					8.2	moderately alkaline	0.2	non saline	7.69
10◦40' 05" N 48◦39' 47" E	Mindigaale 2	0 to 25	5.0	29.0	66.0	SiL	8	moderately alkaline	2.3	slightly saline	9.55
	Mingaale 2	25 to 40	5.0	31.0	64.0	SiL	8	moderately alkaline	2.6	moderately saline	10.20
	Mindigaale 2	40 to 62	5.0	29.0	66.0	SiL	8	moderately alkaline	2.8	moderately saline	10.40
	Mindigaale 1/Higlo-tuug	0 to 25					8.1	moderately alkaline	2.3	moderately saline	12.379
10◦43'28" N 48◦33' 59" E	RAAD	0 to 18	43.0	13.0	44.0	SiC	8.5	strongly alkaline	0.5	non saline	9.40
Latitude longitude Elev.	Site	Depth	CLAY (%)	SAND (%)	SILT (%)	Texture class	pH:H2O	pH classes	EC1: 2.5	Salinity class	Exchang eable calcium (me/100g soil)
	RAAD	18 to 40	21.0	37.0	42.0	L	8.6	strongly alkaline	0.4	non saline	9.80
	RAAD	40 to 62	43.0	15.0	42.0	SiC	8.7	strongly alkaline	0.6	non saline	9.40
10◦21'54" N 48◦21' 17" E 1135	Urur/Ceel-Buh	0 to 26	17.0	57.0	26.0	SL	8	moderately alkaline	0.5	non saline	4.35
	Urur/Ceel-Buh	26 to 40	15.0	65.0	20.0	SL	8	moderately alkaline	0.4	non saline	6.25
10◦40'32" N 48◦41' 39" E 1460	Yuube	0 to 26	37.0	19.0	44.0	SiCL	8	moderately alkaline	0.5	non saline	8.90
	Yuube	26 to 43	41.0	17.0	42.0	SiC	8.1	moderately alkaline	0.5	non saline	8.70
	Yuube	43 to 120	35.0	13.0	52.0	SiCL	8	moderately alkaline	0.4	non saline	7.95

Latitude longitude Elev.	Site	exchangeable sodium (me/100g soil	Extractable phosphorus (mg P/kg)	Carbon (%)	Nitrogen (%)
	Xubeera 1	1.90	4.10	3.79	0.38
	Xubeera 1	0.00	0.80	4.42	0.04
10◦44'54" N 48◦06' 57.7" E 1287	Hadaaftimo	0.00	4.30	6.35	0.07
	Hadaaftimo	0.10	14.80	7.21	0.45
	Hadaaftimo		0.00	7.13	0.06
	Hiil-Buraan		3.17		
9◦47'23" N 48◦20' 40" E 915	Xin-Qori	0.00	3.40	4.85	0.07
	Xin-Qori	0.00	5.80	4.52	0.06
	Xin-Qori		12.62		
9◦41' 33" N 48◦53' 02" E	Kalxileed		4.63		
	Kalxileed		0.78		
	Kalxileed		2.24		
	Kuri- kuris/Cawasane		2.18		
9◦58' 04" N 49◦15' 55" E	Lucda/Sherbi		2.19		
	Lucda/Sherbi		3.85		
10◦40' 05" N 48◦39' 47" E	Mindigaale 2	0.00	1.80	5.66	0.05
	Mingaale 2	0.00	1.40	5.67	0.04
	Mindigaale 2	0.20	1.90	5.44	0.06
	Mindigaale 1/Higlo-tuug		1.858928042		
10◦43'28" N 48◦33' 59" E	RAAD	0.00	3.60	5.67	0.09
	RAAD	0.00	3.20	5.58	0.07
	RAAD	0.10	15.00	5.57	0.08
10◦21'54" N 48◦21' 17" E 1135	Urur/Ceel-Buh	1.20	15.30	9.09	0.04
	Urur/Ceel-Buh	2.60	2.00	9.52	0.02
Latitude longitude Elev.	Site	exchangeable sodium (me/100g soil	Extractable phosphorus (mg P/kg)	Carbon (%)	Nitrogen (%)
10◦40'32" N 48◦41' 39" E 1460	Yuube	0.00	2.00	5.84	0.07
	Yuube	0.10	0.00	5.95	0.06
	Yuube	0.30	0.00	6.19	0.05

Annex 7: Charcoal Production Estimates

ID	X	Y	Town/village	Estimate charcoal production/month (nbr of trucks)	Estimate grass harvesting production/month(nbr of trucks)
1	226134	1179256	Badhan-Hubera	0	0
2	260043	1170707	Cawsane 1	0	0
3	245810	1181990	Mindigale	0	0
4	233295	1185338	Raad-Lako	0	150
5	183441	1191499	Hadaftimo	0	NK
6	819596	1189649	Yuube	10	8
7	205026	1131536	Ceel-Buh	0	0
8	217083	1120425	Mindihir	1	0
9	256206	1129640	Buran	60	0
10	236565	1109102	Bali Busle 2	10	0
11	824062	1159844	Carmale	45	45
12	204997	1079387	Xingalool	0	0
13	186317	1102456	Sibayo	0	0
14	183631	1069370	Wardheer	100	0
15	823705	1086113	Damala Xagare	0	0
16	828859	1050364	Sarmanyo	120	0
17	224034	1057455	Baraktaqol	300	0
18	260920	1078158	Dahar	600	0
19	290756	1091000	Sherbi	0	0
20	286553	1175315	Ceel Dofar	0	0
				1246	203

1 truck = 200 x 50kg bags

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