

An Integrated Approach towards Natural Resources Management and Prevention of Resource-Based Conflicts in Sudan

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Abstract: *The study aims to provide evidence for the current natural resources mismanagement and to contribute in developing proper mechanism (model) to improve solidarity in natural resources management. The study area, White Nile and Sinnar States, lies within the arid and semi-arid climatic zones of Sudan where rain-fed farming and animal breeding are the dominant systems of food production. The successive episodes of droughts and fluctuations in rainfall patterns caused decline in land capability and reduction in crop yield. This situation forced the traditional farmers to expand and cultivate more land in most cases at the expense of the pastoral routes and transhumant. The current status triggers resource-based conflicts and necessitates policies and strategies for proper natural resources management. The study adopted an integrated approach of combining remote sensing data (images of Landsat 1999, 2010 and 2014), field surveys, consultations and workshops and discussions with stakeholders. The research developed a conceptual model that integrated four pillars (Information Providers, natural resources managers, owners and beneficiaries of the land resources and the Policy and Decision Makers (enactment)). Accordingly, the natural resources were assessed and the causes of conflict on resources were figured out. The result of this research showed evidence of natural resources deterioration and diminishing of rangelands due to agricultural expansion and mismanagement among other factors that contribute to conflicts. Rangeland in 1999 covered 34% of the total area, in 2010 27% and in 2014 it occupied 15% of the study area with reduction of 19% in area during the last 15 years. It also revealed the poor communications between the actors and the stakeholders in addition to their previous weak capacity and inadequate information on natural resources. The results of consultation and workshop discussions gained the acceptance and satisfaction of stakeholders as related to the model and the proposed integrated approach for vision, views and information exchange and sharing. The research concluded that the proposed model could be adopted to improve the solidarity in natural resources management and mitigation and prevention of conflicts in the study area and elsewhere in Sudan.*

Keywords: Solidarity, natural resources, conflicts, conceptual model

1. Introduction

The Study area comprises White Nile and Sinnar States, where rain-fed farming and animal breeding are the dominant systems of food production. Sudan has one of the largest livestock populations in Africa, including camels, cattle, sheep, and goats, which depends mostly on the natural rangelands. The study area accommodates approximately 12% of the Sudan livestock population (Federal Ministry of Animal Resources report 2010). The successive episodes of droughts and fluctuations in rainfall patterns caused decline in land capability and reduction in crop yield (Elsidig, 2007; Mohamed, 2013). This situation forced the traditional farmers to expand and cultivate more land in most cases at the expense of the pastoral routes and transhumance in the study area as well as in close arid regions of Sudan (Ayoub, 2006; Sulieman, 2008; Adam, 2011). Expansions in rain-fed and irrigated agriculture, overstocking livestock and deforestation are among land use trends that resulted in natural resources and environmental degradation and trigger resource-based conflicts (Gerald and Dorothy, 2013; UNEP 2014).

This study was carried to provide information on the land resources to support their sustainable use and implement an innovated approach and mechanism to improve solidarity in natural resources management and prevent resource-based conflicts. A conceptual model that integrates four pillars (Information Providers, natural resources managers, owners

and beneficiaries of the land resources and the Policy and Decision Makers (enactment) was developed and adopted to generate information and to solidify visions of the stakeholders on natural resources management. Accordingly, the natural resources were assessed and the causes of conflict on resources were figured out.

Information on existing land pattern and change through time is prime prerequisites where reliable information can be generated from remotely sensed data and shared routinely for planning and land management applications (Anderson et al, 1976; Rogan and Chen, 2004; Hamid 2000). For this study information on land use/ land cover was generated using Landsat multi-temporal images dated 1999, 2010 and 2014. Field surveys and consultation workshops were carried out in 2014 jointly with the natural resources managers (Ministry of Animal Resources 2009) addressing beneficiaries (Pastoralists and Farmers) and policy makers of the two States and showing evidence of natural resources deterioration and diminishing of rangelands.

All data and information were integrated in a GIS environment for analysis that resulted in identification of areas with low/high potential in respect to rangelands development. The findings from workshops and the results of the analysis were integrated and shared by the stakeholders as a vital step towards improving solidarity in natural resources management and prevention of resource-based conflicts in the study area.

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2. The Study Area

The study area lies between long $31^{\circ} 00' - 35^{\circ} 00' N$ and lat $11^{\circ} 00' - 15^{\circ} 00' E$ (Figure 1). White Nile state occupies $4,003,800 \text{ Km}^2$ while Sennar state occupies $4,083,100 \text{ Km}^2$ and both making an area of 8086900 Km^2 . The climate of the area is tropical semi-arid according to Mohamed and Mohamed (2010). The average annual rainfall is 400-750 mm which falls mainly in the months of May–September. The landform is characterized by extensive cracking clay

soils (Vertisols) as part of the old alluvium deposits of the flat central clay plain of Sudan which are laid by Blue and White Nile Rivers. This includes White Nile (Kenana) and Blue Nile flood plains with few scattered Jebels and low Azazas. The Azazas are residual yellowish-red soils developed in-situ from remnant Basement and Sandstone formations that are rich in Ferro-magnesium minerals (Williams and Adamson, 1982).

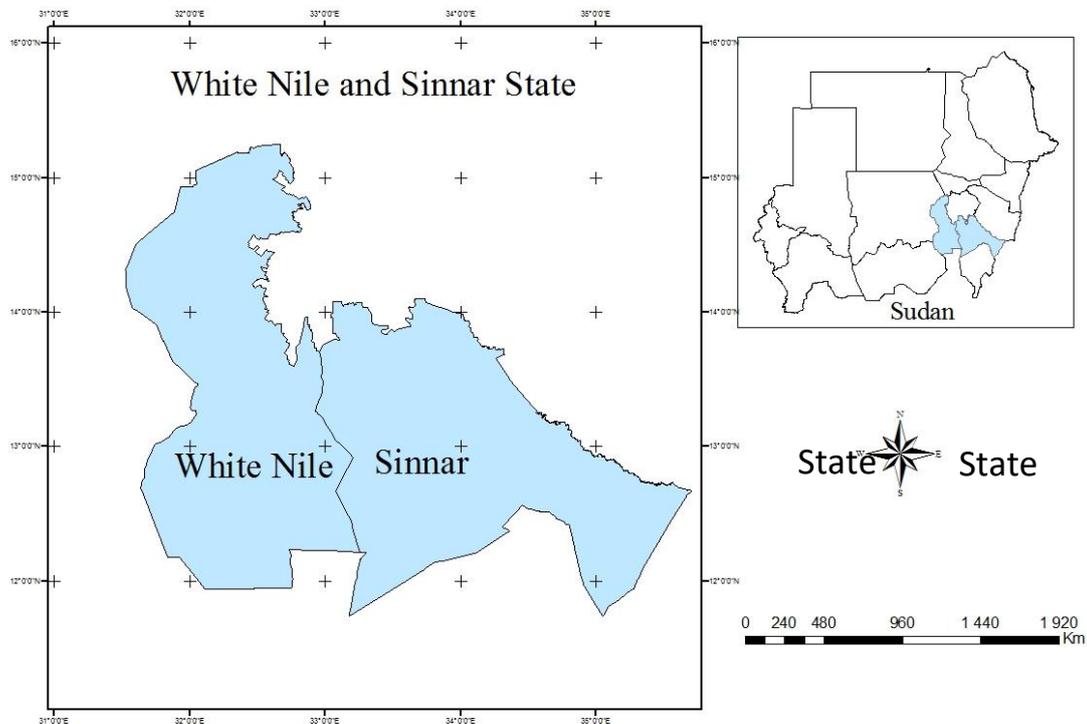


Figure 1: Location of the study area

According to Harrison and Jackson (1958) the natural vegetation is belonging to the low rainfall woodland savannah on clay (rainfall exceeding 400mm), woodland savannah alternating with tall grass areas (rainfall exceeding 570 mm) in Sennar State, while in the White Nile State the vegetation cover is divided into two divisions, the Semi-Desert and the Woodland Savannah on clay. According to Biodiversity Project Survey (1999), the rangelands in Sennar state constitutes about 40% of the total area of the state. The corridors of traditional livestock migration routes stretch between wet and dry season grazing areas. Seasonal water courses, deep khors, natural water pools, Maya and Azaza areas around pediments are potential grazing areas. Crop residues from rain-fed and irrigated schemes in the area are also important grazing sources. In the White Nile State the Baja range is the major rangelands in the State. According to Africover project (FAO 2003) the rangelands area in 1999

covered 46% of Sennar State and 36% of the White Nile State area.

3. Materials and Methods

The research developed and adopted a conceptual model that integrates four pillars (Information Providers, natural resources managers, owners and beneficiaries of the land resources and the policy and decision makers (enactment). All four pillars have same weight to contribute each in his field, in the process of natural resource management and resolve or mitigate conflicts, mainly the resource-based conflicts. Information should be generated, managed in each field and shared by all stakeholders who formed the pillars. Figure 2 shows the model.

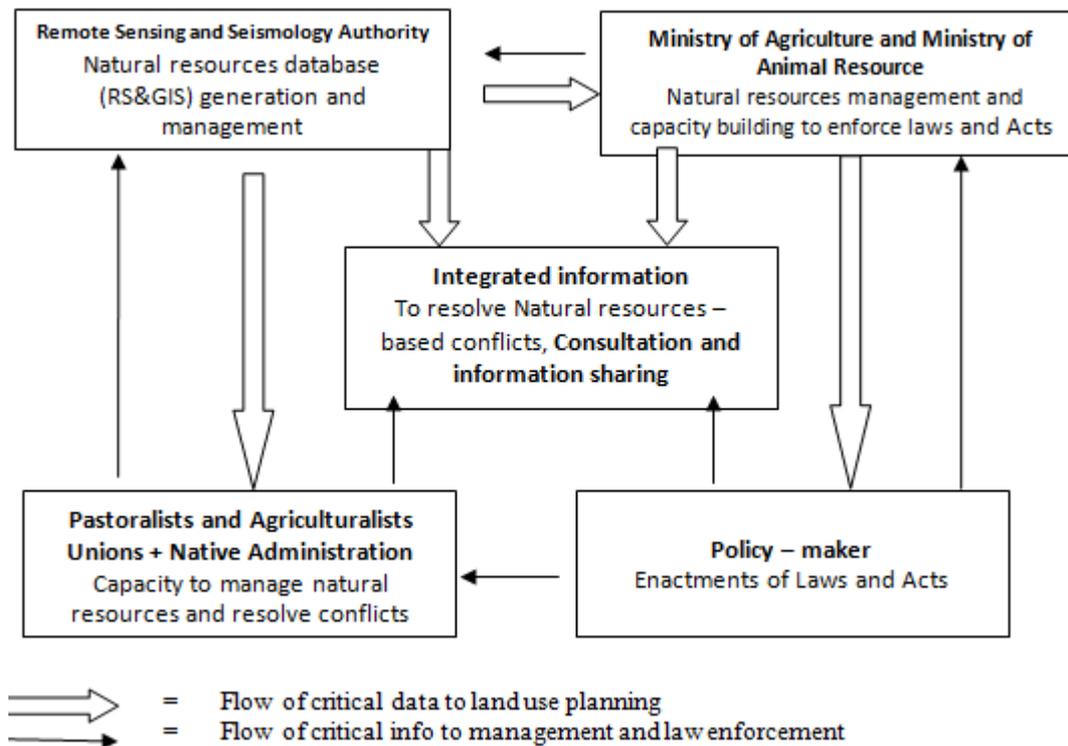


Figure 2: A Model showing Actors and their Role in Natural Resources

4. Management and Conflicts Resolution

An integrated approach of combining remote sensing data, field surveys, consultations and workshops and discussions with stakeholders was used to generate information on natural resource of the study area. Land cover (the observed bio-physical cover on the earth's surface) was assessed as a critical parameter for environmental databases.

Images from Landsat Thematic mapper (TM), Enhanced Thematic Mapper plus (ETM+) and Landsat 8 with their spatial resolution of 30 and 15m were analyzed visually and digitally adopting the FAO Land Cover Classification System (LCCS) to generate information on land cover/land use of the study area for year 2014. Information on land cover of 1999 and 2010 (FAO 2003 and 2012) was integrated in the analysis. Field surveys were carried out during October, November and December 2014 for land cover and land use information validation. Sampling of vegetation and estimation of rangeland parameters was performed. Information was collected from (27) observation points within selected livestock routes and their positions were recorded by GPS. Land use/cover change detection was done by simple post-classification comparison of two dates using 2014 as base image.

Different types of data (e.g. topography, soils, geology and hydrology) from different sources were manipulated, updated, enhanced and incorporated as GIS layers and as an integral part of the rangelands database. The produced database incorporated with socio-economic data is subjected to further analysis and used as base for strategic rangelands planning. Workshops and consultations with stakeholder were conducted as vital and efficient methods to solidify visions in the process of natural resources management and prevention of conflicts in selected priority areas.

5. Results and Discussions

Land Use Assessment

Land cover/use change assessment, analysis and monitoring were performed to generate information that is critical in developing strategies and policies in study area. The analysis showed evidences of conflicting uses of lands. Land use changes, mainly rain-fed cultivation/ grazing and their impacts on the natural resources and their consequences, were clearly identified with the support of remote sensing data analysis and field surveys. Land cover/ land use maps of the study area showed the geographic extent of rangelands and the agricultural areas in the year 2014. Geomorphology and soils of the study area being the main parameter that controls or governs land uses. Figures 3 and 4 are the land use and soils of the study area. The land use/cover change detection revealed information on how much was the change. Table 1 shows areas under the two main land uses in 1999, 2010 and 2014.

The statistics (Table 1) showed that the total area of the White Nile State is 4083100 Hectare. According to FNC (2003), in 1999 35.7% of the total area was covered by agriculture and 45.5% by rangeland. FAO (2012) reported in Sudan Atlas (based on 2010 images) that agriculture covered 50.3% of the area and rangelands covered 31.7% of the White Nile State area in year 2010. Based on RSSA assessment in 2014 the area covered by agriculture account to 59.5% of the State area and rangelands covered 26%. Decline trend in rangelands areas was clearly depicted by the multi-temporal satellite data analysis.

In Sennar State the total area is 4003800 Hectare. According to Biodiversity Survey (1999) 40% of the State was covered by rangelands including forest, in the same year 1999 FNC (2003) assessment of Sudan Cover revealed that the

rangeland cover was estimated to be 23.2 % of the area. In 2010 the rangelands cover 22.5% of Sinnar State, while in year 2014 according to RSSA report the status showed that 70% of the state area was allocated for agriculture including the demarcated mechanized rainfed scheme. Only 4% of the state area was left as rangelands. The area under rangelands

in the two states (the study area) in 1999 was 34.5% while in 2010 it was 27.2% and in 2014 it was 14.8% % of the total area. There is approximately 19% reduction in rangelands area within these 15 years and most of it in Sinnar State (from 23% to 4% reduction excluding rangelands area of the Dinder National Park (DNP).

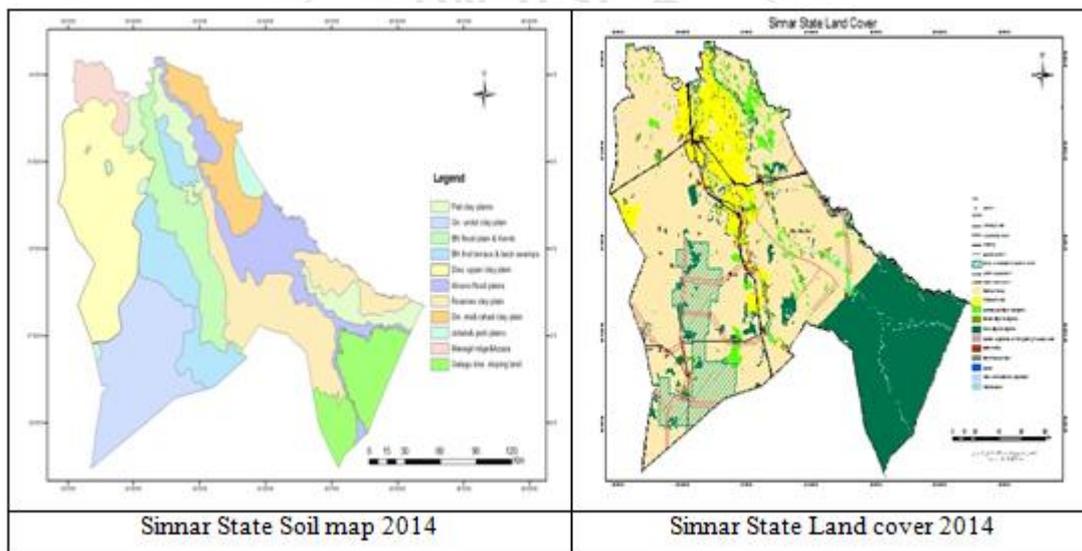
Table 1: Agriculture and Rangelands Areas in White Nile and Sinnar States

State Area Hectare	Land use	1999		2010		2014	
		Area ha	%	Area ha	%	Area ha	%
White Nile 4,083,100	<i>Agriculture</i>	1,459,893	36	2,054,539	50	2,433,100	60
	<i>Rangelands</i>	1,859,603	46	1,296,306	32	1,041,500	26
Sinnar 4,003,800	<i>Agriculture</i>	1,976,948	49	2,458,947	61	2,809,300	70
	<i>Rangelands</i>	931,460	23	904,678	23	161,900	4*

*Excluding Dinder National Park rangelands

The major land use change that has occurred in the area during the 15 years is the increment of the agricultural land at the expense of the pasture land. In Sinnar State the suitability of the soils could be one of the factors that encouraged this trend. Where policy and land use Acts play

major role in this change. Ayoub (1999); Moghraby(2013); FAO (2001); Pualet al (2009); and UNEP (2014) reported the influence of land use policies on the current changes in semi-arid areas of Sudan.



Figures 3: Land cover and soils of Sinnar State

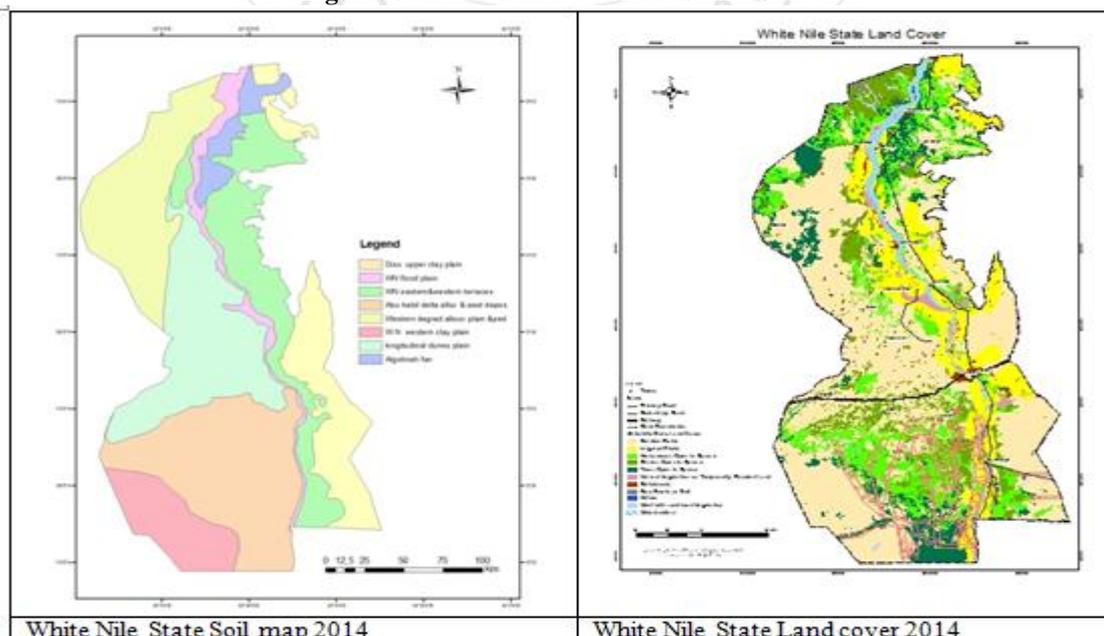


Figure 4: Land cover and soils of White Nile State

6. Rangelands Status

The research revealed deterioration of rangelands that could be attributed to deforestation, overgrazing, wildfire and resources mismanagement (over utilization and underutilization) and this is in agreement with Sulieman (2008) and Adam (2010) who attributed the causes of degradation /desertification in Sudan to the clearance of forest and rangelands for mechanized rainfed agriculture and shifting cultivation. The results revealed degradation in natural vegetation cover and loss of good range that could be attributed to climatic condition, mainly rainfall variability and this result is supported by Hamid (2000) and Elsidig (2007) who stated that the declining trend in rainfall in Sudan has negative impact on livelihood (decline in agricultural production and increase in poverty and vulnerability). However, Mohamed (2013) argued that there is temporary decrease in rainfall rather than a part of persistent long term climate change and this was in an agreement with Hamid (2000) who reported decrease/increase in vegetation cover based on rainfall variability. A number of studies have

examined vegetation trends at semi-arid areas of Sudan and reported its dynamic changes (Hamid 2000; Mohamed 2013; Suilman 2008).

Poor management of the rangelands in the study area is depicted by Figure 5 and 6 and supported by field observations. Figure 5 shows clearly signs of degradation due to overutilizations. Those areas are devoid of vegetation (karab lands along Wadis and Khors, burnt areas and other bare areas. Figure 6 shows lands with high potential for rangelands development. Those lands are underutilized. They are covered by vegetation but they are neglected and not considered for development. Currently there is no or minimum utilization of the rangelands in the northern part of the White Nile State where there no livestock watering points, Figure 6a.. The limiting factor is shortage in drinking water; this problem could be solved through water harvesting and spreading programs. Also considerable part of land is covered by fragmented forest mainly thicket forest that restricts animal movement and prevent growth of grasses, Figure 6b.

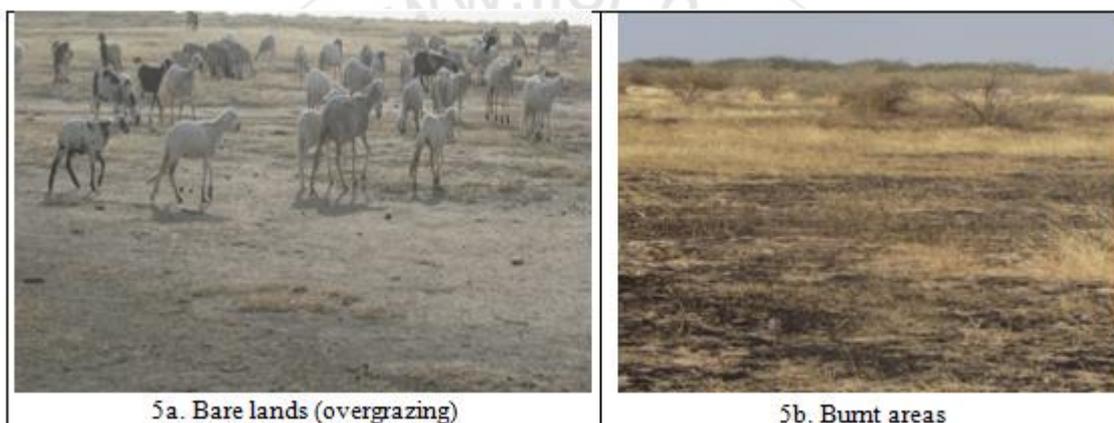


Figure 5: Rangelands mismanagement- Over-utilization



Figure 6: Rangelands mismanagement - Under-utilization

7. Causes of Conflicts

The results of this study figured out the main causes of conflict, that emerged due to the scarcity of rangeland in general (Table 1 and figure 3 and 4) and specifically the blockage of livestock routes as shown by figure 7. The main recognized cause of conflicts is land use change which is

mainly caused by agricultural expansion. Agricultural expansion is a continuous process in the study area; it engulfs some of the grazing areas for livestock and blocks access to drinking water and routes for other grazing lands.

Generally these grazing livestock were moving from place to place using the livestock routes or corridors locally known

by murhal. ("Murhaal" as defined by Saeed (2010) "Murhaal is a living space for free grazing with pasture, water and reproduction depending on the season". The corridor width according to Range and Pasture Legislation of 2013 is 2 Km. According to Saeed, (2010) livestock routes or "Mraheels" have been progressively narrowed by the expansion of rainfed cultivation by both smallholders and large mechanized/commercial schemes. Corridors' widths are reported in places to be as narrow as 20 m, far below viability for sustaining a livestock herd and its movement without intrusion into cropped fields edging the routes.

Figures 7a and 7b show evidence of blockage of livestock routes by agricultural fields.

Elsammai and Mukhar (2013) reported that Land use and land tenure are behind the failure to address sustainability issues in development initiatives, rural poverty and environmental issues. Hence they recommended the inclusion of land policy in the national policy with emphasis on how to manage the arid lands and adjust the current land laws.

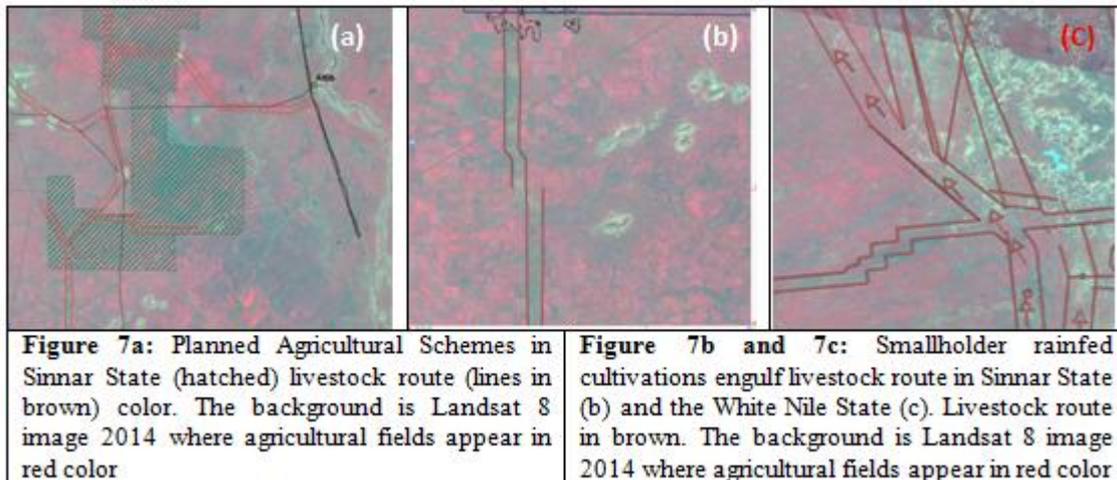


Figure 7: Agricultural fields engulfs grazing areas and blocks livestock routes

Another cause of conflicts is the loss of potential rangelands that is clearly depicted by remote sensing data as an evidence of policy role in conflicts. The pattern of range utilization is characterized by seasonal movement within and outside the different states of Sudan. Many of the southern states of present Sudan used to depend on the grazing resources of the northern states of South Sudan during the dry season for a considerable period of time. The secession of Southern Sudan created a new situation that entailed the movement of the nomads to be restricted within their domains. As well, there is an increase in livestock population, in Sinnaar State livestock population increased from 4,105,190 heads in 2005 to 4,584,090 in 2010 and in the White Nile State it increased from 8,089,958 in 2005 to 8,602,693 in 2010 (FMAR report 2011). This was attributed mainly to the migration of herds from South Sudan to Sudan. According to the research results the estimated total range production in these rangeland areas is far below the feed requirement of the livestock for the whole year (Mahmoud and Fadmula 2014). This requires exploring of other alternatives to provide solutions for the welfare of the local pastoralists.

was figured out from image interpretation and confirmed during the workshop consultations 2014.

8. Approach towards sustainable Natural Resources Management

The research updated and generated information on land use, hydrogeology and soils of the study area, in addition to limited information on livestock routes, watering points and other relevant socio-economic data. All information was integrated into the geo-database. The approach includes component of institutions capacity building in information generation and management to serve as backbone in the process of the natural resources planning and management (Figure 2).

Conflicts are aggravated by the absence of up-to-date information on the natural resources. Adequate information regarding natural resources distribution and their current utilization is vital for land use planning and resource management. Lack of information on present land use complicates the problem due to the issuance of multiple rights and uses for the same tract of land in absence of information. An example for this is the development of agricultural schemes within the livestock route. This problem

The produced geo-database allows monitoring and managing the natural resources. It supports decision making through development of different models and scenarios that predict for example locations and timings of pasture- and agriculture-related conflicts, and landfire monitoring, prediction and automatic mapping. Also the research outcomes and database allowed mapping and demarcation of potential sites for water harvesting and rangelands development (Salih and Hamid 2015) and serve as a base for future developmental strategies and policies (Hamid 2000).

Field surveys, awareness and consultation workshops carried out in 2014 jointly with the natural resources managers (Ministry of Agriculture and Ministry of Animal Resources) addressing beneficiaries (Pastoralists and Farmers) and policy makers of the two States were meant to show evidence of the natural resources deterioration and

diminishing of rangelands. The consultation workshops attended by 185 persons with an aim to encourage communication, coordination and maintain mutual relations between stakeholders. It established platform for data sharing and exchange of views and idea for problems solution. Such consultations paved the way towards collaboration and expected to improve solidarity in resource management and conflict resolution.

9. Conclusions

The study concluded that:

- 1) Remote sensing data from Landsat 30 m resolutions is suitable for land use land cover classification, documenting Land cover/use changes and provide evidence of the impacts of land use laws and Acts on the study area.
- 2) There is reduction in rangelands during the last 15 years 1999-2014. 19% of the total area of the rangeland has been converted to cropland in addition to that there is a loss of good range approximately 5% of the range area is over/under utilization due to poor management.
- 3) The national land use policy is recognized as a main cause and driver of conflicts. Act 1970; Land for all and the Mechanized Rainfed Agriculture Act 1980 have resulted in vast deforestation and overgrazing. The Encouragement of Investment Act 1999 which calls for the promotion of investment creates favorable conditions and privileges for investors without giving consideration to local communities such as smallholder farmers and pastoralists, hence enhances resource deterioration and conflicts between the two groups.
- 4) Moreover the present land use Acts have weakened the Native Administration role in land management and weakened the state capacity to enforce the enacted law if there is any.
- 5) The proposed integrated approach that combined Information Providers, natural resources managers, owners and beneficiaries of the land resources and the Policy and Decision Makers (enactment) gained the acceptance and satisfaction of stakeholders as related to the model and the proposed integrated approach for vision, views and information generation, exchange and sharing. As stated in UNEP (2014) sound environmental governance, which builds on equitable and sustainable management of natural resources, plays a key role in supporting sustainable livelihoods and building lasting peace.
- 6) The proposed model could be adopted to improve the solidarity in natural resources management and mitigation and prevention of conflicts in the study area and elsewhere in Sudan.

10. Recommendations

Sets of measures for better resource management and conflicts prevention were drawn based on the research findings and workshop consultation

- 1) Emphasize and support the use of remote sensing and GIS technology to update the natural resources database and conduct rangelands inventories and support and improve systems of information generation on resources availability, accessibility and their current and potential

use and establish *Rangelands Management Information System*.

- 2) Enhance and encourage collaboration and information sharing and exchange of views and ideas related to resource management (participatory approach through regular meetings and consultation workshops) and maintain full coordination between the farmers and herdsmen unions in order to create mutual relations and to achieve mutual benefits.
- 3) State a clear land use policy and develop a land use plan that should be environmentally and socio-economically sound. Enact or reinstate laws regarding land use planning and enforcement and strengthening the institutions capacity and the Native Administration to enforce the law.
- 4) Further research and field works should be carried out focusing on tracking the implementation of the integrated approach outcomes in resources management and conflicts resolution.

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