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'-29° 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 with the 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 months (in which rainfall is less than half the potential evapotranspiration). 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 provides much 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 an 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.

3. Materials and Methods

Images from ASTER 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 components including 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-calcareous with moderate pH and they are non-saline. The topsoils have strong medium blocky structures. The permeability is moderate to moderately 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 farming 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 Soils were classified 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 brief description 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 covered 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-calcareous 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 Raqaba’ soils were classified as: Entisols and Vertisols, figure 2 and Table 1.

(3) Atmoor Soils
These are the sandy materials of the in situ weathered sandstone ridges. They occupy the upper northern slopes close to the sandstone 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-calcareous 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 existence at much wetter climatic conditions and some of them survived our present dry climtes. These soils were classified as: Alfisols, Inceptisols and Entisols (USDA 2006), figure 2 and Table 1.

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

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5. Biodiversity and Land Use

Abyei area is characterized by its open forest, woodland and extensive rangelands. Since pastoralism 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 watermelons 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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Components</th>
<th>Description (Physiography and Soils)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Raqaba Ez Zarga recent alluvium</td>
<td>Cracking clay 70% 15% Naga 15% Raqaba</td>
<td>Nearly flat plains dominated by cracking clays and located close to Depressional areas with some Raqabas.</td>
</tr>
<tr>
<td>10</td>
<td>North Eastern Clay plain Naga’a Complex</td>
<td>Cracking Clay 55% Naga 25% Atmor 10% Raqaba</td>
<td>Depositional clay plains with some depressions.</td>
</tr>
<tr>
<td>11</td>
<td>Upper Raqaba Ez Zarga Backswamps &amp; Cut-off Raqabas</td>
<td>Raqaba 60% Cracking Clay 25% Naga</td>
<td>Levee &amp; Backswamp Complex of Bahr El Arab.</td>
</tr>
<tr>
<td>12</td>
<td>Dissected erosional sandy plain (Atmoor)</td>
<td>Naga 45% Atmor 45% Cracking Clay</td>
<td>Northern Sand plains.</td>
</tr>
<tr>
<td>13</td>
<td>Dissected Naga’a – Atmoor Complex</td>
<td>Naga 40% Cracking Clay 30% Atmor</td>
<td>Degradational Sloping clay and sandy plains, dissected by numerous Raqabas originating from northern highlands.</td>
</tr>
<tr>
<td>14</td>
<td>Northern Alluvial fans and Naga’a</td>
<td>Naga 50% Cracking Clay 30% Atmor</td>
<td>Degradational Sloping clay and sandy plains, dissected by Raqabas originating from northern highlands.</td>
</tr>
<tr>
<td>15</td>
<td>North eastern alluvial plains</td>
<td>Cracking Clay 60% Naga</td>
<td>Depositional clay plains with some depressions.</td>
</tr>
</tbody>
</table>
limited use of forest for fire wood or as a rangeland is noticed. The main woody species: Acacia seyal, Balanites aegyptiaca, Acacia gerrardii, Anogeissus leiocarpus. The main grasses: Hyparrhenia confines, Brachiaria obtusiflora, Schoenfeldia gracilies, Sorghum lanneolatum. 

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, Balanites aegyptiaca, Anogeissus leiocarpus. The grasses are: Brachiaria obtusiflora, Hyparrhenia confines and Rottoebelia exaltata.

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, Balanites aegyptiaca, Acacia polyacantha. Grasses: Brachiaria obtusiflora, Hyparrhenia confines and Schoenfeldia gracilies.

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, Balanites aegyptiaca, Acacia polyacantha. Tha main grasses are: Hyparrhenia confines, Rottoebelia exaltata, Brachiaria obtusiflora, Schoenfeldia gracilies and Aristidamutabilis.

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

6) **Grass / Forest / bare soil**: This unit is a complex of forest grasses and bare soil (degraded) the unit is intensively grazed. The main woody species are: Acacia seyal, Balanites aegyptiaca, Acacia gerrardii, Lannea humilis, Asparagus Africana. Grasses: Schoenfeldia gracilies, Aristidamutabilis, Setaria incrassata, Hyograghlaspinasa.

7) **Forest / grass on Atmoom**: 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: Combretum glutinosum, Terminalia lauriflora, Albizia amara, Anogeissus leiocarpus, Guierasenelegalis. The main grasses are: Aristidamutabilis, Schoenfeldia gracilies and Andropogon gayanus.

8) **Grass rain-fed cultivation**: Small patches of cultivation occur on different soils including Atmoom. The unit is dominated by grasses and sparse trees. The main woody spp.: Scattered Combretum, Glutinosum, Terminalia. The grasses are: Schoenfeldia gracilies, Andropogon gayanus, Aristidamutabilis. 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, Dichrostachys cinerea, ziziphus, Spina-christi, Dalbergiamelanoxylon. The main grasses are: Hyparrhenia confines, Rottoebelia exaltata, Brachiaria obtusiflora and Setaria incrassata.

10) **Shrubs / grass**: The main woody species are: Acacia seyal, Dichrostachys cinerea, Acacia polyacantha, ziziphus, Spina-christi, Dalbergiamelanoxylon. Grasses: Hyparrhenia confines, Brachiaria obtusiflora, Rottoebelia exaltata and Setaria incrassata.

11) **Reggaba riverine Vegetation**: The main woody species: Evergreen, Celtisintegrigolia, Gardenia lutea, Tamarindus indica, Diospyros mespiliformis, Acacia sieberiana, Ziziphus, Spina-christi, Carvexaudansonii, pilostigma reticulatum, and Ficus spp. on the banks. The dominant perennial Grasses are: Echinochloa stagnina, vetiverianigrntana, 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 make of edible parts of trees and shrubs naturally occurring in the area provided a small portion in the livestock feed.

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 K) through defined migration routes (Marahel).

The rangeland natural vegetation associations according to the field survey (March 2007) can be classified as:

- Acacia seyal – Balanites aegyptiaca woodland savannah/tall annual and perennial grasses on dark cracking clay soil.
- Albizia amara – Combretum – Anogeissus leiocarpus – Acacia gerrardii woodland/tall short and tall, annual and perennial grasses on non-cracking clay soil (Naga).
- Combretum glutinosum – Guierasenelegalis – scleroarya-terminaialaureiflora (board leafed) woodland savannah/short and perennial grasses and forbs on sand soils (Quz 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 Reqaba 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 _ Balanitesegyptiaca with tall grasses,
  comprising few annuals (Rotobelliaexaltata, Brachiariaabtusiflora,
  Andropogongayanus, Panicumsubalbidum and hyparrhenia spp. Many woody useful species are
  encountered.
- The riverine vegetation is composed of ever-green tall
  trees with some short profused trees:-
  \[
  \begin{align*}
  &\text{Tamarindusindica} \\
  &\text{Celtisognaphyllo} \\
  &\text{Ziziphuspina-christi} \\
  &\text{Dierytronerosipliformis} \\
  &\text{Ficusapp} \\
  \end{align*}
  \]
  Providing food for humans
  and feed for domestic and
  wild herbivors

- Grandenialutea \\
Crataceademonii \\
Acaciasieberiana \\
Piliottigmarecticulatum

- Gardoud Proposed Nature Reserve (RNP):
  Characterization of land 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), figure 3.
  - Overgrazing is 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 heavy 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.

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 heavy cut trees are: Acacia seyal and Anogeissus.
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On the dark cracking clays, although complete eradication of
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serious problem, because large quantities of seeds are
confined to the shallow and deep cracks and evenly scattered
on the soil surface.

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:-
- 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 and its tributaries. 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.

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References


