Assessment of Land Resources and Biodiversity for Sustainable Peace and Development. Abyei Area, West Kordofan State, Sudan

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Abstract: *The study was conducted in Abyei area to provide basic land resources information that could help decision makers and planners in setting up plans for agricultural development and other land intensive Livelihoods initiatives. Abyei area lies in South Kordofan State between Latitude 9° 38'- 10° 15' N and Longitude 28° 11' - 29° 45' E, within a previous conflict zone. In order to avoid conflict over resources and achieve a sustainable peace and to enhance poverty reduction initiative in Abyei the assessment and mapping of its natural resources and biodiversity was performed using remote sensing and GIS technology. Images from ASTER 2005, SPOT of 2006 and Landsat Thematic Mapper (Landsat 5 TM) of year 2000 were used in this study. Visual image interpretation aided with digital image processing and field observations were the adopted methods. The results revealed production of set of land resources maps at scale 1:150000 that include Physiography & Soils, Drainage System, Vegetation, Settlements/ infrastructure, Nature Reserve Boundary and the Land Resources maps.The results showed that Abyei land System is part of a regional landform system composed of a repeating pattern of physiographically interrelated land units created by surface drainage and water flow processes (e.g. deposition and erosion) mainly along Bahr El Arab and Bahr El Gazal. The study area is dominated by the repeated pattern of the four elements (Physiography, soils, vegetation and drainage). The study concluded that the land resources are under more intensive pressure and high demand under post war hence, their characterization and assessment are exceptionally needed for planning and development to ensure a proper management and sustainable use of these resources. The study recommended detailed and ultra-detailed surveys, supported by high quality remote sensing data to characterize the land units for management purposes especially in irrigated projects of high input capital (e.g. vegetable and fruit farming).*

Keywords: Abyei area, Land resource, Assessment, Sustainable peace, Remote sensing

1. Introduction

To avoid conflict over resources and achieve a sustainable peace and to enhance poverty reduction initiative in Abyei, the assessment and mapping of its natural resources and biodiversity is highly demanded. The advancement of computerized Geographical Information System (GIS) allowed the integration of multiple data types (remotely sensed data, topographic maps, thematic maps and ancillary data) and makes the way paved to produce sound natural resources map that is more useful for planners, policy makers, investors and the community for proper and sustainable management of the natural resources.

The processes of mapping the natural resources usually necessitate extrapolation or interpolation of information about natural resource distribution and patterns. The extrapolation is often done from data already collected by scientists at specific location while interpolation is done using remote sensing data. The work was carried out utilizing remote sensing data as the main source of data augmented with ground truthing. Six maps were produced at scale 1:150000 and UTM projection; those are Vegetation map, Physiography & Soils, Drainage System, Settlements/ infrastructure, Nature Reserve Boundary Map and the Land Resources Map.

The study was carried to provide basic land resources information to help the decision makers and planners in setting up plans for agricultural development and other land intensive Livelihoods initiatives. The assessment of land resources will enable development agencies and investors to select the most potential areas for feasibility studies for investment and initiation of new development projects. The study has also proposed a site as for development of natural reserve on the south eastern part of the area. In these parts the natural conditions are favorable for such activity due to the biodiversity of the environment and the availability of water for longer periods in the channels and depressions.

2. The Study Area

Abyei area is located at the south western edge of South Kordofan State. Abyei area falls approximately between Latitude 9° 38′- 10° 15′ N and Longitude 28° 11′- 29o 45′ E. The study included a total land area of about 10,000 Km2. Figure 1 shows Location of the study area. The area is composed of a nearly level plain which is generally sloping gently to the south east withthe exception of the north eastern parts which are sloping towards the south and the south west. The fairly distinctive natural features of soils, vegetation and land form usually occur in repeating and complex pattern

The study area lies within the Dry Monsoon climate with long dry season and warm winter (Kevie and El Tom 2004). The average water surplus in the humid months is 10 to 20% of the annual potential evapotranspiration. The average annual rainfall ranges from 750 to 1000 mm. There is a pronounced

dry season with 5 to 7 dry monthsin which rainfall is less than half the potential evaptranspiration). Generally 3 to 4 months are humid in a growing season of 5 to 7 months. Mean minimum temperatures of the coldest month (December or January) are 17 to 20° C.

Surface and ground water resource are abundant throughout the area. Raqaba system which dominates the area providesmuch of the surface waters. It was estimated that the Raqaba system and depressions could provide as much as 50

million M3 annual discharge of water and Bahr AL Arab could provide similar figures annually (Abdulla et al 2005).Moreover, Abyei is part of a extended rift structure filled with sedimentary formations forming an aquifer complex which is hydrologically known as the Baggara Basin. The ground water in the basin occur at any depth below 110, however groundwater of good quality is warranted at depth exceeding 400 m below groundwater surface.
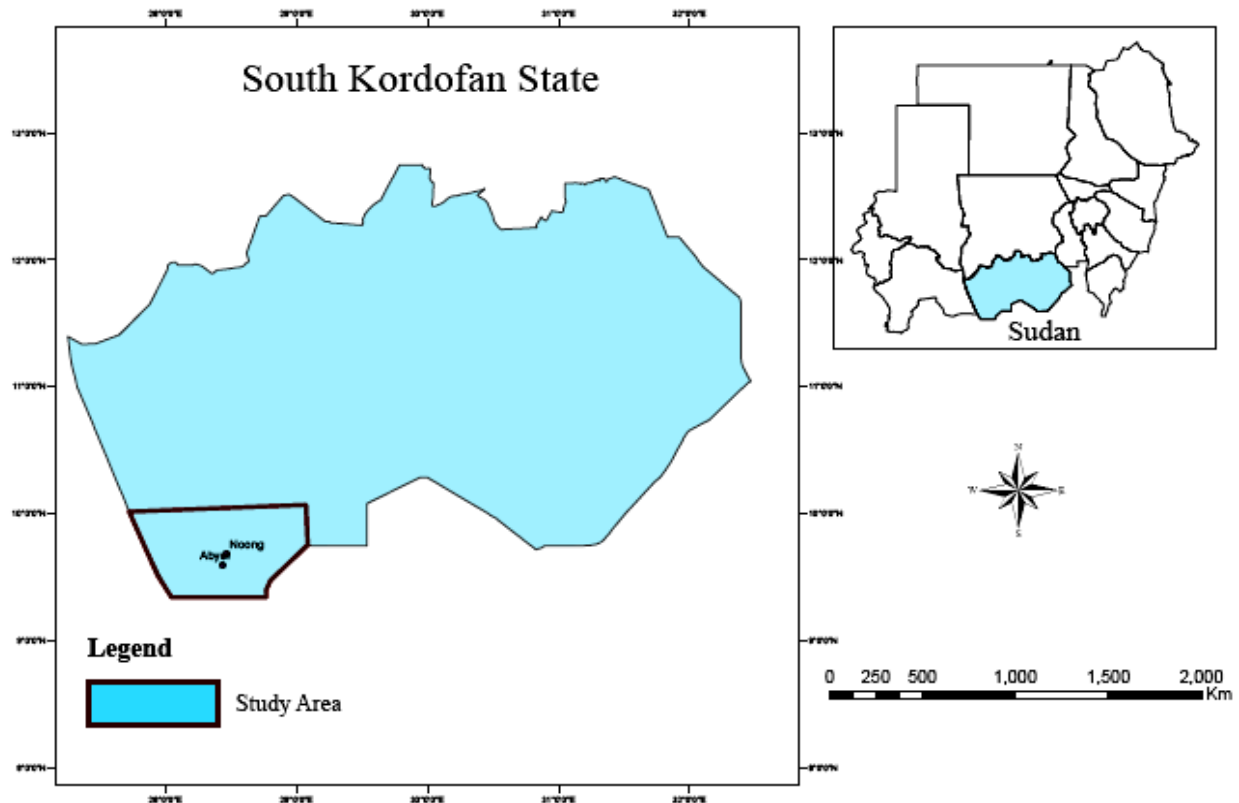

Figure 1: Location of the study area

3. Materials and Methods

Images fromASTER 2005, SPOT of 2006 and Landsat Thematic Mapper (Landsat 5 TM) of year 2000 were used in this study. Existing Information from maps and reports including; physiography and soils map at a scale 1:250.000 dated 1992, vegetation and land use map at a scale 1:250.000 dated 1992 and published reports were used also. Two main software packages; ArcGIS, and ERDAS (Geographic Information System and remote sensing software) were used for image interpretation, map manipulation and analysis in addition to ArcView Software.

Based on visual image interpretation aided with digital image processing and field observation, set of land resources maps were generated for Abyei area. ASTER, SPOT and Landsat TM are the main data sources for the map units. Visual interpretation and an on-screen digitization methods were used to delineate (12) vegetation/land use categories in the area. The land use/ land cover classification system which was adopted for this study is based on "land cover classification system (LCCS)" FAO (2003). Fifteen (15) map units were identified to represent the physiography and

soils of the area according to USDA system (Cock 1975). Natural resources mapping process was carried out in four phases that involves data collection, satellite image interpretation,field survey and land resources mapping. The adopted approach for Land Resources Mapping focuses on assessment, analysis and integration of results from four natural and environmental components those are; soils and land suitability, land cover and land use assessment, rangeland and environmental hazards analysis

4. Results and Discussions

Land Resources Assessment and Mapping
The adopted approach for natural resources assessment and mapping incorporates results from four natural and environmental componentsincluding soils and land suitability, land cover and land use assessment, rangeland and environmental hazards analysis.

Soils and Land Suitability Mapping Units
(1) Naga'a Soils
Naga'a in local language means bare ground without vegetation. Naga'a soils are flat land tracts of limited extent

occupying relatively higher sites within the Abyie Depositional – Erosional alluvium system. The soil surface is usually hard, smooth non cracking and in some places covered with 2-5 cm very fine alluvium sand. The soils are dark brown to dark greyish brown in color with silty clay textures. They are characterized by numerous fissures at top soil with few pressure faces at lower depths and generally the profile is homogenous. The soils are mostly non-calcarous with moderate pH and they are non-saline . The topsoils have strong medium blocky structures. The permeability is moderate to mderately slow but often it gets very slow when the soils are wet. These soils are marginally suited for most of the common rainfed crops and very limited rainfed farmingt is practiced on these soils. These soil occupy shedding sites beside their sealed non-cracking surface which together make them droughty immediately after the rainy season(Cook, 1975; Pacheco and Dawoud, 1976). Nada's Soilswereclassified according to USDA 2006 as: Inceptisols and Vertisols. Figure 2, is an image map shows the soil mapping units of the study area and Table 1 shows breif describtion of the fifteen soil mapping units.

(2) Raqaba' Soils
The bottom of the Raqaba' (narrow meandering water course) is occupied by heavy silty clay and heavy clay soils which normally develop wide cracks when these bottoms get dry. Usually the bottoms are densely occupied creaping aquatic grasses. The soil surface is usually covered by numerous cracks which help develop of many very hard polygons of silty clay materials. Raqabas usually have narrow terrace of very fine alluvium coverd with very fine alluvium sands and characterized by presence of continuous cluster of huge trees which delineate the Raqaba.The soils are dark brown to dark greyish brown in color with silty clay and clay textures. They soil are usually moist and wet down the profiles with common gleying conditions at subsoil and substratum. The soils are mostly non-calcarous with moderate pH and they are non-saline. The permeability is slow but often it gets very slow when the soils are wet.

The Raqaba' with their associated natural components provides water, shade and pasture for animals particularly during summer season. No farming is practiced in Raqaba or its components. Bridges and similar infrastructures along these water courses should be engineered adequately to allow the smooth flow of water and easy passage of animals and wildlife. The Ragaba' soilswere classified as: Entisols and Vertisols, figure 2 and table 1

(3) Atmoor Soils
These are the sandy materials of the in situ weathered sand stone ridges. They occupy the upper northern slopes close to the sand stone formation and outcrops. They occupy slightly higher position within the landscape and characterized by nearly level and dissected surfaces.The soils are yellowish and reddish brown in color with sand loam and sandy clay loam textures. They are characterized sealed and at some places by disturbed surfaces. The soils are mostly non-calcarous with moderately low pH and they are non-saline . The topsoils have massive and /or loose surfaces. The permeability is mostly high and slow permeable layer might exist at subsoil and substratum.Due to moisture deficiencies in these soils most of the common early maturing rainfed crops are moderately to highly suited to these soils (Dent and Young, 1981). Some sustainable production of Sorghum, sesame and millet was noticed at some parts of these soils. This is the most naturally fragile component of Abyei area and needs special planning and management especially with increasing pressure of petroleum activities in these areas. The cutting and burning of tall, huge trees of 50 – 100 years old or more could never be replaced. It is evident that all these trees have their early existance at much wetter climatic conditions and some of them survived our present dry climtes. These soils wereclassified as: Alfisols, Inceptisols and Entisols (USDA 2006), figure 2 and Table 1.
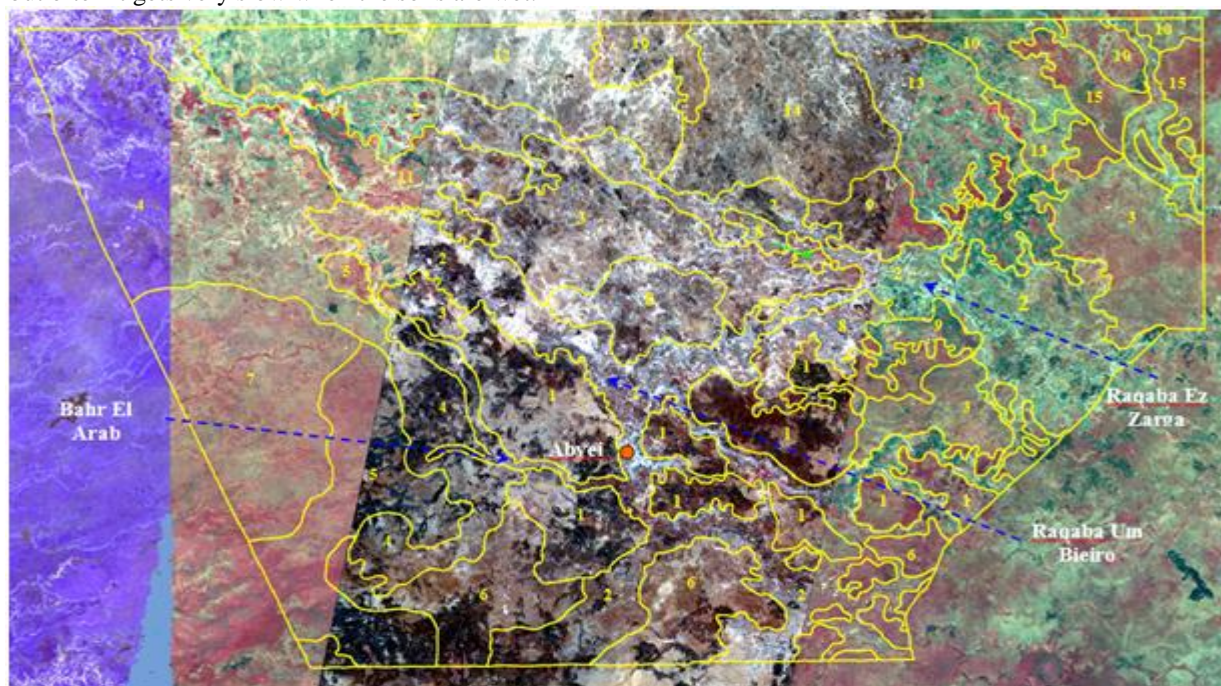

Figure 2: Image map of Physiography and soils of the study area

Table 1: Description of Land Resources Mapping Units of the Study Area

Symbol	Name	Components	Description (Physiography and Soils)
1	Recent flat Alluvial plains	80% Cracking clay 15% Nagaa 5% Raqaba	Nearly flat plains dominated by cracking clays and located close to Depressional areas with very few depressions. The main soils are the nearly flat alluvium cracking clays.
2	Raqaba system - Middle & lower parts	50% Raqaba 30% Cracking clay 20% Nagaa	Levee & Backswamp Complex of Bahr El Arab & two Raqabas (Um Bieiro – Ez Zarga). These form a complex pattern of Raqaba, cracking clay and Naga soils
3	Raqaba Ez Zarga Backswamps & Cut-off Raqabas – Middle parts	50% Cracking clay 30% Raqaba 20% Nagaa	Complex of cut-off Raqaba and back swamps at Raqaba Ez Zarga middle slopes. The cracking clays dominate this complex pattern.
4	Upper Bahr El Arab Backswamp & Cut-off Raqabas	35% Cracking clay 35% Nagaa 30% Raqaba	Depressions, backswamps and Naga of Bahr Al Arab at the upper slopes. The complex is shared by the three main types of soils.
5	Slightly higher Dissected Erosional plain (South Western Alluvial fans)	40% Raqaba 30% Clay 30% Nagaa	Watershed higher lands dividing Bahr el Arab drainage system from Bahr El Gazal system.
6	Semi-recent flat alluvial plain	75% Cracking clay 15% Nagaa 10% Raqaba	Nearly flat plains dominated by cracking clays and located close to Depressional areas
7	Dissected Sloping Erosional plain (South western Alluvial fans)	35% Raqaba 35% Cracking Clay 30% Naqaa	Watershed higher lands dividing Bahr el Arab drainage system from Bahr El Gazal system. This unit it has a unique Physiography since it is sloping towards Bahr Al Gazal.
8	Raqaba Um Bieiro Backswamp & Cut-off Raqabas	60% Raqaba 30% Cracking Clay 10% Naqaa	These are abandoned water channels and levees created by stream meandering located at the northern parts of Abyei.

Symbol	Name	Components	Description (Physiography and Soils)
9	Raqaba Ez Zarga recent alluvium	70% Cracking clay 15% Nagaa 15% Raqaba	Nearly flat plains dominated by cracking clays and located close to Depressional areas with some Raqabas
10	North Eastern Clay plain Naga'a Complex	55% Cracking Clay 25% Nagaa 10% Atmoor 10% Raqaba	Depositional clay plains with some depressions
11	Upper Raqaba Ez Zarga Backswamps & Cut-off Raqabas	60% Raqaba 25% Cracking Clay 15% Nagaa	Levee & Backswamp Complex of Bahr El Arab
12	Dissected erosional sandy plain (Atmoor)	45% Nagaa 45% Atmoor 10% Cracking Clay	Northern Sand plains
13	Dissected Naga'a – Atmoor Complex	40% Nagaa 30% Cracking Clay 20% Atmoor 10% Raqaba	Degradational Sloping clay and sandy plains, dissected by numerous Raqabas originating from northern highlands.
14	Northern Alluvial fans and Nagaas	50% Nagaa 30% Cracking Clay 10% Atmoor 10% Raqaba	Degradational Sloping clay and sandy plains, dissected by Raqabas originating from northern highlands.
15	North eastern alluvial plains	60% Cracking Clay 20% Nagaa 10% Raqaba 10% Atmoor	Depositional clay plains with some depressions

5. Biodiversity and Land Use

Abyei area is chaharacterized by its open forest, woodland and extensive rangelands.Since pastorlism and raising of animals are major activities, vegetation and rangelands are mainly used for these purposes. Cattle, sheep and goats are widely seen across the area searching for pasture and water.Limited traditional agriculture is practiced on a very small scale and done as a secondary activity to animal raising. The main crop is sorghum. Groundnut and millet are grown in the northern part of the area minor crops are water melons and okra. The settlement pattern is very difficult to be recognized in the satellite image, the only recognized settlement is Abyei city. Other villages are very small and composed of few huts that are always found on the elevated parts of the Ragaba system. The settlement pattern is a complex that includes adjacent to the village a very small field of rainfed cultivation and animal enclosures.Eleven land cover/ land use classes were identified to describe the main vegetation and Land use types of the study area, those are;

1) **Open Forest:** The tree cover in this unit is more than 65% and most of the area is underutilization. And a

limited use of forest for fire wood or as a rangeland is noticed.The main woody species:-*Acacia seyal, Balanitesaegyptiaca, Acacia gerrardii, Anogeissusleiocarpu*s. The main grasses:- *Hyarrhenia confines, Brachiariaobtusiflora, schoenfeldiagracilies, Sorghum laneeolatum*

2) **Open Woodland:** This unit is composed of trees and shrubs with 65% cover and a limited use for firewood and as a rangeland. The main woody species are:*Acacia seyal, Balnitesaegyptica, Anogeissusleiocarpus.* The grasses are:*Brachiariaobtusiflora, Hyarrheni confines* and*Rottoebeliaexaltata.*

3) **Open Forest/grasses** It is a complex unit formed of almost 60% of trees and 40% of grass that mainly used as rangeland. The main woody species:-*Acacia seyal, Balnitesaegyptica, Acacia polyacantha.* Grasses:- *Brachiariaobtusiflora, Hyarrhenia confines* and*Schoenfeldiagracilies.*

4) **V. Open Forest** The tree cover is in a range of 60% to 40%,. This unit is the main rangeland area. The main woody species are:*Acacia seyal, Balnitesaegyptica, Acacia polyacantha.* Tha main grassesare:*Hyarrhenia confines, Rottoebeliaexaltata,Brachiariaobtusiflora, Schoenfeldiagracilies*and*Aritidamutablis.*

5) **Grassland.** The unit is composed of grasses and sparse trees and used as rangeland. The main woody species are:*Acacia seyal, Balnitesaegyptica*, widely distributes. Grasses:- *Hyarrhenia confines, Brachiaria obtusiflora, Sorghum laneeolatum, Rottoebelia exaltata, Setaria incrassata.*

6) **Grass / Forest / bare soi**l. This unit is a complex of forest gasses andbare soil (degraded) the unit is intensively grazed. The main woody species are: *Acacia seyal, Balnitesaegyptica, Acacia gerrardii, Lanneahumilis, Asparagus Africana.*Grasses:- *Schoenfeldiagracilies, AristidamutablisSetariapallidde-fusca, Hyograghlaspinasa.*

7) **Forest /grass on Atmoor Soil:** The main use of this unit is rainfed cultivation where *sorghum,* Millet, groundnut and beans are the main crops. The dry season grazing is the second land use type that based on dry grasses and crops residues and by-products. The main woody species are:*Combretumglutinosum, Terminalialaxiflora, Albiziaamara, Anogeissusleiocarpus, Guierasenegalensis. the main grasses* grasses are:*Aristidamutablis, Schoenfeldiagracilies*and*Andropogongaynus.*

8) **Grass/ rain-fed cultivation.** Small patches of cultivation occur on different soils including Atmur . The unit is dominated by grasses and sparse trees. The main woody spp.:- Scattered *Combretum, Glutinosum, Terminalia.* The grasses are :- *Schoenfeldiagracilies, Andropogongayans, Aristidamutablis.* The cultivated crops are:sorghum,millet, groundnuts and beans

9) **Grass / shrubs;** The unit is dominated by grasses almost 60% and 40% shrubs. The main woody species are:*Acacia polyacantha, Dichrostochuscineria, ziziphus, Spina-christi, Dalbergiamelanoxylan.*The main grasses are:*Hyarrhenia confines, Rottoebeliaexaltata, Brachiariaobtusiflora*and*Setariapallidefusca*

10) **Shrubs / grass:** The main woody species are: *Acacia seyal, Dichrostochuscineria, Acacia polyacantha, ziziphus, Spina-christi, Dalbergiamelanoxylan.*Grasses:-

Hyarrhenia confines, Brachiariaobtusiflora, Rottoebeliaexaltata and Setariaincraggata.

11) **Reggaba riverine Vegetation:** The main woody species:- Evergreen, *Celtisintegrifolia, Gardenia lutea, Tamarindusindica, Diospyrosmespiliformis, Acacia sieberiana, Ziziphus, Spina-christi, Cartevoadansonii, piliostigmareticulatum, and Ficus spp.* on the banks.The dominantperennial Grasses are*: Echinochloastagnina, vetiverianigritana, Oryzabarthii, Oryzalongistaminata and cyperus,* as water loving plant on Ragaba floor.

6. Rangeland Resources

The rangeland resources or the grazing resources in the Abyei surveyed area can be divided into three distinct categories:-
- Grazing or pasture made of edible annual, perennial short and tall grasses and forbs that grow naturally.
- Browse stuff consisting of edible parts of trees and shrubs naturally occurring in the area.
- Crop residues and crop by products of millet, sorghum and groundnut, grasses predominate in the whole area followed by the wood browse spp. The crop residues and crop by products provide a small portion in the livestock feed this is mainly because the areas put under food and cash crops by the agro-pastoralists (Dinka) and the transhumant pastoralists Messeriya are small.Abdalla et al 2005.

During the rainy season, the area is entirely deferred (to grazing and browsing) a part from very light use performed by the few sedentary agro-pastoralists small ruminants (shoats = sheep and goats) and some few cattle kept in the Luaks.During the dry season (November – June) the survey area becomes under intensive use by the Messeriya who come from their wet season grazing north of the railway line Abu zabad –Nyalla. The Messeriya reach their dry season grazing area north of Bahr Alarab (River Kir) through defined migration routes (Maraheel).

The rangeland natural vegetation associations according to the field survey (March 2007 can be classified as:-
- *Acacia seyal – Blanitesaegptiaca* woodland savannah/ tall annual and perennial grasses on dark cracking clay soil.
- *Albiziaamara – combretum – Anogeissusleiocarpus-Acacia gerrardii* woodland/ short and tall, annual and perennial grasses on non-cracking clay soil (Naga).
- *Combretumglutinosum – Guieraseneglensis – sclerocarya-terminalia*laxiflora (board leafed) woodland savannah /short and perennial grasses and forbs on sand soils (Qoz and Atmour).
- The Reqaba water courses and their fringes. The fringes carry tall evergreen woody spp. that provides browse material and cool shade for livestock of all classes (goats, sheep cattle and wild herbivores. The Rqgaba water courses support perennial tall grasses that give re-growth when the dry stems are burned. The re-growth is very palatable. The browse spp. contributes appreciably during the dry seasonforming a good component of animal feed. By the end of the cool season (Winter) the browse spp. produces leaves in response to temperature and humidity change they are generally high in protein and other

nutrients (Fruits, pods and tender green leaves) when the grasses nutritive value is low during the dry season.
- Crop residues and by-products:-These are composed of straw, haulms and straw of groundnut and other legume crops.

Rumamer Proposed Nature Reserve (RNR)

Nature or natural reserve is known to be an area of land designated to conserve the biological diversity of fauna and flora, the other natural resources and cultural aspects. The nature reserve also protects watershed and sequesters carbon dioxide by decreasing its % in the air. The reserve improves the weather in the adjacent area, performs as special area for sustainable development, due to the mutual respect of nature and mankind on meeting needs of human communities adjacent to it, as long as there is no misuse. The loss in the plant cover results in large loss of genetic resources especially animal species. Most of the proposed reserve is located to the north of Bahr Elarab (River Kir) extending east of Rumamer village. The predominant vegetation types are composed of:

- Acacia seyal _ Balanitesaegyptiaca with tall grasses, comprising few annuals (*Rotobelliaexaltata, Brachiariaobtusiflora*, and many perennials (*Andropogongayanus, Panicamsusbalbidum and hyparrhenia spp*. Many woody useful species are encountered.
- The riverine vegetation is composed of ever-green tall trees with some short profused trees:-

Tamarindusindica
Celtisintegrifolia
Ziziphusspina-christi
Diorpyrosmespiliformis
Ficusspp

} Providing food for humans and feed for domestic and wild herbivors

Grandenialutea
Cratevaadonsonii
Acacia sieberiana
Piliostigmareticulatum

The seasonal river waters course and the Raqaba floors carry perennial grasses such as *Echinochloastagnina, vetiveriaoryzabarthii and oryzalongistamenata* that provides grazing during the dry season to domestic and wild animals.

- The wild animals observed during the short period of the survey are:- monkeys, Bush pig activities on the soil searching for grasses root buds and Guinea fowls (Numidameleogris) everywhere.
- Flying birds were seen in the riverine zone in swarms.
- During the survey live fire was observed at a distant of less than 100m, from the road.
- Movements and seasonal migrations of wild animals are dictated by seasonality of the environment (during the period of high water and rainfall (June – November) and during the dry season (December – June).

From the fore going, the proposed nature reserve area is very rich of intact woodland savannah vegetation, that with reduced un-uncontrolled fire hazard, wild animals will return

to the reserve area; provided that the collaboration and active participation of the people (sedentary) is fully acquired. The proposed reserve should have a well-defined boundary, patrol roads, defined livestock; corridors that used to cross the area should not be blocked. The transhumant pastoralists who spend the whole dry season in the reserve and its vicinity should be oriented, sensitized and represented in the reserve protection and management plans committees.

The proposed nature reserve; objectives, expected inputs, the division of responsibilities, the expected development inputs and above all the direct benefits the sedentary agro-pastoralists and the transhumant pastoralists gains should be advocated and clearly stated. Intensive surveys should be conducted during the wet season and dry season throughout, the proposed nature reserve area to document both the funa and flora by species and densities.

7. Environmental Hazards

The main environmental problems in Abyei area: these are:-
- Overgrazing.
- Uncontrolled bush fire.
- Intensive wood cutting along the accessible roads and around the outskirts of settlements.

The heavily cut trees are: *Acacia seyal* and *Anogeissus*. Overgrazing is a serious problem in the vicinity of water sources in the non-cracking clay soils (Gardoud), figure 3. On the dark cracking clays, although complete eradication of the ground cover occurs during every dry season, it is not a serious problem, because large quantities of seeds are confined to the shallow and deep cracks and evenly scattered on the soil surface.

Uncontrolled bush fires are intensively and extensively occurring along the accessible roads, migration routes and in areas where slash burning is practiced to prepare the land for cultivation, figure 3.

The intensive wholesale wood cutting in the area is practiced to meet the returning IDPS demand to build their settlements, to produce charcoal and fire wood for house hold use and the market suggested recommendation to offset the rangeland problems:-
- Regarding the phenomenon of overgrazing which is always associated with water sources vicinities and along the migration routes on the non-cracking clay soil (Gardoud) could be minimizedby seeding of indigenous plants seeds adapted to the environment of the degraded site, early before the rain commences; because at this time the area is to some extent under less grazing pressure.
- For control of bush fires, set by the agro-pastoralists or the nomadic transhumant pastoralists, fire line construction networks should be attempted to confine fire spread to limited area.
- Intensive awareness campaignfor sustainable use of resources among both land users (Messariya who cause most of the fires, and the Dinka) must be conducted. The act concerning the protection of rangeland and regulation of livestock migration of 2001, of the former west

Kordofan state should be reviewed and activated to conserve, preserve natural resources and halt conflicts among agro-pastoralists and nomads reduction.

- For intensive wood cutting, selective thinning with dense plants should be encouraged and the cutting height should not be above or below 50cm height above the soil surface.

The cutting should be done following simple guidelines and methods. Cutting at proper height will give an opportunity for coppicing: hence maintaining the woody stand to some extent intact and regretting.

Figure 3: Overgrazing on (Gardoud) soils and fire and wood cutting in (Atmoor) soils

8. Conclusions and Recommendations

1) Abyei land System is part of a regional landform system composed of a repeating pattern of physiographically interrelated land units created by surface drainage and water flow processes (e.g. deposition and erosion) mainly along Bahr El Arab and Bahr El Gazal. The land system is characterized by the existing repeated pattern of Ragaba (seasonal water channels), Naga'a (flat slightly higher non-cracking alluvial plain), Cracking clay alluvium (slightly Depressional). This land system is bordered by the higher Atmoor sandy plains at the northern parts.

2) Bahr El Arab, RagabaEzZarga and Ragaba Um Bieiro, RagabaEsShaikh and Ragaba El Keik are the main drainage channels within the study area. The first three Ragabas are generally flowing in a south easterly direction towards Bahr El Gazal to join White Nile and last two are flowing from the north to the south direction towards RagabaEzZarga. Although some of the south western parts are draining towards Bahr El Gazal but most of the south eastern areas are drained by Bahr El Arab anditstributaries. Due to channel meandering, sedimentation and the on-going aridity processes, numerous channels have been detached and turned into back swamps and depressions with the appearance of scattered convex sites and levees.

3) Although the area is dominated by the repeated pattern of the four elements (Physiography, soils, vegetation and drainage), but the flat nature of Abyei land have largely contributed in creating a very **complex pattern**. Accordingly, the land units in inventory mapping of such large areas like Abyei, are usually associations of two or more components for each element.

4) In such a complex pattern of land units it could be concluded that detailed and ultra-detailed surveys, supported by high quality remote sensing data are definitely needed to characterize the land units for management purposes especially in irrigated projects of high input capital (e.g. vegetable and fruit farming).

5) The land resources are under more intensive pressure and high demand under post war period. Under the prevailing peace conditions more nomadic and semi-nomadic transhumant pastoralist with hundreds of animals are moving freely beside thousands of returnees who are looking for farming lands, wood for fuel and building houses. Characterization and assessment of land resources are exceptionally needed for planning and development to ensure a proper management and sustainable use of these resources.

9. Acknowledgements

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