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# COMMUNITIES' PERCEPTIONS OF LAND DEGRADATION: A CASE STUDY IN THE SAVANNA BELT OF THE WHITE VOLTA BASIN

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**Abstract**

*This study explores the views and perceptions of land users on land degradation and the possible mitigation measures within the White Volta Basin in Ghana. Twenty-three (23) communities were selected within the catchment to evaluate their perceptions of land degradation indicators, socio-ecological drivers and possible mitigation measures to combat the degradation in the basin. Group discussion and field observation with local people in the communities were employed to gather data on direct and indirect causes of land degradation as well as possible mitigation measures. Data collected were analyzed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistical methods were used to explore the data and Relative Importance Index (RII) of the degradation indicators, direct and indirect causes was computed in order to prioritize these issues in the study area. Eight indicators were used by the farmers and other land users to identify degraded land in the area. These indicators were readily observable and were similar in characteristics to those scientists commonly use. Formation of rills/gullies, change in soil colour and increased in barren land area were the most common observable indicators used in identifying degraded land in the study area. Poor soil management and deforestation are perceived to be the most important causes of land degradation in the basin. Increasing human population and poverty were perceived to be the indirect drivers responsible for the degradation. Key possible mitigation measures to reduce the degradation in the basin include: controlled bush burning, minimum tillage and stone bunds.*

**Keywords:** ***Land degradation, Indicators, White Volta Basin, Perception***

## INTRODUCTION

Land degradation (LD) sets in when the potential productivity associated with a land use system becomes unsustainable. Land degradation has eaten up huge proportion of the land area in the world since in the nineteenth century. Estimates by the Global Assessment of Land Degradation (GLASOD) in early nineties (Oldeman *et al.*, 1991) indicated that about 15% of all global productive land has been degraded. Bai *et al.*(2008) reported an increase in the degraded global land area to 24%. Recent report by Lal *et al.* (2012) confirmed that about a quarter of the global land area has been degraded and a major consequence is an estimated 12% decline in global food production in the next 25 years (International Food Policy Research Institute- IFPRI, 2011).

In Africa, land degradation has long been recognized as a critical problem affecting livelihoods and food security. It is estimated that two-thirds of Africa's productive land is affected by land degradation while nearly all the land area prone to soil and environmental degradation (Vlek *et al*., 2008; TerrAfrica, 2009; FAO, 2011). These statistics do not exclude the White Volta

Basin (WVB) in West Africa which is a key resource to the development of the riparian countries (Ghana, Burkina Faso and Togo). The WVB suffers varied forms of degradation ranging from soil degradation (soil erosion and nutrient depletion), vegetation degradation and water resources degradation (Environmental Protection Agency, 2005; Le *et al.*, 2012; Adanu *et al.*, 2013; UNEP-GEF Volta Project, 2013)

This paints unpromising picture especially for the rural people who solely depend on land for their livelihood. As a global problem, the need to tackle it has been recognized by various international bodies such as the United Nations Convention to Combat Desertification, the Conventions on Biodiversity and Climatic Change, and the Millennium development Goals (UNCED, 1992; UNEP, 2007).

Land degradation itself is complex in nature, posing a great challenge in its appraisal. A major challenge hampering effective monitoring and assessment of land degradation is the fragmentation of current knowledge in structure, procedure as well as criteria and indicators. This impedes the flow of knowledge between land degradation monitors at the local, national, regional and international levels making the results of such studies inapplicable to yield its purported benefits (Stringer & Reed, 2007; Bauer & Stringer, 2009; Reed *et al.*, 2011). For instance assessment of land degradation at the international and national scales focused mainly on expert opinions to quickly assess degradation at a global coverage with minimum cost (Oldeman*, et al.*, 1991; UNEP, 1997). Unfortunately, such assessments are biased and hardly incorporated the perception and knowledge of the indigenous people who directly utilize and manage the land at the local scale.

The views of communities/land users of degradation are quite divergent from scientific point of view even though they sometimes overlap. The disparity in perspectives between that of the scientifically-trained professional and those of local people is reflected in the criteria and indicators used in the degradation appraisal (Stocking & Murnaghan, 2001). This can also be reflected in actors' perceptions of land degradation drivers as well as relevancies of mitigating measures.

Many recommended and promoted land degradation mitigation technologies/measures e.g. Sustainable Land Management for Mitigating Land Degradation (SLaM), People Land Management and Environmental Change (PLEC) just to mention a few in northern Ghana and many others in the basin have not fully achieved their set objectives partly due to divergence between the perspectives of the scientists, technology developers and the views of land users who are expected to implement the findings and recommendations (Stocking & Murnaghan, 2001). Thus, they failed to incorporate the knowledge of local people, who are the direct users of land and initiators of the degradation process, in the appraisal and development of the intervention towards fighting land degradation and sustainable land management. The perspectives of local land users remain a critical input in the design and implementation of any mitigation measure for land degradation. This study explores the views and perception of land users on land degradation and the possible mitigation measures within the White Volta Basin in Ghana. The information generated is relevant to the design and effective promotion of acceptable land management technologies and practices in the area.

## MATERIAL AND METHODS

### Study Area

The study was conducted in a sub catchment (Nawuni catchment) within the White Volta Basin in West Africa which is shared mainly by Burkina Faso and Ghana (Figure 1) between April 2013 and January 2014. The WVB lies between latitudes 9° 30′ N and 14° 00′ N, and longitudes 2°30′ W and 0°30′ E. It is the second largest catchment after the Black Volta Basin in the Volta Basin. It covers a total land area of about 106,000 km$^2$ (Diekkrüger & Obuobie, 2008) and represents 28 % of the total Volta catchment area (Awotwi *et al*., 2014). The basin is inhabited by about 7 million people (Balk & Yetman, 2004) whose activities have both positive and negative effects on the basin. It is also an ecosystem that suffers severe degradation varying from land use/cover conversion, vegetation degradation to soil loss by erosion (Droogers *et al.*, 2006; UNEP-GEF Volta Project, 2013).

The main natural vegetation cover is savanna woodland. It is characterized by short, closed and scattered drought resistant trees and grasses of about 3m high. *Adansonia digitata, Ceiba pentandra, Parkia biglobosa, Faidherbia albida, Khaya senegalensis, Tamarindus indica* are the indigenous trees commonly found in the area. Exotic tree species also found in the area include: *Tectona grandis, Magifera indica, Azadirachta indica, Anacardium occidental, Eucalyptus spp. and Moringa oleifera.* These trees are interspersed with a variety of annual grasses such as *Panicum maximum, Pennisetum purpurem and Andropogon gayanus.*

The predominant land use in the basin is agriculture. This involves the cultivation of annual crops such as: *Vigna unguiculata* (beans), *Oryza sativa* (rice), *Sorghum bicolor,* (sorghum) *Pennisetum glaucum* (millet), and *Arachis hypogaea* (groundnuts). The cultivation of tree crops such as *Anacardium occidental* (cashew) and *Magifera indica* (mango) is gaining prominence in the study area. The vegetation cover is reported to have been degraded over the years partly due to agricultural land expansion, fuel wood harvesting and cattle overgrazing (Gyasi *et al.*, 2011; UNEP-GEF Volta Project, 2013; Awotwi *et al*., 2014). Bush fires are rampant in the area and contribute to land degradation through destruction of vegetative cover (Gyasi *et al.*, 2011; UNEP-GEF Volta Project, 2013).

Other human activities such as small scale surface gold mining, sand and gravel winning, quarrying, infrastructure development and expansion are also emerging land uses which are on the ascendency partly due to increasing population, urbanization and developmental projects of these two countries (Ghana and Burkina Faso) to achieve middle income status by the year 2020 (Centre for Democratic Development, 2002). This quest for development by both countries is likely to create pressure on the natural resource base and consequently their degradation within the basin.

Luvisol was reported to be the predominant soil type in the basin (Andah *et al.*, 2003).

The low vegetative cover coupled with the rampant annual bush fire during the dry season exposes the soils to various forms of erosion. The soils have suffered leaching over a long period of time (Benneh *et al.*, 1990) making it deficient in major nutrients (Senayah, 1994; Amegashie *et al.,* 2012). Nitrogen and phosphorous which are macro nutrients for plant growth are the most deficient nutrients of which the depletion rates are 35kg/ha/y and 4kg/ha/y, respectively (Asiamah & Dedzo, 1999).

The Nawuni sub-basin which is a sub-basin of the White Volta Basin stretches from lat. $9^{\circ}$ 87′ N to $11^{\circ}$ 15′ N and Lon. $0^{\circ}$ 5′ W to $1^{\circ}$ 26′ W (Figure 1). Over 95% of the sub-basin lies in Ghana and hence the study at this scale focused on only the Ghana part. In Ghana, it covers two political regions (the Northern and Upper East Regions) and 16 districts. It is home to nearly two million people with most communities being rural and the people mainly depend on agriculture for their sustenance (Ghana Statistical Service, 2010; UNEP-GEF Volta Project, 2013). The Nawuni sub-basin is part of the WVB and hence the general description of the WVB above also applies to the sub-basin. Land degradation is one of the challenges within this sub-basin. Soil erosion, decline in soil fertility, vegetation degradation among others are the different types of land degradation in the sub-basin (CERSGIS, 2010; Yiran *et al.*, 2011; Amegashie *et al.,* 2012).

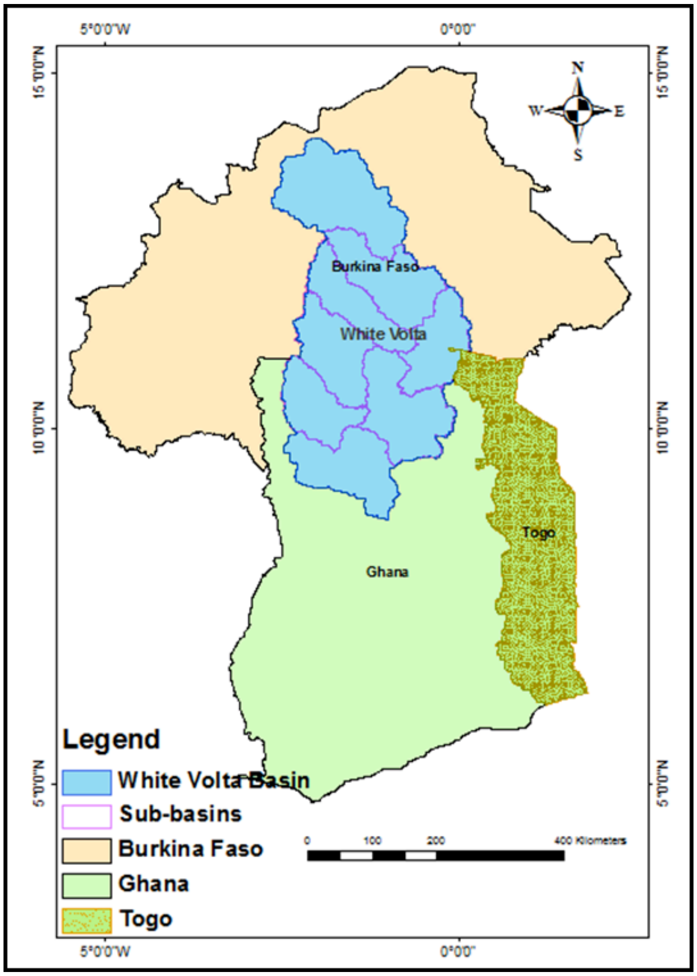


**Figure 1. Map showing the study area**

**Sampling of communities and Group Discussions**

Twenty-three (23) communities were selected within the catchment to evaluate their perception of land degradation indicators, socio-ecological drivers and possible mitigation measures to combat the degradation in the basin. The sampling frame followed the pattern of degradation mapped at the basin's scale (A precede of this paper). Communities that fell within the degrading pixels of the basin scale results were purposely selected for the study.

Group discussions with local people in the 23 communities were employed to gather data on direct and indirect causes of land degradation as well as possible mitigation measures to the degradation problem. Group discussion is the most appropriate means of addressing the problem identified through consensus (Lindlof & Taylor, 2002; Bai *et al.*, 2008). The group size was however variable depending on the population of the community and the willingness of the people to participate in the discussion. Community chiefs and local government leaders were contacted and used to facilitate group formation. A minimum of ten and maximum of twenty-five people in a group was used through all the communities. The groups entailed both men and woman within the communities who make use of land resources. This composition was appropriate for the study as different interest groups may have divergent perception about land degradation (Stocking & Murnaghan, 2001) and needed to be captured.

The group discussion began with brainstorming exercises to identify (1) perceived direct and indirect causes of land degradation and (2) perceived mitigating measures (Plate 1). These perceived direct and indirect causes as well as mitigating measures were further ranked in order of importance using simple ranking method by the groups (Plate 2). The activities of the groups were guided by trained facilitators to avoid over dominance of elite group members.

Plate 1: Participatory brainstorming

Plate 2: Participatory ranking

**DATA ANALYSIS**

Data on land degradation indicators, direct and indirect causes of land degradation as well as sustainable land management techniques collected in each of the 23 communities were coded, entered and analyzed using Statistical Package for Social Sciences (SPSS) software. Descriptive statistical methods were used to explore the data. Relative Importance Index (RII) (Kometa & Olomolaiye 1997) of the degradation indicators, direct and indirect causes was computed (Equation 1) in order to prioritize these issues in the study area. This was computed based on weights assigned to the various ranks of each variable (degradation indicator, causes and mitigation measures).

Weights were assigned based on rank reversal and in this case, the most important variable by rank was assigned the highest weight while the least important variable was assigned the least weight (Aabeyir *et al.*, 2010). The overall rank was then assigned based on the RII. The value ranges from 0 to 1. The RII of each variable was computed as follows:

Relative importance Index (RII), $$RII = \frac{\sum w}{A * N} \qquad [1]$$

*Where w = weight assigned to each rank (based on reversal of ranks), A = highest weight and N= total number of communities.*

Kendall tau-b correlation analysis (Field, 2006) was further performed to explore the relationship between the perceived land degradation indicators, direct and indirect causes of land degradation in the area.

## RESULTS AND DISCUSSION

### Indicators for Identifying Degraded Land in the WVB

Major indicators used by the farmers and other land users to identify degraded land are summarized in Table 1. Eight of them were identified and ranked by the 23 communities. Generally, they are readily observable indicators and are similar in characteristics to those scientists commonly use (UN/FAO, 1997; Stocking & Murnaghan, 2001; Kosmas *et al.*, 2012; Waswa, 2012). The results showed that formation of rills and gullies which are indicators of soil erosion, change in soil colour as indicator of soil fertility decline and increased in bare areas as an indicator of vegetation cover loss were the most common observable indicators used in identifying degraded land in the study area. These three indicators were ranked the same by 21 out of the 23 communities. Scarcity of wild animals and poor species composition were considered the least observable indicators although widespread as they occur in 12 out of the 23 communities surveyed.

The range of the rankings emphasizes the agreement among the communities in identifying an indicator as being important. This implies that, there is high agreement between the communities in ranking formation of rills/gullies as a major observable indicator of land degradation in the area than the others. However, the range in the ranking of increase in pest and diseases showed high disagreement in the communities ranking as there is wide disparity between the minimum and the maximum ranks.

The significance of these ranks was better reflected in the magnitude of the relative importance indices and overall ranks (Table 1). Based on the RII, formation of rills/gullies was ranked as the most important observable indicator of land degradation in the area with RII of 0.88. This was followed by change in soil colour with RII of 0.78. The least perceived observable indicators were decreased in numbers of soil macro organisms and prevalence of devegetation which had RII of 0.29 each. Though the two had the same range and RII, decreased in numbers of soil macro organisms had an overall rank of 6 while prevalence of devegetation had an overall rank of 8 because the minimum and maximum ranks of decreased in numbers of soil macro organisms are better than prevalence of devegetation.

**Table 1: Rank scores and RII of observable indicators in the White Volta sub basin**

| *Observable indicators* | *Ranks* | | | | | *SW* | *RII* | *OR* |
|---|---|---|---|---|---|---|---|---|
| | *F* | *M* | *Min.* | *Max.* | *R* | | | |
| Formation of rills/gullies | 21 | 1 | 1 | 2 | 1 | 162 | 0.88 | 1 |
| Change in soil colour | 21 | 2 | 1 | 5 | 4 | 143 | 0.78 | 2 |
| Increased in barren land area | 15 | 3 | 1 | 6 | 5 | 93 | 0.51 | 3 |
| Scarcity of wild animals | 12 | 4 | 2 | 6 | 4 | 60 | 0.33 | 5 |
| Scarcity of most useful plant species | 12 | 4.5 | 3 | 6 | 3 | 55 | 0.30 | 6 |
| Decreased in numbers of soil macro organisms | 14 | 5 | 3 | 7 | 4 | 54 | 0.29 | 7 |
| Increased in pest and diseases | 21 | 4 | 3 | 8 | 5 | 87 | 0.47 | 4 |
| Prevalence of devegetation | 15 | 5 | 4 | 8 | 4 | 54 | 0.29 | 8 |

*F: Frequency, M: Median, R: Range, SW: Sum of weight, RII: Relative importance index, OR: Overall rank*

The ability of the communities to agree on these indicators may stem from the fact that the criteria used are common to and well understood by all of them and easily discernable by the land users. For instance degraded soils were commonly identified due to the formation of rills, gullies, change in soil colour, presence of stones and weed species in the area. Also, local people were able to discern these indicators because they are directly linked to ecosystem productivity. They know that the soil fertility is declining due to the persistent decline in the yields of crops, the general health of the crops and other vegetation. A similar study done in Kenya revealed that farmers were able to discern the degrading nature of the land by the use of similar indicators (Odendo *et al.*, 2011).

Communities ranked decreased in numbers of soil macro organisms and prevalence of devegetation to be the least important observable indicator in identifying land degradation in the area. One reason for which communities perceived these to be less important in the area could be that, these indicators are not directly linked to tangible ecosystem services of their interest as land users are more aware and concerned about the immediate effects of the degradation than its indirect effects (Stocking & Murnaghan, 2001).

Also, the ranking of prevalence of devegetation to be less important in the area may also be due to security reasons. Local communities are often times being blamed for ill land use practices that lead to land degradation (GEF, 2002; Barry *et al.*, 2005; Gyasi *et al.*, 2011; Anzagira, 2012). Because of this notion, many communities are afraid that they will either be punished or be deprived of their productive lands by the government if they rank this particular type of indicator high in the area.

The importance and validity of the above statement are evident in the results of the correlation analysis (Table 2). The correlation results revealed that there is a moderate to strong positive significant correlation between change in soil colour and scarcity of wild animals ($r = 0.76$, $p = 0.05$), and also prevalence of devegetation ($r = 0.50$, $p = 0.05$). There is also a significant positive correlation between prevalence of devegetation decreased in numbers of soil macro organisms ($r = 0.60$, $p = 0.05$). The positive correlation is expected since change in soil colour as result of the decline in soil fertility in croplands pushes farmers to open more vegetated areas to increase crop production. The removal of natural vegetation through various means such as crop production, infrastructural development, mono plantations development could also have a significant negative implication on the species composition as reported by Maitima *et al*. (2004) that the loss of native vegetation leads to the loss of indigenous plant and animal biodiversity as well as the plant cover.

There is however a significant negative correlation between formation of rills/gullies and change in soil colour ($r = -0.58$, $p = 0.05$). This could be the masking effect of chemical fertilization as it was recognized as one of the mitigation measures to land degradation in the study communities (Table 7).

**Table 2: Kendall tau-b coefficients for correlation between observable indicators of LD in the basin**

| ***Observable indicators*** | Formation of rills/gullies | Change in soil colour | Increased in barren land area | Scarcity of wild animals | Scarcity of most useful plant species | Decreased in numbers of soil macro organisms | Increased in pest and diseases | Prevalence of devegetation |
|---|---|---|---|---|---|---|---|---|
| Formation of rills/gullies | - | -.575* | -0.273 | -0.375 | -0.164 | -0.267 | -.483* | -0.372 |
| Change in soil colour | | - | -0.501 | .757* | -0.129 | 0.289 | 0.12 | .501* |
| Increased in barren land area | | | - | -0.739 | -0.39 | .602* | 0.249 | 0.332 |
| Scarcity of wild animals | | | | - | -0.037 | 0.471 | 0.071 | 0.267 |
| Scarcity of most useful plant species | | | | | - | 0.101 | .926* | 0.085 |
| Decreased in numbers of soil macro organisms | | | | | | - | 0.22 | .748* |
| Increased in pest and diseases | | | | | | | - | 0.345 |
| Prevalence of devegetation | | | | | | | | - |

**Correlation is significant at the 0.05 level (2-tailed).*

## Perceived Direct Causes of Land Degradation in the Area

The perceptions of the direct causes of land degradation by communities in the White Volta Basin are presented in Table 3. Communities perceived that, there were seven major direct causes of land degradation in the area. Among the seven, climate change had the highest frequency (23), followed by poor soil management with a frequency of 22. Even though climate change had the highest frequency, there is a wide variation between its minimum and the maximum ranks (Min. =1, Max. = 7) indicating a disagreement between the communities in ranking this cause. On the other hand, poor soil management with a frequency of 22 had a better range between the minimum and maximum ranks (min. =1, max. =5) indicating a good agreement between communities in ranking this variable. Infrastructural development had the least frequency of 10.

The RII revealed that, poor soil management was the most important cause of land degradation perceived by the communities in the area followed by deforestation with RII of 0.84 and 0.63 respectively. Infrastructural development had the least RII index of 0.21.

**Table 3: Median of rank score of the perceived direct degradation causes**

| Direct Causes of LD | Rank Statistics | | | | | SW | RII |
|---|---|---|---|---|---|---|---|
| | *F* | *M* | *Min.* | *Max.* | *R* | | |
| Poor soil management | 22 | 1 | 1 | 5 | 4 | 136 | 0.84 |
| Poor range management | 14 | 2 | 1 | 3 | 2 | 83 | 0.52 |
| Deforestation | 19 | 3 | 1 | 6 | 5 | 102 | 0.63 |
| Surface mining | 15 | 4 | 1 | 4 | 3 | 72 | 0.45 |
| Infrastructural development | 10 | 4.5 | 3 | 6 | 3 | 34 | 0.21 |
| Climate change | 23 | 5 | 1 | 7 | 6 | 70 | 0.43 |
| Overgrazing | 20 | 4 | 2 | 6 | 4 | 81 | 0.50 |

*F: Frequency, M: Median, R: Range, SW: Sum of weight, RII: Relative importance index.*

Based on field observation and personal communication, cultivation of highly vulnerable soils and insufficient soil conservation measures were key characteristics of the basin. Cultivation along river banks, slopes and water courses similar to reports by other authors was evident in the area (GEF, 2002; Gyasi *et al.*, 2011). These resulted to soil erosion by water and consequently loss in soil fertility.

Also, deforestation which was ranked second in the list could be due to the persistent clearing of vegetation for farming, excessive gathering of fuel wood, local timber, fencing materials, rampant bushfires and removal of fodder (especially the cut-and-carry system) (GEF, 2002; Malyon, 2013; Awotwi *et al*., 2014).

Similarly, communities perceived seven indirect causes of land degradation in the area (Table 4).

Frequencies of ranked score of the perceived indirect degradation causes indicated that population pressure and poverty recorded the highest ranks of 20. There was a high agreement between the communities in ranking these variables as their minimum and maximum ranks as well as their ranges were close (Table 4). Pests and diseases had the least ranked frequency of 12 with wide variation between the minimum and maximum ranks. Population pressure was therefore perceived as the most important indirect cause of land degradation in the area. It had RII of 0.78, followed by poverty which had RII of 0.74. Pests and diseases were perceived as the least important cause of land degradation in the area with RII of 0.17.

**Table 4: Perceived indirect causes of land degradation in the basin**

| **Indirect Causes of LD** | **Rank Statistics** | | | | | **SW** | |
|---|---|---|---|---|---|---|---|
| | *F* | *M* | *Min* | *Max* | *R* | | |
| Population pressure | 20 | 1 | 1 | 4 | 3 | 126 | 0.78 |
| Change in demand & consumption | 13 | 2 | 2 | 5 | 3 | 75 | 0.47 |
| Poverty | 20 | 2 | 1 | 3 | 2 | 119 | 0.74 |
| Inadequate labour | 14 | 3 | 2 | 5 | 3 | 66 | 0.41 |
| Education & support services | 14 | 4 | 1 | 5 | 4 | 62 | 0.39 |
| War and conflict | 19 | 5 | 2 | 6 | 4 | 63 | 0.39 |
| Pests & diseases | 12 | 6 | 4 | 7 | 3 | 27 | 0.17 |

*F: Frequency, M: Median, R: Range, SW: Sum of weight, RII: Relative importance index.*

The Ghana population and housing census data confirmed the increasing trend in the population growth within the WVB (Ghana Statistical Service, 2005, 2010). The consequential effect of increase in population as identified by some authors (FAO, 2001, 2011; Gyasi *et al.*, 2011); leads to increase in demand for land resources which eventually lead to resource degradation.

Political administrative regions located within the White Volta Basin, particularly those in Ghana were classified as poor. According to International Fund for Agricultural Development (IFAD, 2013) the poverty rates in the three northern regions of Ghana, encompassing over 90% of the White Volta Basin, were high and this was likely to have negative implication to land management and use. The high poverty rates in these regions also pushed the energetic youth to migrate to areas they could be gainfully employed to earn income. As a result only the ageing and generally less dynamic population especially in the rural areas were left and these were unable to manage the land sustainably. Thus, the deficit of rural labour through migration (WMO, 2005; Ezeaku & Davidson, 2008; Gyasi *et al.*, 2011) can lead to abandonment of traditional resource conservation practices such as compost preparation, stone bunding and terrace maintenance (FAO, 2011; Gyasi *et al.*, 2011) which are healthy practices to land management and use. Poor people also continuously mined the land and more often invested less in their lands leading to over-exploitation and degradation (FAO, 2011; Nkonya *et al.*, 2011).

A Kendall tau-b correlation analysis between perceived direct causes of land degradation (Table 5) indicated that, there was a positive significant correlation between poor soil management and poor range management ($r = 0.68$, $p = 0.05$), poor range management and surface mining ($r = 0.73$, $p = 0.05$). Also, surface mining, infrastructural development, climate change as well as overgrazing were highly positively correlated ($r = 0.91$, 0.53, 0.65 respectively at $p = 0.05$). Also there was significant positive correlation between climate change and overgrazing ($r = 0.49$, $p = 0.05$). On the contrary, a negative correlation existed between poor soil management and the rest of the degradation causes (Table 5).

**Table 5: Kendall tau-b coefficients for correlation between direct drivers of LD**

| **Direct Causes of LD** | *Poor soil management* | *Poor range management* | *Deforestation* | *Surface mining* | *Infrastructural development* | Climate change | *Overgrazing* |
|---|---|---|---|---|---|---|---|
| Poor soil management | | .677* | -.440* | -.804* | -.672* | -.417* | -0.39 |
| Poor range management | | | -.816* | .730* | 0.467 | 0.175 | 0.19 |
| Deforestation | | | | 0.358 | 0.311 | 0.016 | 0.311 |
| Surface Mining | | | | | .909* | .533* | .654* |
| Infrastructural development | | | | | | 0.412 | 0.426 |
| Climate change | | | | | | | .486* |
| Overgrazing | | | | | | | |

**Correlation is significant at the 0.05 level (2-tailed).*

Kendall tau-b coefficients for correlation of perceived indirect causes of land degradation revealed that a perfect positive correlation exist between climate change and education and support services as well as war and conflict (Table 6). There was also a significant positive correlation between poverty and inadequate labour ($r = 0.86$, $p = 0.05$). Also a significant positive correlation existed between poverty and war and conflict ($r = 0.51$, $p = 0.05$). Inadequate labour and war and conflict were positively correlated ($r = 0.60$, $p = 0.05$) as well as education and support services, and war and conflict ($r = 0.67$, $p = 0.05$). Population pressure, change in demand and consumption showed negative correlation with all the other indirect causes (Table 6).

**Table 6: Kendall tau-b coefficients for correlation between indirect drivers of LD**

| **Indirect Causes LD** | Population pressure | Change in demand & consumption | Poverty | Inadequate labour | Education & support services | War and conflict | Pest and diseases |
|---|---|---|---|---|---|---|---|
| Population pressure | | | -.717* | -.640* | -.645* | -0.438 | -0.25 |
| Change in demand & consumption | | | -.667* | -0.51 | -0.632 | -0.406 | . |
| Poverty | | | | .856* | 0.508 | .512* | 0.41 |
| Inadequate labour | | | | | 0.419 | .603* | 0.78 |
| Education & support services | | | | | | .673* | 1.00* |
| War and conflict | | | | | | | 1.00* |
| Pest and diseases | | | | | | | |

**Correlation is significant at the 0.05 level (2-tailed).*

## Preferred Mitigation Measures

The communities' preferred mitigation measures against land degradation are presented in Table 7. Controlled burning recorded the highest frequency of 18 followed by stone bunding with frequency of 17. There was a high agreement between communities' perception in ranking these measures as high with their minimum and maximum ranks being the same or closed to each other. Controlled burning was perceived as the most important mitigation measure to land degradation in the area as it had a high relative importance index of 0.66. Minimum tillage and stone bunds were perceived to be the next important mitigation measures with RII's of 0.53 and 0.51 respectively.

**Table 7: Preferred mitigation measures**

| Mitigation measures | Rank Statistics | | | | | SW | RII |
|---|---|---|---|---|---|---|---|
| | *F* | *M* | *Min.* | *Max.* | *R* | | |
| Controlled burning | 18 | 1 | 1 | 6 | 5 | 106 | 0.66 |
| No burning | 10 | 2 | 1 | 4 | 3 | 59 | 0.37 |
| Crop Rotation | 6 | 3 | 1 | 4 | 3 | 31 | 0.19 |
| Minimum tillage | 15 | 2 | 1 | 5 | 4 | 85 | 0.53 |
| Stone bunding | 17 | 3 | 1 | 6 | 5 | 82 | 0.51 |
| Organic manuring | 10 | 3.5 | 1 | 6 | 5 | 42 | 0.26 |
| Mineral fertilizers | 14 | 5 | 3 | 7 | 4 | 44 | 0.27 |

*F: Frequency, M: Median, R: Range, SW: Sum of weight, RII: Relative importance index*

The perception of communities about controlled burning to be the most important mitigation measure in the area could be due to the prevalence and devastating effect of the annual bush fires in the area. Bushfire in the savanna ecological zone had been recognized to be one of the major socio-economic problems hindering the economic progress of the inhabitants in the area. This threat does not only affect the density and diversity of the vegetation in the savanna ecosystem but also reduces agricultural output in the area (Senayah *et al.,* 2005; Yiran *et al.,* 2011; Anzagira, 2012). Several tracts of lands, including farm produce as well as human and animals' lives are reported lost annually due to uncontrolled bush burning in the area. So it is not surprising that controlled burning was being perceived by communities to be the most important mitigation measure in fighting land degradation in the area. It was also considered to be less capital intensive to implement.

Minimum tillage and stone bunds were perceived to be the next important mitigation measures in the White Volta basin. These fall within the category of soil and water conservation measures. Looking at the above causes of degradation, local communities perceived that these technologies were the panacea to the degrading nature of their soils. Minimum tillage was reported to have advantages over the traditional tillage system (slash and burn system and hoeing). It was more economical in terms of energy, labour and equipment requirements in crop production (Boahen *et al.*, 2007; Asumadu *et al.*, 2013). Also, since farmers are interested in maximizing profit in their farming business, they would readily prioritize minimum tillage system for adoption in land management and utilization.

Stone bunds on the other hand were reported to protect the land from erosion in heavy rainy years. They also improve rainwater harvesting, retention and infiltration into the soil and thus increase the amount of water available to plants. They also improve diversity and vegetation cover when plants are allowed to grow along the bunds. Stone bunds intervention is perceived to be easy to implement at the local level with very minimum resources (Diabene, 2012). It is a well-known technology use by the people in the area, which can be implemented with available local materials with minimal technical knowhow.

## CONCLUSIONS AND RECOMMENDATION

This study explores the views and perception of local communities about the problem of land degradation and the possible mitigation measures within White Volta Basin of Ghana.

Local communities perceived that the land is degrading by the observation of some eight (8) environmental indicators. Principal among the perceived indicators of land degradation in the WVB are formation of rills/gullies, change in soil colour and increased in barren land area. Poor agricultural soil and rangeland management, deforestation and climate change were perceived to be the direct drivers of land degradation in the basin. Increasing human population, change in demand and consumption for food and fuel wood, poverty and inadequate labour were perceived to be the indirect drivers responsible for the degradation in the basin. Key possible mitigation measures to reduce land degradation in the basin include: controlled bush burning or no burning, minimum tillage and stone bunding of slopping lands. Others are crop rotation, organic manuring and mineral fertilization.

Poverty was identified as one of the key drivers of land degradation in the basin. It is therefore recommended that, government and non-governmental organizations should introduce income generating activities into these communities within the basin to help alleviate poverty. This will also enable land managers to invest in their land and reduce resource over-exploitation. Also government and non-governmental organizations should support farmers and other land users to adopt the identified mitigation measures to help reduce land degradation. We further recommend in-situ measurement to confirm the findings since the study was mainly based on perception. Nevertheless, for effective control and prevention of land degradation in the White Volta Basin, it is indispensable to incorporate this wealth of local knowledge with the scientific knowledge

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