Stakeholders' Perception on Impacts of Natural Environment Deterioration and Armed Conflict on Plant Production: Case Study of North Darfur State - Sudan

Abubakr M. Juma Siam*[1], Ibrahim Ali Elnour[1] and Yousif M. Ishag Jimpy[1]

[1]Department of Forestry and Range Sciences, Faculty of Environmental Sciences & Natural Resources, University of Al Fashir, P.O.Box125, El Fasher, North Darfur, Sudan

Corresponding author: abmjsiam@gmail.com

Received: December 12, 2018 Accepted: February 4, 2019

Abstract: *The study was conducted to assess the awareness and perception of local farmers with the causative factors of environmental degradation and to analyze the interactions of natural resources, rural livelihoods and armed conflict in North Darfur State. Six localities: El Fasher, Maleit, Malha, Kabkabia, Darsalam, and Omkadada were selected as study field using stratified random sampling method. A total of 300 interviewees were randomly selected for the household survey adopting semi-structured interviews. Questionnaires were used to collect socioeconomic characteristics. Key informants' interviews and group discussions were also used to obtain additional information. The results revealed that great changes have been taken place in quantity and quality of natural vegetation towards negative trends according to respondents' views. Majority of interviewees agree that the disappeared vegetation types were more palatable to livestock. About 88% of interviewees are farmers and agro-pastoralists, where their main food crops are millet and sorghum. While the cash crops are represented in groundnuts, water melons, and tobacco. However, during last decades the crop production was kept decreasing pattern due to climatic and anthropogenic factors spreading food insecurity. The impacts of ecosystem resource diminishing and armed conflict on each other and their effects on livelihoods became clear and recognizable by the local people. The community perception of ecosystem degradation in the area could be used to set strategies for conservation and rational use of natural resources. The study recommends for further investigation about the impacts of natural resource degradation on livelihood and plant productivity in the region.*

Keywords: Environmental degradation, Food security, Livelihoods, Natural resources

1. Introduction

Natural resources are building blocks and strongly linked to the livelihoods of most countries in Africa and elsewhere and are the basis of subsistence in many poor communities (Maranga *et al.*, 2010; Lind *et al*., 2012; Sinare and Gordon, 2015). Natural resources account for 26% of the

wealth of low-income countries (UNEP, 2007a) and are the mainstay of many developing economies. The world natural ecosystems are capital assets if properly managed; they yield flow of vital services including the land, water, and production of goods such as food, fiber, timber, bioenergy, and can be foundation for transformative change (Daily *et al.*, 2000; Harris, 2004; Sanginga *et al*., 2010; Power, 2010; Nawrotzki *et al*., 2011; ADBG, 2014). Thus, livelihoods of mankind collectively remain natural environment dependent. For example in Africa more than 320 million people depend on dryland forests to meet their various basic needs and more than 90% of the populations in Sub-Saharan Africa rely on firewood and charcoal as source of fuel energy (Chidumayo and Gumbo, 2010). It is obvious that, natural resources play dual role in life net, it is part of ecosystem component on a side and of socio-economic system on the other side. In that sense means, measures, and approaches to restore degraded environments have social and economic implications (Gebregziabher *et al*., 2017; Masoudi *et al*., 2018; Amiraslani and Caiserman, 2018).

In North Darfur natural recourses are considered to be backbone of life, as livelihoods of more than 80% of populations depend on rural agricultural activities competing over diminishing resources (PA, 2014). Moreover, the dominant energy source in rural as well as urban North Darfur is firewood and charcoal. Cereal crops mainly millet and sorghum are tend to be staple food particularly for rural dwellers in Darfur (Hadi, 2013a). However, under increasing rates of populations, frequent occurrence of drought, and ongoing armed conflict; the deterioration of natural resources become inevitable (Jasper and O'Callaghan, 2008; Abdelaziz *et al*., 2012; Lind *et al*., 2012; Sulieman *et al*., 2013). Severe arid condition on the northern parts of State had pushed people to the southern parts causing acute pressure on natural resources (Siam *et al*., 2014; Abdalla, 2014). In Darfur a third of the forest cover was lost between 1973 and 2006 (UNEP, 2007b), destroying the vast sources of livelihoods and subsistence of local communities. Cycles of drought in the 1970s and 1980s and the resulting desertification of the northern parts of Darfur rendered different groups against each other in disputes over increasingly scarce natural resources (Jasper and O'Callaghan, 2008). Thus, causes of catastrophic armed conflict erupted in Darfur in 2003 were might partially refer to environmental factors. Resource management institutions are entirely collapsed in the area and more than 25%

of the population have been displaced (PA, 2014).

Thus the recognition of degradation causative elements by stakeholders including local people and respective institutions tends to be corner stone towards collective action for situation improvement. Awareness of rural men and women with the situation of resources; increases the likelihood that their needs and priorities are heard and addressed by policy makers (Kaaria and Osorio, 2015; Wayessa and Nygren, 2016). People have to learn to manage ecosystems in order to assure sustainability in broad sense which implies securing long term productivity and protecting given resources (Laresen, 1995; Blaikie, 2006; Harvey *et al*., 2018; Okereke and Stacewicz, 2018). Because, lack of public awareness about the importance of ecosystem often leads to its misdeem and degradation (Mohammed and Mengist, 2018). The aim of this study was to assess the awareness, identification, and recognition of local community with the causative factors of environmental degradation and to highlight interactions of natural resources, rural livelihoods and armed conflict in North Darfur State. The specific objectives were to: (1) assess the perception of local community with the impacts of natural environmental factors on vegetation type and crop production, (2) evaluate the impacts of fragile natural environment on vulnerability of local people to food insecurity, and (3) identify the effects of armed conflict on agricultural production and livelihoods of rural community in North Darfur State.

2. Material and Methods

2.1. Description of the study area

North Darfur State locates between latitude 12-20^{o}N and longitude 24-27^{o}E occupying area of 290,000 Km^{2}. Climate is typical Saharan-Sahelian zone. Magnitudes of rainfall range from zero in the north to 500 mm/year in the south with rainy season lasts about 75 days whereas 90% of rain falls between July and September (Abdalla, 2014). The average of higher and lower temperatures is 41 and 18 ^{0}C respectively (Hadi, 2013b) in El Fasher. Months of May and April show the highest rates of temperature; meanwhile December and January are the lowest (FMS, 2015). North Darfur occupies more than half of the area of greater Darfur region, and includes part of the high volcanic origin mountain known as Jebel Marra in the southwest site (Abdalla, 2014). The area between 16 – 20^{o}N is entirely desert with no land use activities and equivalent 50% of whole area of the State (Fadul, 2004). To the south there is slightly more rainfall with the eastern side

characterized by plain lands with low sandy hills (Abdalla, 2014).

The key feature of vegetation is desert and dry savanna consists of annual grasses and perennial woody thorny and dwarf trees and shrubs (Abdalla, 2014) with few broadleaved tree species around water courses. The main perennial natural tree and shrub species include *Acacia tortilies, Acacia melifera, Acacia nubica, Boscia senegalensis, Caparis deciduas, Maerua crassifolia, calotropis procera, Leptadenia pyrotechnica, Balanites aegyptiaca* in the sandy and clay rocky areas, while *Fedherbia allbida, Acacia nilotica, and Ziziphus species* grow on the water courses basins. The main annual natural plant species are: *Aristida sp, Cenchrus setegrus, Hygrophyla spinosa, Euphorbia sp, Ipomea sp, Dactyloctenium aegyptium, Echinochloa sp, Tribulus terristeris, Eragrostis sp, Schenofeldia gracilis, Sporobolus marginatus, Tephrosia uniflora, Striga gensnerioids* and *Cida cordifolia*. Sandy soils are the main soil of area found either in stabilized or moving dunes. While clay soils are found on the coasts of river and water courses. In this study, the natural environment and natural resources are used interchangeably. The term environment generally refers to a natural resource base that provides sources and performs sink functions (Bucknall, 2000; Sanginga *et al*., 2010).

North Darfur is bounded on the northwest by Libya, on the west by Republic of Chad and West Darfur State, on the east by Northern State and North Kordofan, on the southeast by West Kordofan, on the south by East and South Darfur, and on the southwest by Central Darfur State. North Darfur State consists of 17 localities: El Fasher, Maleit, Malha, Kutum, Kabkabia, SarafOmra, El Sireaf, Um Buru, Kornoi, Tina, Tawila, Darsalam, Omkadada, Klaimendo, El Taweisha, Alliet, and El Kuma. El Fasher town is capital of the State. The names of all localities are derived from their administrative headquarter towns. Six localities (Figure 1) namely: El Fasher, Maleit, Malha, Kabkabia, Darsalam, and Omkadada representing different geographical directions of the State were selected for the data collection, their coordinates are shown in Table 1.

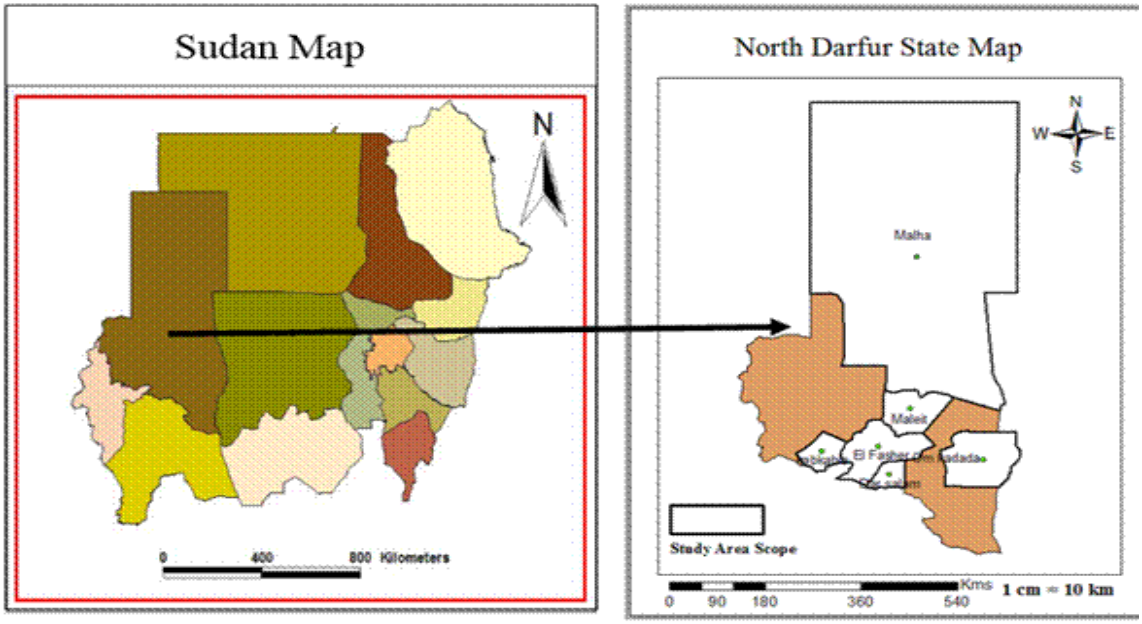

Figure 1: North Darfur map shows the six study localities

Table 1: Coordinates of six study localities in North Darfur state

Locality	El Fasher	Maleit	Malha	Omkadada	Kabkabia	Darsalam
Latitude	13.63° N	14.25° N	15.01° N	13.23° N	14° N	13.03° N
Longitude	25.33° E	25.45° E	26.27° E	26.62° E	24° E	25.33° N

2.3. Types of data and method of collection

Data of study were obtained from primary and secondary sources. Primary sources include questionnaires, field visits, interviews and discussion with key informants in addition to personal accumulative observations. The fore mentioned six localities were selected for household and field survey using stratified random sampling method. A total of 300 interviewees (50 per each locality) were randomly selected for the household survey using semi-structured interviews. Questionnaires were used to collect socioeconomic characteristics (viz. gender, age, education level, occupation, vegetation status, crop type, production trends, factors affecting production). Additional information was also obtained through key informants' interviews and group discussions. Secondary sources based on extensive scientific literature, and records pertinent to the subject. Cereal crop production including total production

and consumption demand for period of 25 years (1991-2015) were obtained from Planning Unit (PU) of State Ministry of Agriculture (SMA). Agricultural production data of 2006 and 2007 were not available, because the data of 2006 were incomplete and the survey was not taken in 2007. Forest tree and rangeland plant status were obtained from Forest National Corporation (FNC) and Directorate of Rangeland and Fodder (DRF) respectively. Rainfall records of localities for 30 years (1985-2015) were obtained from El Fasher airport and agricultural meteorological stations in the State. Figure 2 shows rainfall of El Fasher locality for 30 years (1985-2015).

Figure 2: Rainfall variables for the period from 1985 to 2015 at El Fasher locality

2.4 Statistical Analysis

For the calculation of means and percentage of variables the Statistical Package of Social Science (SPSS) was used. Relationship between five localities coordinates (longitudes and latitudes) and average of respective total rainfall was established using excel program regression analysis and the significance of correlations was tested at $P = 0.05$. Darsalam locality was excluded from regression analysis due to incomplete of respective rainfall data.

3. Results

3.1 Perception of local communities of the impacts of ecosystem deterioration on natural vegetation and crop production

3.1.1 Status of the natural vegetation

Compared to the last two decades abundance of natural vegetation is poor today according to the views of 47.4% of interviewees (Figure 3). Forty percent of respondents considered the abundance of vegetation is medium and only 12.6% believe that is good. Eighty seven percent

of El Fasher and more than 60% of Kabkabia and Omkadada interviewees indicated that the plant abundance is poor. Seventy percent of Maleit and more than 40% of Darsalam and Malha interviewees believed the change of plant abundance is medium. On the other hand, more than 80% of farmers indicated that many plant species in the area were disappeared (Figure 4). Hundred percent and 90% of Omkadada and Malha dwellers respectively were responded that many plant species were disappeared. It is worth mentioning that 89% of respondents were indicated that the disappeared plants belong to preferred-plant species by animals (Figure 5). Hundred percent and more than 90% of Malha and El Fasher interviewees respectively indicated that the disappeared vegetation types are belonging to palatable plant species for animals.

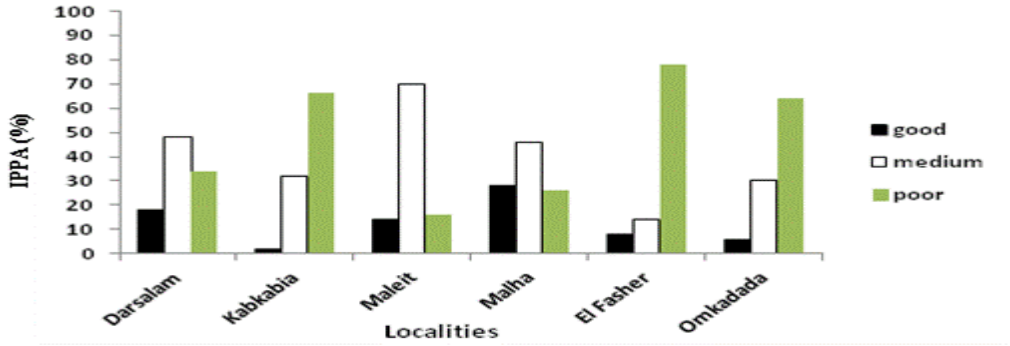

Figure 3: Interviewees' perception of plant abunndace (IPPA) at six localities in North Darfur. Black, white, and green columns represent good, medium, and poor respectively.

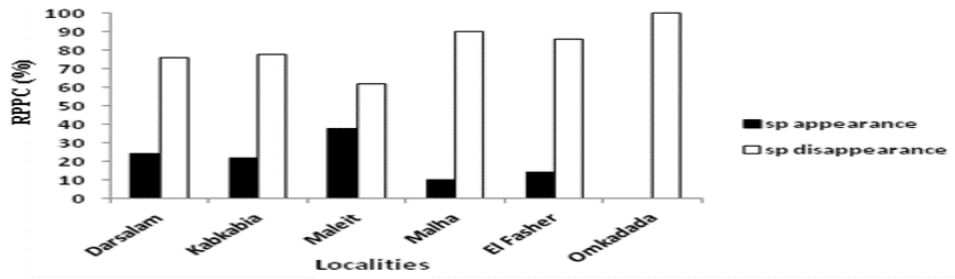

Figure 4: Respondents' perception plant species change (RPPC) at six localities in North Darfur. Filled and empty columns represent plant species appearance and disappearance, respectively

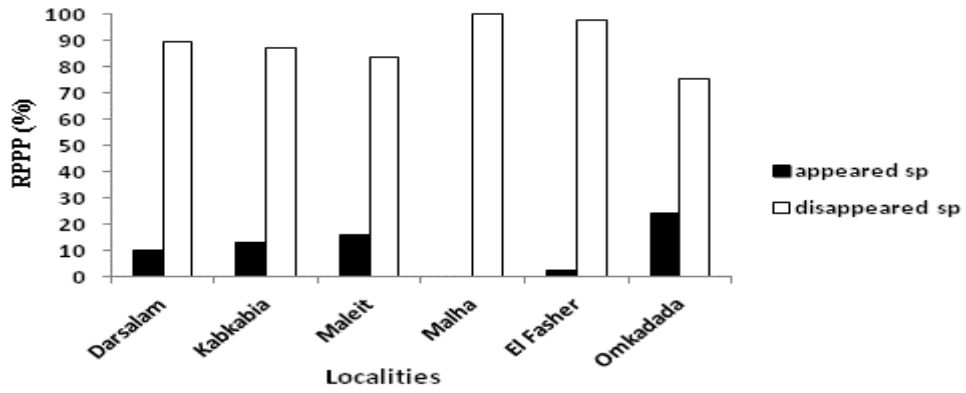

Figure 5: Respondents' perception of plant species preference (RPPP) by animals at six localities in North Darfur. Filled and empty columns represent appeared plant and disappeared plant species, respectively

3.1.2 Socio-economic characteristics

The results revealed that male and female household head represent 66.3 and 33.7% respectively among the respondents (Figure 6). About 55% of interviewees are farmers and 33% are agro-pastoralists (Table 2). In El Fasher locality the female household represents 56%. The age of household head range 40-59 and 20-39 years represent 47.7% and 41% respectively. More than 85% of interviewees have acquired reading and writing level of education.

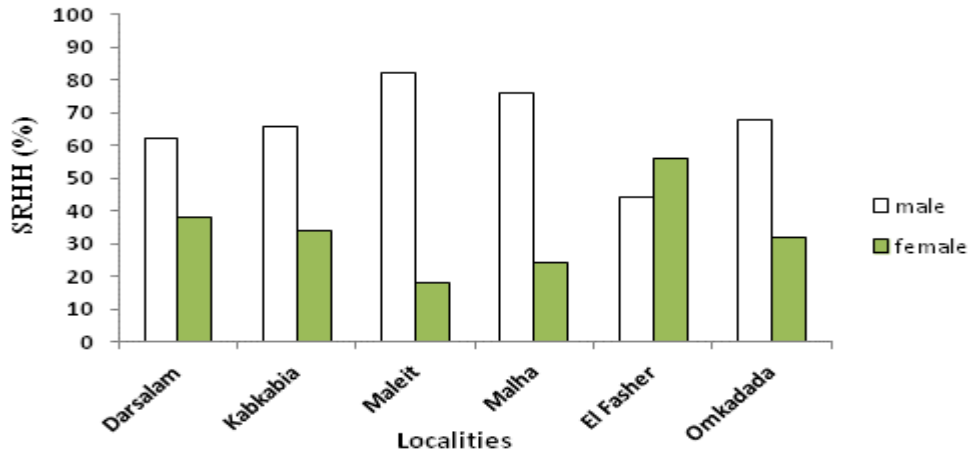

Figure 6: social gender of respondents' household heads (SRHH) at six localities in North Darfur

Table 2: Basic socio-economic and education of interviewees at six localities of North Darfur State

Locality	Age of house hold head (%)			Education (%)		Occupation (%)			
	20-39	40-59	>60	Illiterate	Literate	Farmer	Pastoralist	Agro-pastoralist	Others
Darsalam	44	50	6	4	96	48	2	28	22
Kabkabia	46	38	16	14	86	68	0	4	28
Maleit	50	48	2	8	92	48	2	48	2
Malha	40	46	14	20	80	20	6	72	2
El Fasher	44	46	10	12	88	80	0	18	2
Omkadada	22	58	20	28	72	64	6	26	4
Average	41	47.7	11.3	14.3	85.7	54.7	2.7	32.7	10

Table 3: Types of food and cash crops grown at six localities of North Darfur Sate

Locality	Millet (%)	Sorghum (%)	Water melon (%)	Groundnuts (%)	Tobacco	Millet + sorghum (%)	Millet+ watermelon + Groundnuts (%)	All + others (%)
Darsalam	12.2	6.1	8.2	44.9	2	8.2	14.3	4.1
Kabkabia	19.5	12.2	4.9	14.6	0	43.9	0	4.9
Maleit	70	0	0	0	0	28	0	2
Malha	38	0	2.1	2.1	0	53.2	0	4.6
El Fasher	12.2	2	0	0	10.2	4.1	0	71.4
Omkadada	4.1	0	8.2	0	0	0	73.5	14.2
Average	26.3	3.2	3.9	10.2	2.1	22.1	15.1	15.8

3.1.3. Crop production

Table 3 shows that main crop type produced in North Darfur is millet as indicated by more than 26% of respondents. In addition to that about 22.1% responded they grow millet and sorghum. In Maleit locality 70% of interviewees mentioned that they grow millets. In Darsalam about 45% indicated that they produce groundnuts. In Malha and Kabkabia about 53% and 44% responded that they grow millets together with sorghum. The farmers grow watermelon and groundnuts beside millet represent 73% in Omkadada locality. In El Fasher locality more than 71% responded that they grow all types of crops in the question with various other crops.

For the periods 1990-2003 and 2004 -2015 about 69.3% and 90.7% of respondents respectively indicated that there was decrease in crop production (Table 4 and 5). More than 51% of target group believed that the rainfall was main factor of decrease for the period 1990-2003. Fifty percent of respondents of Kabkabia locality indicated that the insecurity was the reason of production decrease for such period. While for the period 2004-2015, about 42.9%, 25.5%, and 24.5% of respondents indicated that all factors together, rainfall, and insecurity as main factors beyond crop production decrease respectively. In Omkadada 62.8% of surveyed farmers believe that the rainfall variability was a cause of production reduction while 76.6% of Maleit farmers attributed reduction to armed conflict. About 68.8% in Darsalam, 65% in El Fasher, 53.1% in Kabkabia, and 51.2% in Malha linked production decrease with all listed factors (rainfall, armed conflict, desertification, and soil infertility) for the period 2004-2015.

Table 4: Crop production patterns for period from 1990 to 2003 at six localities of North Darfur State

Locality	Production trends (%)		Factors of decrease (%)				
	Increase	Decrease	Rainfall	Desertification	Soil infertility	Insecurity	All
Darsalam	42	58	66.7	3	3	15.2	12.1
Kabkabia	40	60	6.7	3.3	0	50	40
Maleit	62	38	66.7	0	0	33.3	0
Malha	18.7	81.3	84.6	2.6	10.3	2.5	0
El Fasher	12	88	28.3	4.3	21.7	4.3	41.4
Omkadada	4	94	58.3	20.8	20.8	0	0
Average	29.9	69.3	51.4	7	11.7	13.6	15.5

Table 5: Crop production patterns for period from 2004 to 2015at six localities of North Darfur State

Locality	Production trends (%)		Factors of decrease (%)				
	Increase	Decrease	Rainfall	Desertification	Soil infertility	Insecurity	All
Darsalam	6	94	22.9	0	0	8.3	68.8
Kabkabia	2	98	0	0	0	46.9	53.1
Maleit	8	92	8.5	0	0	76.6	14.9
Malha	22	78	46.2	0	0	2.6	51.2
El Fasher	14	86	16.3	7	4.7	7	65
Omkadada	4	96	62.5	20.8	12.5	0	4.2
Average	9.3	90.7	25.5	4.7	2.9	24.5	42.9

As shown in Figure 7 the relationship between average total rainfall and longitudinal coordinates of localities was very strong (R^2 = 0.98), where the precipitation decreases from west to eastwards. However, the rainfall amounts were poorly correlated (R^2 = 0.0002) with latitudes of the localities under this study (Figure 8).

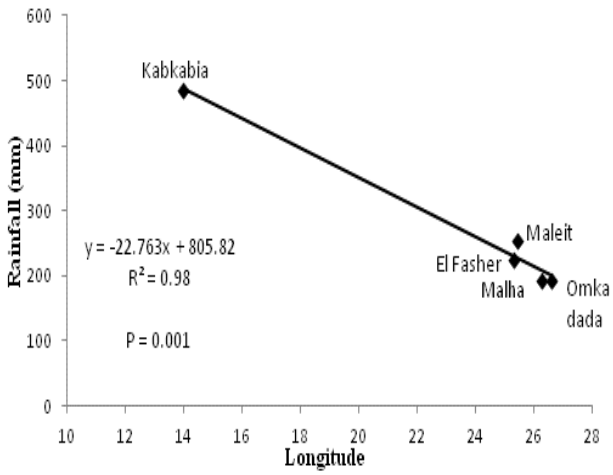

Figure 7: Relationship between precipitation and longitudes of five localities in North Darfur State

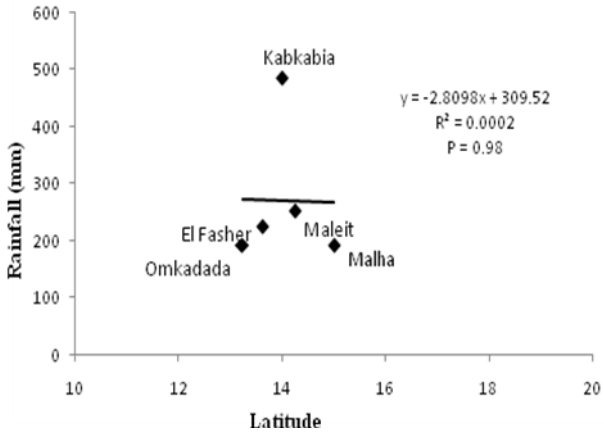

Figure 8: Relationship between precipitation and latitudes of five localities in North Darfur State

4. Discussion

4.1 Local communities' perception of ecosystem deterioration impacts on the natural vegetation and crop production

As shown in the results great changes have been taken place in availability and quality of natural vegetation towards negative trends according to respondents' views. Such changes are presumably exposing North Darfur area to high risks hence making local communities more vulnerable to disturbance of livelihood bases. Fragile natural resource base due to variability of rainfall in amount and distribution within the same year and from year to year has exposed the Darfur region to environmental erosion and production hazards (UNEP, 2007b; Abdelaziz *et al*., 2012). Climate change specially rainfall often affects the plant growth and alters the functioning and resilience of ecosystems such as rangelands and forests, which support the livelihoods of dryland inhabitants (UNEP, 2007b; FAO, 2010, 2012; Kim *et al*., 2016). Magnitude of change in vegetation is locality specific since the majority of El Fasher, Kabkabia, and Omkadada respondents believed that plant availability is poor while those of Maleit, Darsalam and Malha considered the vegetation abundance as medium. It is worth to mention that the magnitude of vegetation change is also subjective as there no standard or quantitative measurements in this study.

However, almost all interviewees in all localities agree that the disappeared vegetation types were palatable to livestock. Thus, disappearance of palatable plant species immediately impact on

livestock production hence livelihoods of people. Profound alterations in plant ecosystems and services they provide to human being and animals are already and will increasingly play a pivotal role in livelihood and food security (FAO, 2007; Backlund *et al*., 2008; ESF, 2010; Somorin, 2010). The community perception of vegetation change in the area could be used to restore and maintain the preferred indigenous plant types. For instance through initiating projects of improved planting techniques and seed germination properties. The assessment and identification of use and knowledge of local rural communities with their surrounding ecosystems assist in setting development, conservation, and community-based natural resource management strategies (Reyes-Garcia *et al*., 2005; Blaikie, 2006; Siam *et al*., 2014). The stakeholders' acknowledgement of the role of natural vegetation in livelihood activities may lead to community support for conservation projects. Local participants' perception of the livelihood project benefits has induced community support for forest conservation in rural areas of Madagascar (Harvey *et al*., 2018).

More than 88% of respondents are crop farmers or agro-pastoralists growing crops and or rear livestock for their livelihoods as detected by socio-economic analysis. The findings agree with statement that in North Darfur more than 80% of populations depend on rural agriculture as base of livelihoods (PA, 2014; SMA, 2014). Although, the majority of household head are male the collective response of interviewees could not be changed since there is no specific livelihood confining specific social gender (Siam *et al*., 2014). On the other side, acquisition of writing and reading level of education by great ratio of respondents shown in the study would help in adoption of environmental awareness and advocacy. It is obvious that main food crops are Millet locally known as *dukhun* and sorghum (*dura*), while the cash crops are represented in groundnuts, water melons, tobacco, and various types of fruits and vegetables. Northern localities namely Maleit and Malha farmers are mainly depend on millet as staple food crop and they don't grow sorghum and tobacco. Cultivation in Darfur is largely taken place in sandy lands and small range practiced in relatively more productive alluvial soil around watercourse. Valley bottomlands are key areas for cultivators and pastoralists providing source of arable or grazing during drought or dry seasons in Savanna Africa (Scoones, 1991). Agro-pastoralism activity which combines sedentary farming and livestock herding is

also common practice in North Darfur as revealed by the study results. However, during last decades the crop production is immensely decreased due to rainfall variability, insecurity, and other factors. According to views of more than 50% of interviewees precipitation was the main factors of production decrease for the period from 1990 to 2003. Many factors such as recurrent drought, rainfall variability and scarcity, desertification, deforestation, overgrazing have acted against agricultural productivity in Darfur (Fadul, 2004; Robinson, 2005). Food insecurity became usual event in North Darfur during the last decades as the total production of cereal runs below the total consumption amounts (SMA, 2014). The rainfall magnitudes were increased towards west localities as exhibited by strong direct longitudes relationship. The phenomenon might be corroborated to the location of some western localities such as Kabkabia within or near Jebel Marra territories where the precipitation is relatively high compared to the other areas of north Darfur. However, either strong or weak correlation between rainfall and geographical coordinates should be taken with caution because rainfall distribution and intensities in North Darfur are greatly varying even within area less than 10 km^2.

Total cereal production failure is a common phenomenon, for instance the deficit of production was more than 90% in 2009 and 90%, in 2004 (SMA, 2004). Consequently farmers expand their cultivated lands horizontally to maximize production for self satisfaction. The horizontal expansion equals 125 -150% compared to that of sixties of last century (Fadul, 2004). The sedentary farmers adopted various strategies to cope with the harsh environment such as rearing small animals, collection of firewood, charcoal, building pole and fruits of some forest trees and dry fodders for selling to buy food crops and other commodities when necessary. However, such trends have compounded degradation of natural environments including forests, range lands and water catchments. The situation after year 2003 was aggravated by armed conflict whereas great sector of rural farmers have been displaced to Internal Displaced Persons (IDPs) camps around larger cities leaving their farmlands behind. Therefore, people believe that armed conflict was main factor beside rainfall in crop production decrease for the period 2004-2015. Within this context, the views of more than 76% and 46% of Maleit and Kabkabia respondents respectively correlated the crop production decline with the impacts of armed conflict over the period following year 2003.

Sedentary farmers' displacement from farmlands in response to armed conflict has resulted huge decrease in crop production. Before conflict there were seasons with sufficient or surplus crop production depending on precipitation conditions, but since 2004 up 2015 there was no year of surplus production (SMA, 2014). Consequently, about fifty percent of respondents linked the crop production decrease with armed conflict beside precipitation variability.

4.2 Impacts of natural resources degradation on armed conflict occurrence

According to the interviews and questionnaires findings the precipitation scarcity with consequent natural resource depletion are widely perceived as causative factors of armed conflict. Decline in precipitation due to regional climate change has been significant stress factor in arid areas of Sudan particularly in Darfur and Kurdufan (UNEP, 2008a); for the period 1978 – 2007 average annual rainfall value was only 194 mm in El Fasher and much of this rainfall is concentrated in a few months of the year. The fragile environment with a consequent food insecurity due to change in the magnitude of rainfall become the dominant and real condition in North Darfur (Hadi, 2013a). Thus, environmental and natural resource degradation seemed to be one of the prominent factors provoked land ownership disputes and conflict between pastoralists and farmers and between pastoralists themselves in Darfur (Fadul, 2004; Bromwich, 2008; Lind *et al*., 2012). There are at least three scenarios could exemplify occurrence of conflict that resulted from increase rate of drought and desertification: acceleration of drought and desertification lead to: (i) deforestation, overgrazing, increase of dry lands, diminishing of water resources, change in seasonal movement of nomads, destruction of crop stands of sedentary farmers by nomad animals, then conflict between nomads and farmers, (ii) low agricultural production, expansion of agricultural lands at the expenses of rangelands, diminishing of grazing areas, entrance of nomad animal to villagers farms, and then development of conflict, and (iii) rangelands degradation, mass death of animals due to lack of pastures and fodder, feed animals with peasants pre-harvesting agricultural crops, thus development of conflict. These scenarios are further triggered by political interventions and ethnic tension causing pervasive conflict. Generally, in Sudan the impacts of climate change and desertification are clearly linked to ongoing war, as there are strong indications that the hardship caused to nomadic communities by precipitation

deficit and desertification is one of the underlying causes of the conflict in Darfur (UNEP, 2007b).

4.3 Impacts of armed conflict on natural resources

The armed conflict erupted in Darfur in 2003 has resulted catastrophic humanitarian situation with large numbers of IDPs and refugees around cities and neighboring countries. Subsequently, insecurity within IDP camps is also became a major issue and affects many informal livelihood activities that have emerged in and around them such as selling wood for construction and fuel, farming, and operating animal driven carts causing further deterioration of local environments (UNEP, 2007b; Lind *et al*., 2012). As IDPs could not able to go faraway from the camps they may cut any vegetation grow near around. The placement of IDP camps around commercial town centers is likely to cause the loss of shelter belts, forestry and farmland (Bromwich, 2008) to sustain demand for fuel, construction material and brick making. The imbalance between accessible biomass production and demand has become greatest near to Darfur's largest cities and caused significant change in vegetation (UNEP, 2008b; Lind *et al*., 2012). According to State FNC Director "high pressure on vegetation cover was made due to needs of fire woods and building poles consequently, woody plants especially trees were cleared out around and near IDPs camps". Two reserved forests with area of 456.6 ha were completely destroyed around El Fasher (FNC, 2011) as consequences of armed conflict, in general the area of 711.8 ha equivalent 28.9% to the total area of reserved forest has been affected negatively. Furthermore, IDPs have uprooted (Plate 1) the illegally cut stem remainders, by doing so inhibited any opportunity of natural regeneration (personal communication).

Plate. 1: In need of fuel wood, elder IDP woman uproots tree at depth of 50 cm near Abu shok camp around El Fasher town

Prevailing insecurity atmosphere caused unsafe grazing lands leading to sharp reduction in livestock owned by rural families whereas average animal heads per household decreased from 407 before conflict to only 55 in North Darfur (Ismail *et al*. 2014). Dependence of great numbers of IDPs camp people on limited source of drinking water has affected underground water table negatively especially near El Fasher and Nyala (Bromwich *et al*., 2007; Nicol *et al*., 2012). On the other hand, it has been observed that the evidence of densely re-vegetation cover in abandoned villages and lands as a positive environmental indicator. This observed improvement of vegetation is likely attributed to population displacement, decline of livestock herds, and decrease of their pressure. Such vegetation recovery could not withstand the domestic needs of returnees that largely involved in fuel energy and building materials. Therefore, search and use the alternative fuel energy and building materials in order to decrease pressure on woody vegetation are prerequisite for sustainable natural resource management.

4.4. Implication of ecosystem deterioration, armed conflict and livelihood interaction

The impacts of ecosystem resource diminishing and armed conflict on each other and their effects on livelihoods have become clear in Darfur. The majority of respondents as shown in this study acknowledged that climatic factors were prime factor for livelihood deterioration before armed conflict occurrence in 2003. However, thereafter the insecurity became prominent factor especially in some localities beyond production decline in crops and livestock. This perceived knowledge of local communities would be used for adopting rational use of natural resources and for building peaceful coexistence between different groups if the other issues are addressed. This perception also could be used to promote and build natural ecosystem rehabilitation and conservation strategies. It is well reported that, the public involvement became a prime principle for contemporary governance of environment and can empower individual and communities response (Swinton *et al*., 2005; Smiley *et al*., 2010). On the other side, abandon of sedentary farmers their farms for long time may cause loss of indigenous knowledge particularly among young generations regard to plant genetic resources including

domesticated and wild species such as drought tolerant and famines food which are key to livelihoods. The consequences of the conflict depleted assets, insecurity, inaccessibility to land and resources, the loss of agro-ecological knowledge among younger generations, may induce further complicated impacts in the region (Lind *et al*., 2012). Many IDPs themselves are not willing their children to return rural homelands but prefer them to move into skilled trades and professions (UN, 2010). Thus, initiation of ambitious plans and strategies for maintenance and conservation of wild plant and local crop genetic resources must be top priority to sustain food security and livelihoods over long and short terms. Many armed conflict related agents have caused destruction of vegetation cover. For instance, Director of State FNC told that (i- because of insecurity and inaccessibility to areas of dead fire woods, bakery and brick kilns owners tended to cut trees not only around towns but also inside the homes, ii- Hybrid Mission of United Nations and African Union in Darfur (UNAMID) which came therein to protect civilians and build peace has established its camps on Hizam El Fasher reserved forest, and iii- fighting groups destroy vegetation covers through various means. To maintain sustainable and community-based natural resources management in Darfur, successful intervention plans should be sought. For example integrated natural resource management research may lead to improved natural resource management practices hence improvement of human wellbeing (Freeman *et al*., 2005; Bagine *et al*., 2010).

5. Conclusion

The results revealed that the abundance of natural vegetation today is either poor or medium compared to the last two decades according to the views of more than 87% of interviewees. Substantial change has occurred in both quantity and quality of natural vegetation exposing the region to risks and disposing the livelihoods of local communities to high vulnerability. About 88% of interviewees in North Darfur State grow crops and/or rear livestock for their livelihoods. However, crop production level was maintained decreasing patterns according to respondents' views. Rainfall was believed to be the main factor of decrease for the period 1990-2003, while for the period from 2004 to 2015, about fifty percent of respondents correlated decline in crop production with armed conflict alongside rainfall variability. The impacts of ecosystem resource diminishing and armed conflict on each other and their consequent effects on livelihoods have become reality in Darfur and well

acknowledged by local communities and respective institutions. Environmental and natural resource degradation seemed to be one of the prominent factors provoked land ownership disputes and conflict between stakeholders spoiling their livelihood activities. The perceived acknowledgement of local communities about the implications of natural plant and crop production deterioration could be used to set principles for natural environment governance and for peaceful coexistence between stakeholders. Based on the study findings the further investigation on the relationship between natural environment deterioration; and livelihood options, mitigation measures, and adaptation mechanisms of local communities can be recommended.

Conflict of interest

The authors declare that the absence of conflicts of interest.

Acknowledgement

The authors thank local communities of study localities specially respondents and key informants for their responses. Thanks extend to governmental institutions: SMA, FNC, and DRF for providing valuable information. Authors also thank Mohamed ElFateh for producing map.

References

Abdalla, S. A. (2014). Desertification in North Darfur State. Journal of Al Fashir University for Applied Sciences 3: 53-78

Abdelaziz, H. H., Abdalla, A. A. and AbdelLatif, M.A. (2012). Optimizing the cropping mix in North Darfur State, Sudan: A study of Umkdada district. Journal of the Saudi Society of Agricultural Sciences, 11: 7–13

Abubaker, M. I. and Salih, A.A. (2009). Food Security. UNESCO Chair for Desertification Studies, University of Khartoum, Sudan

ADBG. 2014. From fragility to resilience: managing natural resources in fragile states of Africa. African Development Bank Group, Tunisie, Tunis

Amiraslani, F. and Caiserman, A. (2018). Multi-stakeholder and multi-level interventions to tackle climate change and land degradation: the case study of Iran. Sustainability, 2018, 2000. https://www.mdpi.com/2071-1050/10/6/2000lhtm. Last accessed 23 January 2019

Backlund, P., Janetos, A., Schimel, D., Hatfield, J., Ryan, M.G., Archer, S.R. and Lettenmaier, D. (2008). Executive summary. In: P. Backlund, A. Janetos, and D. Schimel (Ed.), The effects of climate change on agriculture, land

resources, water resources, and biodiversity in the United States, pp. 1-10. Synthesis and Assessment Product 4.3, U.S. Climate Science Program

Bagine, R. K., Kirinche, G. and Maranga, K.E. (2010). Integrated natural resource management. In: Managing Natural Resources for Development in W. Ochola, P. Sanginga, and Bekalo, I (Ed.), Africa: A Resource Book, pp. 109—164. University of Nairobi Press, Kenya

Blaikie, P. (2006). Is small really beautiful? Community-based natural resource management in Malawi and Botswana. World Development, 34(11), 1942-1957

Bromwich, B. (2008). Environmental degradation and conflict in Darfur: Implications for peace and recovery. Humanitarian Exchange Magazine, 39 . Overseas Development Institute, London, UK

Bromwich, B., Adam, A. A., Fadul, A., A., Chege, F., Sweet, J., Tanner, V. and Wright, G. (2007). Darfur: Relief in a Vulnerable Environment. Tearfund, Teddington, UK

Bucknall, J. (2000). Poverty/Environment Background Paper. World Bank, Washington, DC.

Chidumayo, E.N. and Gumbo, D.J. (2010). The dry forests and woodlands of Africa: managing for products and services. London, UK

Daily, G. C., Soderqvist, T., Aniyar, S., Arrow, K., Dasgupta, P., Ehrlich, P. R., Folke, C., Jansson, A. M., Jansson, B., Kautsky, N., Levin, S., Lubchenco, J., Maler, K., Simpson, D., Starrett, D., Tilman, D. and Walker, B. (2000). The Value of Nature and the Nature of Value. Science 289(5478): 395 – 396

ESF. (2010). European Science Foundation. http://www.esf.edu/cue/documents/Chapin-etal_Biotic-Control_1997.pdf

Fadul, A.A. (2004). Natural resources management for sustainable peace in Darfur. In: Environmental Degradation as a Cause of Conflict in Darfur, conference proceedings, pp. 33-46. UN University for Peace, Khartoum, Sudan

FAO. (2007). Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities. FAO, Rome, Italy

FAO. (2010). The State of food insecurity in the world: addressing food insecurity in protracted crisis. FAO, Rome, Italy

FAO. (2012). Adaptation to climate change in semi-arid environments: Experience and lessons from Mozambique. Environment and Natural Resource Management series 19, FAO, Rome, Italy

FMS. (2015). El Fasher Meteorological Station data. El Fasher, North Darfur, Sudan

FNC, (2011). Forest National Corporation report 2011. Khartoum, Sudan

Freeman, H.A., Shiferaw, B. and Swinton, S.M. (2005). Assessing the impacts of natural resource management interventions in agriculture: concepts, issues, and management. In: B. Shiferaw, H. Freeman, and Swinton, S (Ed.), Natural Resources Management in Agriculture: Methods for Assessing economic and Environmental Impacts, pp.3-16. CAB International

Gebregziabher, D., Sultani, A. and Hofstad, O. (2017). Equity in the distribution of values of outputs from exclosures in Tigray, Ethiopia. Journal of Arid Environments 146: 75-85

Hadi, I. I. (2013a). Effects of climatic changes on millet and sorghum production in North Darfur – Sudan. Journal of Al Fashir University for Humanitarian Sciences. 2: 35-74

Hadi, I. I. (2013b). Impacts of temperature variations on spread of some diseases in El Fasher town. Journal of Al Fashir University for Humanitarian Sciences 1: 107-133

Harris, F. (2004). Global Environmental Issues. John Wiley & Sons Ltd, Sussex, England

Harvey, C.A., Rambeloson, A.M., Andrianjohaninarivo, T., Andriamaro, L., Rasolohery, A., Randrianarisoa, J., Ramanahadray, S., Christie, M., Siwicka, E., Ramoundou, K., Velcehez-Mendoza, S, and MacKinnon, J. (2018). Local perceptions of the livelihood and conservation benefits of small-scale livelihood projects in Rural Madagascar. Society & Natural Resources 31(9): 1045-1063

Ismail, I.M.A., Yassin, O. E., Elgili, M. and I. A. Elnour, I.A. (2014). The Impact of Darfur conflicts on the future of communal grazing in North Darfur State. Journal of Al Fashir University for Applied Sciences 3: 79 - 100

Jaspar, S. and O'Callaghan, S. (2008). Challenging Choices: protection and livelihoods in Darfur. Overseas Development Institute, London, UK

Kaaria, S. and Osorio, M. (2015). Women's participation in rural organizations: why is it important for improving livelihoods and sustainable management of natural resources? Nature & Faune Journal 29 (1): 12-16

Kim, S., Williams, A., Kiniry, J.R., and Hawkes, C.V. (2016). Simulating native C4 perennial grasses with varying rainfall. Journal of Arid Environment 134: 97-103

Larsen, J.B. (1995). Ecological stability of forest and sustainable silviculture. Forest Ecology and Management 73: 85-96

Lind, J., Nicol, A., Altare, C., Guha-Sapir, D., Gupte, J., Justino, P., Kodrou, P. and Longley, C. (2012). Programming for secure livelihoods amid uncertainty: trends and directions in livelihoods, nutrition and food security in Darfur. FAO/WFP/UNICEF, Rome, Italy

Maranga, E.K., Mugabe, P. H. and Bagine, R.K. (2010). Concepts, Theories and Principles of Natural Resource Management. In: W. Ochola, P. Sanginga, and Bekalo, I (Ed.), Managing Natural Resources for Development in Africa: A Resource Book, pp. 47-103. University of Nairobi Press, Kenya

Masoudi, M., Jokar, P. and Pradhan, P. (2018). A new approach for land degradation and desertification assessment using geospatial techniques. Natural Hazards and Earth System Sciences, 18: 1133-1140

Mohammed, I. and Mengist, M. (2018). Status, threat and management of wetlands in the Lake Tana sub-basin a review. Journal of Agriculture and Environmental Sciences, 3(2), 23-45

Nawrotzki, R., Hunter, L.M. and Dickinson, T.W. (2011). Natural Resources and Rural Livelihoods: Differences between Migrants and Non-Migrants in Madagascar. Population Program POP2011-08, Institute of Behavioral Science, University of Colorado Boulder

Nicol, A., Elamin, M., Osman, N., Ali M., Nour S., Elmedani T. and El-Neima, M.A. (2012). Pipelines and donkey carts: A social risk analysis of water availability, access and use in Nyala, South Darfur. Overseas Development Institute, London, UK

Okereke, C. and Stacewicz, I. (2018). Stakeholder perceptions of the environmental effectives of multi-stakeholder initiatives: Evidence from the palm oil, soy, cotton, and timber programs. Society & Natural Resources, 31 (11), 1302-1318

Power, A. G. (2010). Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of Royal Society B, 365, 2959-2971

PA. (2014). Greening Darfur: Natural Resource Management. https://practicalaction.org/greening-darfur-2. Retrieved: November 10, 201

Reyes-Gracia, V., Vadez, V., Huanca, T., Leonard, W. and Wilkie, D. (2005). Knowledge and consumption of wild plants: a comparative study in two Tsiman's village in the Bolivian

Amazon. Ethnobotay Research & Applications, 3, 201-207

Robinson, J. (2005). Desertification and disarray: The threats to plant genetic resources of Southern Darfur, western Sudan. Plant Genetic Resources: Characterization and Utilization, 3(1), 3-11

Sanginga, P. C., Ochola, W. O. and Bekalo, I. (2010). Natural Resource Management and Development Nexus in Africa. In: W. Ochola, P. Sanginga, and Bekalo, I. (Ed.), Managing Natural Resources for Development in Africa: A Resource Book, pp. 11-43. University of Nairobi Press, Kenya

Scoones, I. (1991). Wetlands in Drylands: Key resources for agricultural and pastoral production in Africa. Forestry and the Environment 20(8): 366-371

Siam, A.M.J., Khamis, M. A. and Elnour, I. A. (2014). Environmental and socioeconomic interactions of wild edible and associated woody plants in North Darfur. Journal of Al Fashir University for Applied Sciences 3: 1-22

Sinare, H. and Gordon, L.J. (2015). Ecosystem services from woody vegetation on agricultural lands in Sudano-Sahilian West Africa. Agriculture, Ecosystems & Environment 200: 186-196

SMA. (2014). State Ministry of Agriculture: Agricultural Planning Unit report, El Fasher, North Darfur, Sudan

Smiley, S., deLoe, R. and Kreutzwizer, R. (2010). Appropriate public involvement in local environmental governance: a framework and case study. Society & Natural Resources 23(11): 1043-1059

Somorin, O. A. (2010). Climate impacts, forest-dependent rural livelihood and adaptation strategies in Africa: A review. African Journal of Environmental Science and Technology, 4(13): 903-912

Sulieman, A. A., Abdel Aziz, S. and Ali, A.K. (2013). Socioeconomics and environmental impacts of water scarcity in El Fashir Rural Administrative Unit – Norther Darfur State – Sudan. Journal of Al Fashir University for Humanitarian Sciences 1: 3 -25

Swinton, S.M., Shiferaw, B. and Freeman, H.A. (2005). Assessing the impacts of natural resource management interventions in agriculture: concepts, issues, and management. In: B. Shiferaw, H. Freeman, and Swinton, S. (Ed.), Natural Resources Management in Agriculture: Methods for Assessing economic and Environmental Impacts, pp. 361-375. CAB International

UN. (2010). Beyond emergency relief: Longer-term trends and priorities for UN agencies in Darfur. UN, Khartoum, Sudan

UNEP. (2007a). Global Environment Outlook (GEO4 for dev): Environment elopement. United Nations Environment Program, Nairobi, Kenya

UNEP (2007b). Sudan: post-conflict environmental assessment. United Nations Environment Program, Nairobi, Kenya

UNEP. (2008a). Water resource management in humanitarian programming in Darfur: The case for drought preparedness. Report to review water resource management at IDP camps and host communities in Darfur, United Nations Environment Program

UNEP. (2008b). Destitution, distortion and deforestation: The impact of conflict on the timber and wood fuel trade in Darfur. United Nations Environment Program, Nairobi, Kenya

Wayessa, G.O. and Nygren, A. (2016). Whose decisions, whose livelihoods? resettlement and environmental justice in Ethiopia. Society & Natural Resources 29(4): 387-402