International Journal of Agroforestry and Silviculture ISSN 2375-1096 Vol. 7 (1), pp. 001-011, January, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Dealing with reducing trends in forest ecosystem services through a vulnerability assessment and planned adaptation actions

Monica Idinoba[1]*, Johnson Nkem[2], Fobissie B. Kalame[1], Emmanuel Tachie-Obeng[3] and Benjamin Gyampoh[4]

[1]Center for International Forestry Research (CIFOR), Ouagadougou, Burkina Faso.
[2]Center for International Forestry Research (CIFOR), Bogor, Indonesia.
[3]Environmental Protection Agency (EPA), Accra, Ghana.
[4]Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

Accepted 12 December, 2018

Vulnerability of forest ecosystems in West Africa is likely to be aggravated with current and projected climate and human stresses with implications for adaptation and REDD regimes. This is because vulnerability of the forest ecosystems affects economic sectors and millions of people that depend on their services. This study investigated vulnerability of forest ecosystems through land use land cover (LULC) changes and the availability of economically useful forest ecosystem provisioning services in Ghana and Burkina Faso in the face of different stresses using landsat imageries and Participatory Rural Appraisal. Our analysis indicates that current and projected land cover changes and local perception on availability of forest resources in the different ecological zones are facing a decreasing trend due to various climatic and anthropogenic drivers. Ghana shows a transition in the order of high forest, forest- savanna transition, savanna to widely open cultivated savanna, while study areas in Burkina Faso is experiencing a gradual reduction of dense natural forests reserves towards a more sparse vegetation. Local knowledge in addition to observed changes in LULC can be a useful resource in preparing communities and ecosystems for adaptation as well as contribute to the input based adoption of appropriate policies in REDD schemes.

Key words: Adaptation, forest ecosystem, land use land cover change, REDD, vulnerability, West Africa.

INTRODUCTION

Forest ecosystems in West Africa provide many provisioning (e.g. wood and non-wood forest products) and regulating services (e.g. climate, water and disease regulation) that are important for economic development and for livelihoods (Locatelli et al., 2008; Seppälä et al., 2009). Their ability to continue to provide these services and other functions is mostly determined by climatic conditions and human interference. The growth, survival, regeneration and productivity of the forest ecosystems are climate dependent (Brovkin, 2002) since myriad life forms in these ecosystems use water, light and a certain temperature range for survival. Thus, rainfall patterns and average temperatures characterize forest types, quality and their ultimate ability to function. This explains the differences in forest types along existing climatic gradient in West Africa starting from Ghana (in the coast) to Mali (in the Sahel). The density, composition and species richness of West African forest ecosystem landscapes are fast changing on account of both anthropogenic and climatic reasons. The 1968 – 1973 and 1983 - 1984 drought affected most West African countries (Burkina Faso, Ghana, Mali etc), some natural vegetation began to disappear, trees were lost, land cover thinned out as a result of agricultural expansion, decreased rainfall and pressure from fuel wood collection leading to rapid

*Corresponding author. E-mail: monicaoye@yahoo.com, monica200905@live.com. Tel: +255 688581641.

destruction of vegetation (Reij, 1983). The dead vegetation from land use and land cover changes most of which involves degradation and deforestation, releases CO_2 that contributes actively to global warming (Kanninen et al., 2007). This is relevant to the development of REDD regime on issues of monitoring changes in forest area by forest types (Murdiyarso et al., 2009). The precarious situation of West Africa as a result of environmental changes and evolving patterns of human activities (Gonzalez, 2001) are expected to render forest ecosystems and its users highly vulnerable with devastating effects on economic activities. To deal with current and future limitations posed by these changes on forest ecosystems, there is a need for initiating processes of adaptation through an understanding of the state of vulnerability of forest ecosystems. Adaptation is defined here as an adjustment in social and natural systems in response to climatic and non-climatic stimuli while vulnerability is the extent to which the forest ecosystem is exposed and sensitive to stresses plus the degree to which the people that depend on it are unable to adapt. This report presents the results of field research by the tropical forest and climate change adaptation project (TroFCCA) that investigates changes in land use land cover (LULC) and local perception on the availability of economically useful forest ecosystem services in Ghana and Burkina Faso in the face of different stresses that may hinder national development and livelihood of forest dependent communities. The research also highlights adaptation actions and the usefulness of LULC changes for the development of REDD regimes.

MATERIALS AND METHODS

Study area

This study was conducted over a period of two years (2007 and 2008) in seven selected sites in five different ecological zones in Ghana (8° 00N, 2° 00W), and in Burkina Faso (13° 00N, 2° 00W). In Ghana, the study was conducted in 3 sites in both reserve (under control with less human interferences) and outside reserved forests. These are Wassa Armani district representing the high forest zone in the South Western part of Ghana; Wenchi district of the forest-transitional zone in the middle part of Ghana; and Bawku East district in the North Eastern part of Ghana representing the savanna zone. In Burkina Faso, the Oursi forest reserve in the North (Gorom-Gorom) and Dori in the dry Sahelian zone and the Maro forest reserve (Houndé) and Diebougou in the Soudanian Savana were selected. The choice for sites in this study were based on different agro climatic zones, areas of high dependence on forest resources, forest degradation and undergoing vegetation change, and the designated vulnerable areas in the first national communication to the UNFCCC in Burkina Faso and Ghana. Forest in this study refers to area with tree crown cover of more than 10% (FAO, 2000). However, most of the dry forest in Burkina Faso is fast changing to wooded land which is often still referred to by communities and even institutions as forest.

Data collection and analysis

Land use land cover change analysis

Current and future dynamics of land use land cover were determined using the Land Sat TM satellite images of scene 195055 for 1973, 1986 and 2000 and thematic maps showing the roads, towns, and drainage systems. Remote sensing software: ERDAS IMAGINE 9.1, ArcGIS 9.1, Idrissi Kilimanjaro, ENVI 4.3 and Adobe Photoshop 3.0 soft- wares were used to process the satellite images. The data sets of final maps were analysed and change maps were developed from the actual change and period of change. The method used in this research was that of classification comparison of land cover statistics to find out the quantitative changes in the areas of the various land cover categories.

Climate data

Historical climate data on temperature and rainfall for the study areas were collected and analysed using Excel. Future climate scenarios generated for the study areas using MAGIC SCENGEN based on the Initial national communications of Ghana and Burkina Faso to the UNFCCC.

Vulnerability of forest provisioning services

The effect of the changes in forest cover on the availability of forest products as perceived by local communities were assessed through questionnaires, interviews and focus group discussions. Through a stratified random sampling, interviews were conducted using structured questionnaires with 20 and 30 households in the study sites in Burkina Faso and Ghana respectively. Focus group discussions were also carried out with local resource persons and forest extension staff that helped identifies local names of useful tree species to their scientific names and their local uses.

RESULTS

Climate trends in the study areas

Historical analysis of climatic data show similar progressive increase in temperature (Figure 1). Temperature rise of about 1°C over a 30 year period in Ghana and 1.5°C in Burkina Faso and reductions in rainfall of approximately 20 mm were observed from historical data sets.

Current changes and future projections in land cover in the study areas

The Savanna zone of Ghana

Figure 2 shows the progression in changes in land use land cover from open cultivated and savanna woodland in 1972 to more of widely open cultivated savanna in 2000 with a vivid decrease in savanna wood land. In 1972, 55.6% (1195 km^2) and 44% (953 km^2) of the land in the study area was covered by savanna woodland (more than 25 trees per hectare) and open cultivated savanna

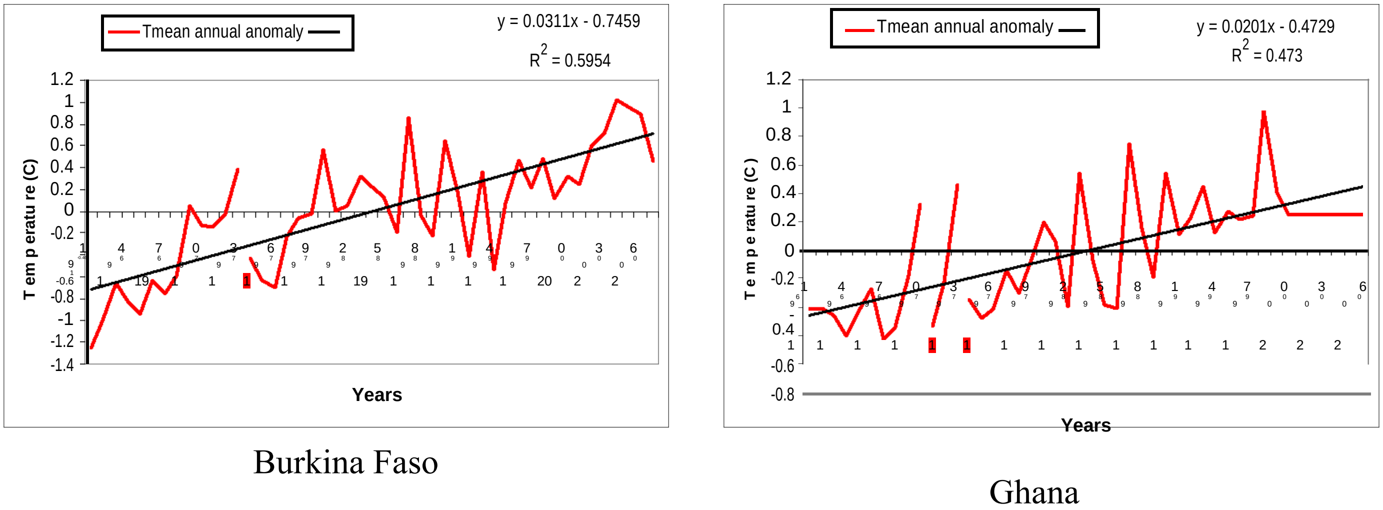

Figure 1. Mean annual temperature trend in the Sahel, Burkina Faso and transitional zone of Ghana.

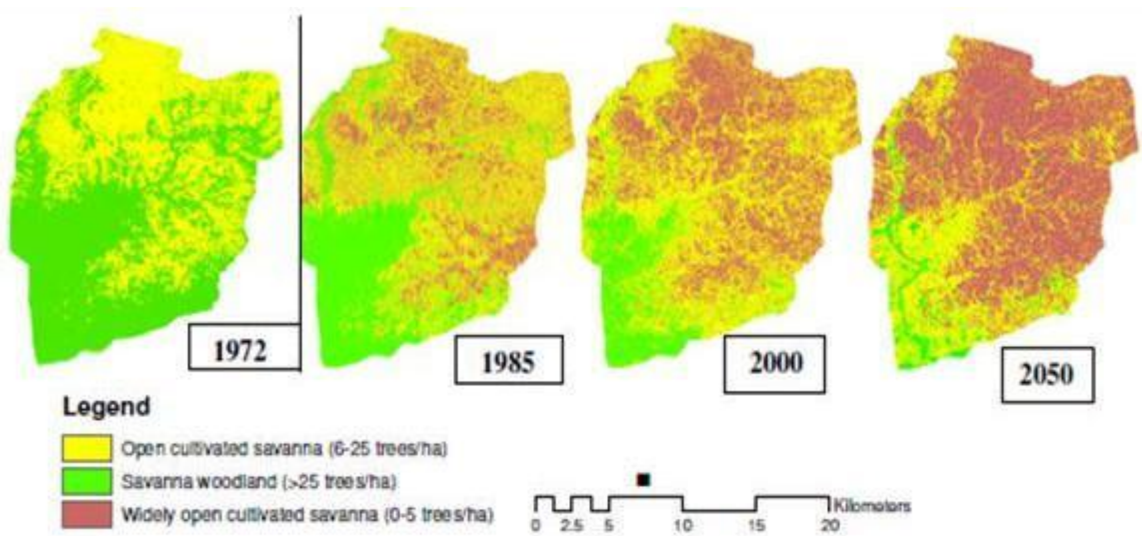

Figure 2. Land use and land cover maps of 1972, 1985, 2000 and 2050 in the savanna zone.

(between 6 and 25 trees per hectare) and there was no widely open cultivated savanna. But by 2000, 33.6% of the savanna ecosystem has been degraded to widely open cultivated savanna.

It is projected to decrease further to 126 km^2 (5.9%) under a business as usual scenario. The widely open cultivated savanna is also projected to increase in cover from 33.6% (722 km^2) in 2000 to 65.5% (1406 km^2) in 2050 and this exposes the area to the threat of desertification.

The forest-savanna transitional zone of Ghana

From Figure 3, the forest-savanna transitional zone which was dominated by open forest (32.3%) and closed savanna woodland (59.4%) in 1972 is seen to have gradually changed with most of the land cover being converted to open cultivated savanna. Open cultivated savanna now occupies 57% of the land surface. The open forest in the transitional zone reduced from 1,629 to 243 km^2 between 1972 and 2000 at a rate of 1.2% per annum and currently only about 5% of the land surface is covered by open forest. The 3,000 km^2 close savanna woodland which existed in 1972 was reduced to only 1,927 km^2 representing 21.2% loss of the land cover between 1972 and 2000. The open forest is projected to cover only 1.2% (59 km^2) of the land surface by 2050 representing an astounding loss of 96.4% beginning 1972. The close savanna woodland spread over 3,000 km^2 in 1972 will be left with a cover of only 898 km^2 by 2050, representing a total loss of 70%.

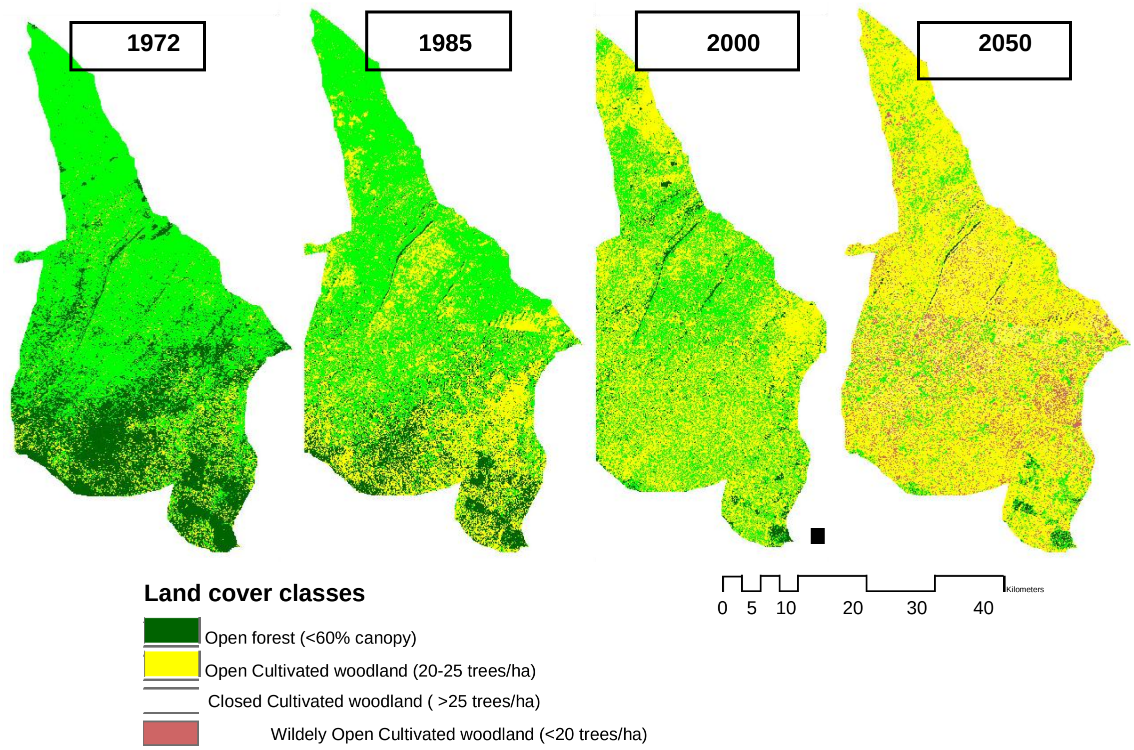

Figure 3. Land use and land cover maps of 1972, 1985, 2000 and 2050 in Forest-savanna.

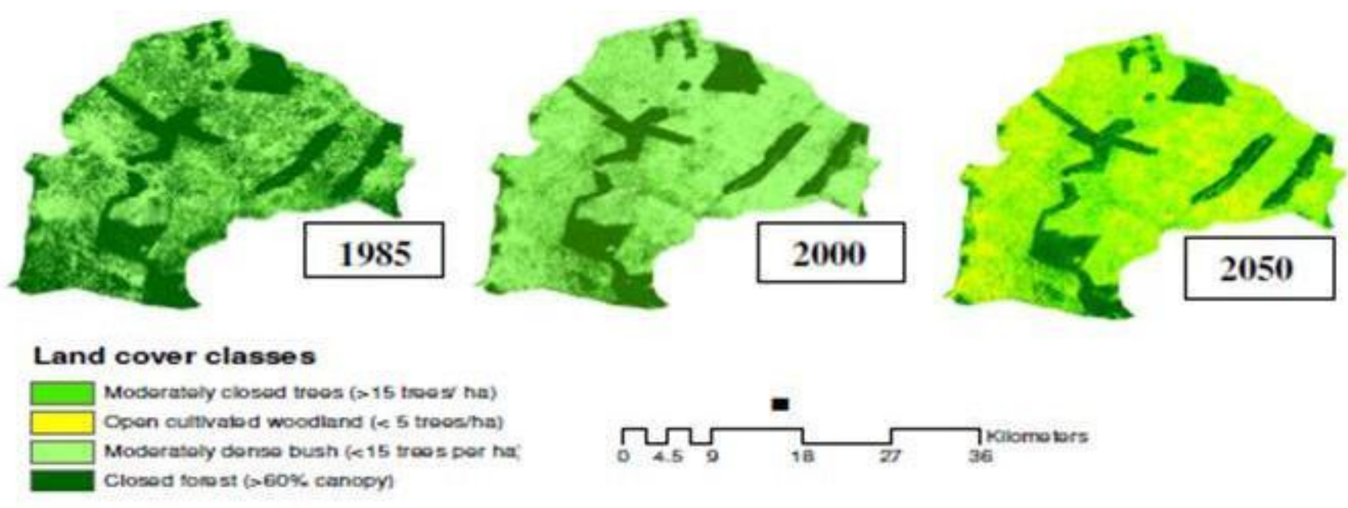

Figure 4. Land use and land cover maps of 1972, 1985, 2000 and 2050in the high forest zone.

The high forest zone of Ghana

1n 1985, more than half of the land cover in the high forest zone (Figure 4) was closed forest but very significant changes are seen in the deforestation of closed tropical forest from 2,736 km^2 in 1985 (57.6% of land cover) to 1,623 km^2 in 2000 which is 34.2%. The moderately closed bush has also been reduced from 7.4% of the land cover in 1972 to 5.9% in 2000. However, the moderately dense bush (less than 15 trees per hectare) has increased from 1,661 km^2 in 1972 which was 35% of the land cover to 2,842 km^2 representing 60% of the land cover due to extensive cocoa plantations often caused by conversion of forests to cocoa

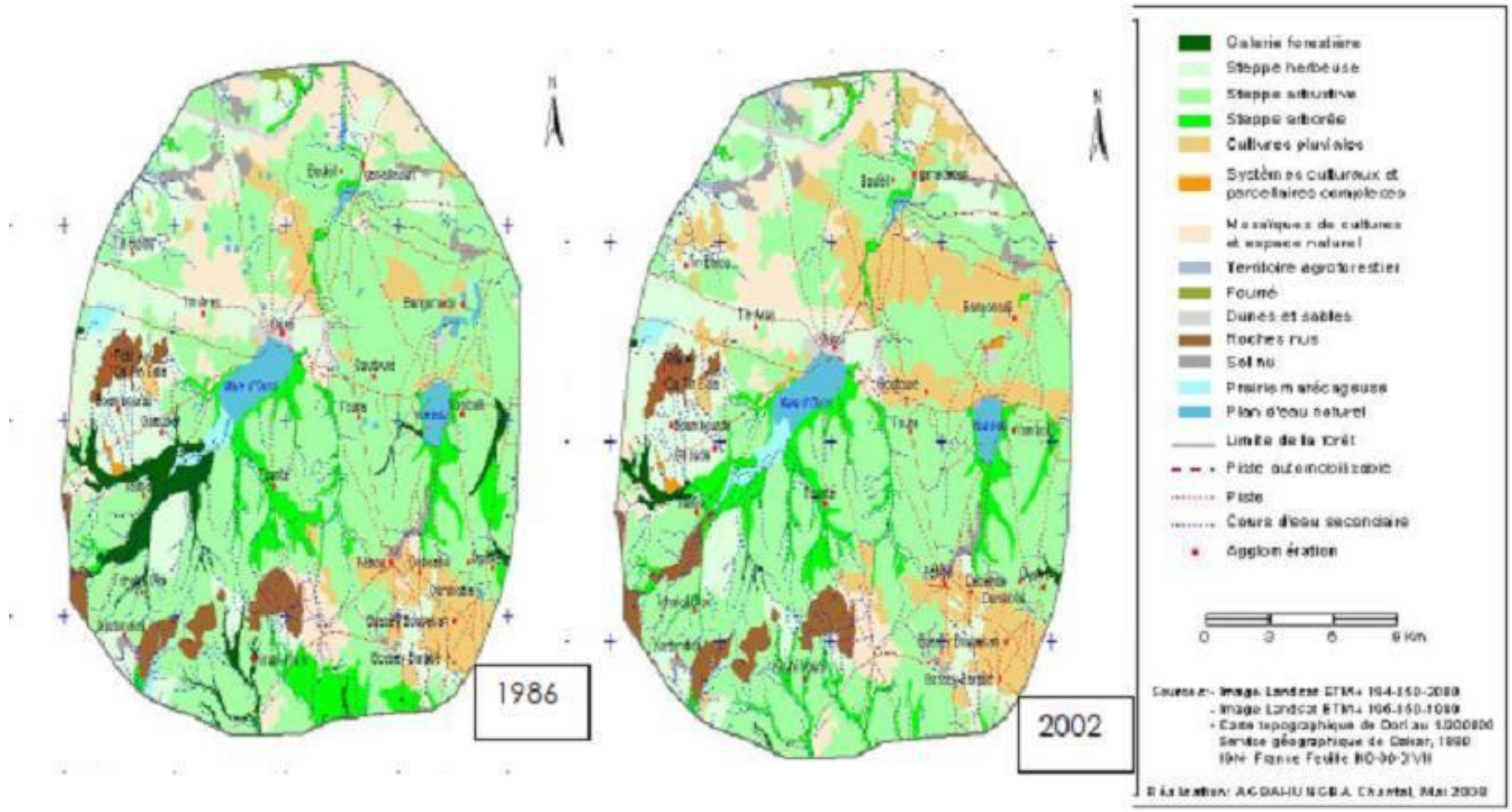

Figure 5. Land use land cover change maps of 1986 and 2002 in dry Sahelian zone.

plantations. About 1,131 km^2 (24%) is projected to be converted to open cultivated woodland by 2050.

The Oursi dry Sahelian zone of Burkina Faso

In the Oursi reserve, a significant reduction in the riparian forest along the river from 1986 to 2002 is observed. The forests were mainly found along the river banks and this has significantly decreased from 3311 ha in 1986 to 662 ha in 2002 (Figure 5). The shrub steppe (steppe arbustive) and steppe woodland (steppe arboree) also reduced from 47446 and 6662 ha in 1986 to 43555 and 6315 ha, respectively, in 2002. By 2050, all forest along the water bodies in the Oursi reserve are projected to disappear and areas covered by steppe woodland and shrubs would also likely to reduce from 6325 ha and 43555 ha in 2002 to 5385.75 ha and 34093.89 ha, respectively (Table 1).

The Maro Soudanian savanna zone of Burkina Faso

In 1986, most of the Maro reserve was covered by

Table 1. Land use/ land cover change and projections for 2050 in the Oursi forest reserve.

Vegetation cover	Changes in area (ha)				Future projections	
	1986	(%)	2002	(%)	2050	(%)
Riparian forest	3311	3.52	662	0.70	0.00	
Steppe woodland	6662	7.08	6325	6.72	5385.75	5.72
Shrub steppe	47446	50.40	43555	46.27	34093.89	36.2
Grassy steppe	13391	14.23	13555	14.40	13231.36	14.06

Note: Other land cover types in the area are not relevant to this study.

shrub savanna (arbustive savanna) (46%) and savanna woodland (26%). The shrub savanna has further increased to cover almost half of the entire land cover whilst the savanna woodland has decreased considerably to 14% in 2002. In 1986 about 5% land was covered with forest plantations but these disappeared totally by 2002 (Figure 6). Projections of future vegetation cover in the Maro Forest reserve by the year 2050 indicate a considerable reduction in the natural vegetation specifically the forest along the rivers and the savanna woodlands. The riparian forests and savanna woodlands are projected to reduce to 1206.30 ha and 349.86 ha by 2050 from 2958 ha and 9382 ha respectively in 2002. The shrub savanna, however, is projected to increase slightly from 27552 ha in 2002 to 29999 ha, in 2050 (Table 2).

Local perception on the vulnerability of forest goods

Almost all the people surveyed (93%) in Burkina Faso alluded to the strong effect of climate variability on the productivity of most trees. According to the village head of Djolera community in Diebougou, “torrential rainfall coupled with windstorms that uproot trees in their locality is often now than before”. As evidences of changing climate, 83% of the respondents cited more frequent drought and late rains, 57% indicated high temperatures while 26% cited flooding. They also stated that these observed changes over the past few decades have affected the productivity of many tree species often leading to wilting and death. Fifty-seven percent (57%) of respondents claimed a general low regeneration of many plant species and the shea tree (*Vitalaria paradoxa*) in particular leading to a major decline in the number of trees of this economically vital species. Eighty-seven percent (87%) of the respondents said shea butter trees have been effectively reduced per ha with 52% rating this decline between 1 - 5%, while 25% and 10% of the respondents rate the decline of shea butter trees between 6 -10% and 11 -15% respectively.

On the level of threat of lowered productivity and extincttion that the shea tree species faces in their perceptions, 88.7% of respondents pointed out that the tree is threatened of which 13.7% judged this threat to be very high. More than half (75%) of the respondents recognised that the shea tree is threatened but were not sure of the extent of threat while 11.25% of respondents believed that the tree was not threatened. The respondents felt that the major threats to the productivity, and even existence of the shea tree, are bushfires, droughts, low rainfall, insects and pests, clearing for cultivation and firewood collection. In Ghana, the status of some tree species in the forest and Savanna zones of Ghana in the last 40 years was felt by the local communities to be scarcer and on a faster degree of degradation than it has ever been. The respondents’ indicator for scarcity was identified as the length of time it takes now to search for some products from the forest. Irregular availability of a number of NTFPs species was also observed as due to changes in their productivity. They were of the opinion that this state of decline was very likely to intensify in the future with changes in land use and the changing climate. About 17% believed that both climatic and human factors are responsible for the state of decline of forest resources, 8% made references to the changing rainfall patterns, increasing droughts and bush fires especially in the savanna zones, while 75% of the respondents believe that the drivers of the changes in species composition and species availability in the humid forest area are mainly human induced. Such human activities include high demand of land for cocoa plantations which is influenced by international trade opportunities, increased mineral explorations and surface mining, slash and burn farming methods, illegal exploitation of natural resources through uncontrollable felling of trees, migration of Fulani herdsmen engaged in over-grazing of available fodders and high livestock populations and above all a spontaneous rise in the population of settler farmers who are themselves second and third generations of the migrant farmers from the drier northern parts of Ghana and beyond who settled on these lands several decades back.

DISCUSSION

Though the interplay between climatic and human drivers on forest ecosystem vulnerability is complex, an understanding of climatic influence, land use land cover trends, local perception and knowledge, and could help

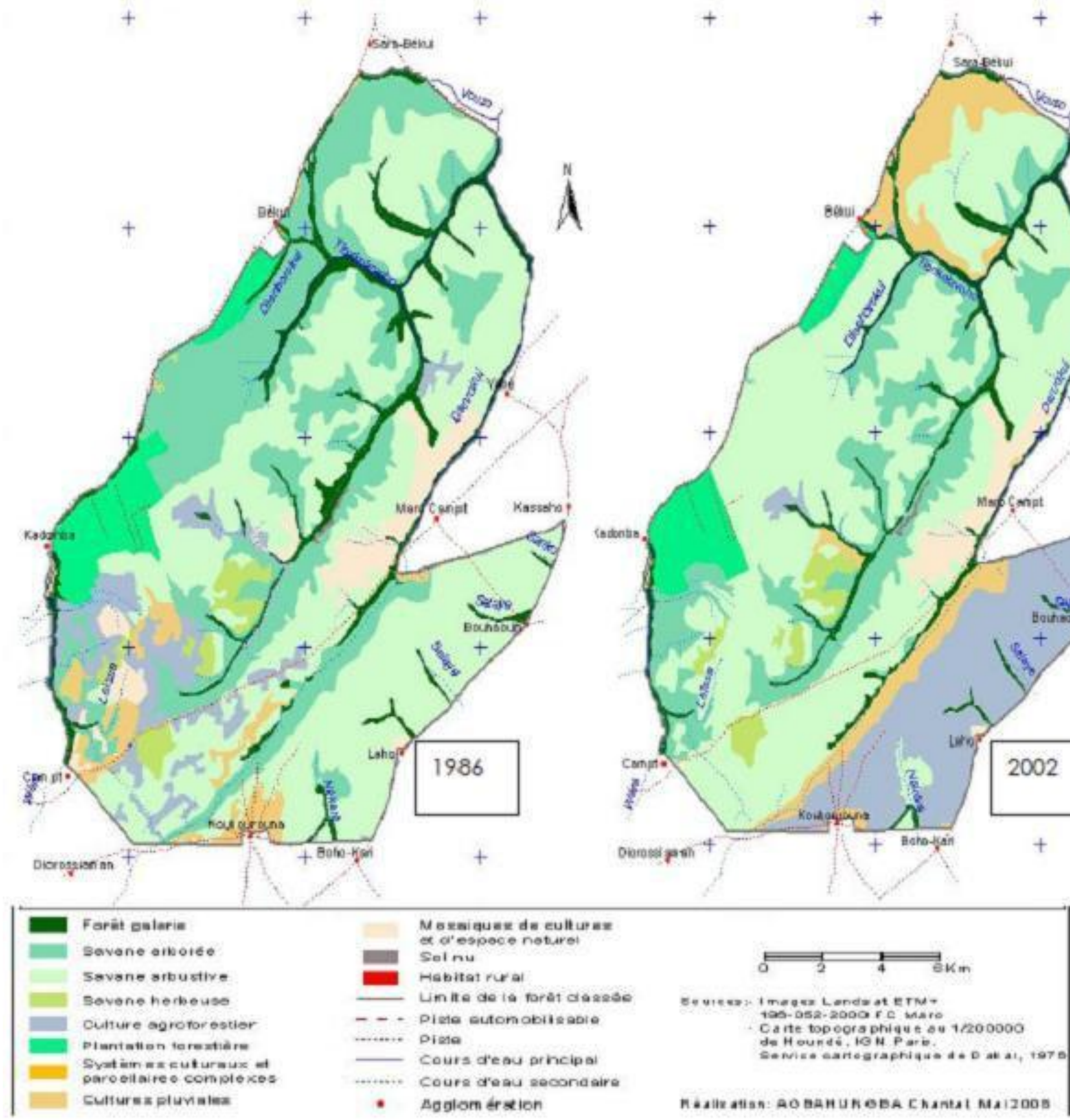

Figure 6. Change in land cover in the Maro reserve from 1986 to 2002.

determine the mechanisms by which the vulnerability of the ecosystem can be reduced to ensure continuous flow of services to meet the needs for adaptation and mitigation.

Vulnerability of forest ecosystems and the changing climate

Although, the losses in forest cover, productivity, distribution and availability of forest goods is dominated by human interferences in the study area, climate variability and change also plays significant role in affecting many aspects of forest ecosystems. Several studies have linked the effect of changing climate to forest ecosystem. Seppälä et al. (2009) reported impacts of climate change on forest ecosystems to include tree growth and dieback, insert out breaks, species distributions and the seasonality of ecosystem processes.

Leemans and Eickhout (2004) noted that with 1 - 2°C of warming, the adaptive capacity of most species and ecosystems is limited and forests will be among the ecosystems to experience problems first because they lack the ability to migrate or stay within climate zone they

Table 2. Land use/ land cover change and projections for 2050 in the Maro Forest Reserve.

Vegetation cover	Changes in area (ha)				Future projections	
	1986	(%)	2002	(%)	2050	(%)
Riparian forest	3775	6.98	2958	5.47	1206.3	2.23
Savanna woodland	13881	25.68	9382	17.36	349.86	0.65
Shrub savanna	24865	45.99	27552	50.97	29999.07	55.5
Grass savanna	1060	1.96	1060	1.97	965.77	1.78
Forest plantation	2637	4.88	0			

Note: Other land cover types in the area are not relevant to this study.

are adapted to. They noted that at a warming rate of 0.3°C per decade (3°C per century), only 30% of all impacted ecosystems and only 17% of all impacted forests would be able to adapt. McClean et al. (2005) estimates that between one-quarter and one- half of a total of 5,197 species of African plants will be severely affected by climate change since the life zones in which nearly all these species can live would either shrink or shift. Significant loss of flora and fauna have already occurred in the Sahel (ECF and Potsdam Institute, 2004) due to the droughts in West Africa during the 1970s and the consistent decline in rain-fall till the 1990s that caused a 25 - 35 km southward shift of the Sahelian, Sudanese and Guinean ecological zones (Gonzalez, 2001; EPA, 2000; DNM, 2007; SP/CONEDD, 2007). In the past the regional droughts in West Africa have coincided with periods of unprecedented forest fires and this may re-occur in higher magnitude with the projected droughts and reduced rainfalls.

Observational records show increased temperature of about 1°C in Ghana and 1.5°C in Burkina Faso and projections of future climate from the National Communications of both Ghana and Burkina Faso indicates that by 2050, average temperatures could be 2 to 6°C higher than current situations; this may have severe impacts on forest ecosystems in these two countries. Rise in temperature and rainfall can favour occurrence of insect infestations as was attested by the local communities in the case of the shea butter tree in Diebougou, Burkina Faso. The projected drying, anticipated changes in the ranges of tree species, forest composition and in the size and occurrence of insect populations (Volney and Flemming, 2000) will also affect the dynamics of forest fires (Kalame et al., 2009; Biringer, 2003) especially in the Northern part of Ghana. This is because bushfires are predominant in the dry savanna and Sahel regions of Northern Ghana compared to the humid tropical rainforests of the south (FAO, 2001).

Land use land covers change and REDD regime

With the high dependency of African countries on land base economy, climate change will place a serious strain on livelihoods and national development due to it impacts on the productivity and resilience of ecosystems which provide at least 75% of most livelihoods' income and gross domestic products. Africa needs the forests for adaptation and development in similar magnitude as the world need forests for mitigation. Most of the human drivers of LULC change in the study areas such as expansion of cocoa plantations, mining, slash and burn farming, logging, grazing and firewood collection are crucial for livelihood and national development needs that are fundamental to adaptation. Ghana's economy for instance relies on cocoa exports. While these drivers may be useful for adaptation, they are major sources for CO2 emission. This calls for synergies between mitigation and adaptation in forest-based activities. REDD therefore should take into account issues of adaptation, livelihood and national development.

Irrespective of the motives for deforestation and degradation, land cover of the study areas is facing a decreasing trend. Time series LULC results show 60% deforestation of forest in the high forest and forest savanna transition over the past 3 decades. Meanwhile, then closed savanna woodland in the forest savanna transition in the savanna zone declined by about 54% between 1972 and 2000. The study also revealed increasing threats of desertification and land degradation.

A situation that will force indigenous farmers to go for the remaining forest for agricultural cultivation since their degraded farmlands are less productive. Several studies have also showed similar pattern of decline. Antwi (1999) showed that at the beginning of the last century, 79,513 km^2 (33%) of Ghana's total land area of 238,540 km^2 was covered by high forest.

Currently, only 7% of the total land area is covered by forests whilst shrub lands, savanna, and grasslands occupy 64% and cropland and crop/natural vegetation mosaic covering the 22% (Earth trends, 2003). Ghana lost an average of 135 000 ha of forest per year between 1990 and 2000, amounting to an average annual deforestation rate of -2% (FAO, 2007) . Between 2000 and 2005, Ghana's forests decreased by a further 115,000 hectares, with a rate of forest change of - 2% per annum. In total, between 1990 and 2005, Ghana lost 26% of its forest cover, or around 1,931,000 ha (UNEP, 2008).

Similarly, Maro and Oursi natural forests in Burkina Faso have been decreasing gradually from denser vegetation towards more sparse vegetation with the appearance of grassy patches in previous forested areas. It is important to note that these forests are reserve forests with limited human interference, yet sizable changes in land cover is observed. This may be due to the impacts of recurrent droughts in the past decades. Between 1990 and 2005, Burkina Faso has been loosing its little vegetative cover at 24000 ha (-0.3%) per annum (FAO, 2007) reaching a total of 1.6% decrease in forest cover (UNEP, 2008). Currently forests occupy less than 1% of the land; shrub lands, savanna, and grasslands occupy 85% and crop-land and crop/natural vegetation mosaic covering14% of the total land area of 274 000 km^2 (27,360,000 ha) (Earth trends, 2003). The result is that almost 90% of lands of Burkina Faso are at risk of desertification (FAOAGL, 2003).

Studies on changes in forest areas by forest types is an important component of monitoring, reporting and verifying (MRV) deforestation and degradation under REDD schemes (IPCC, 2003b). Nevertheless, the extent to which land use planning and governments' policies that encourage some of the human drivers of deforestation and degradation in pursuit of national agenda remains a complex issue to address.

LULC changes for the region are on the rise and this point to the need for adequate and appropriate policies to address the drivers of deforestation and degradation. Appropriate policy framework for REDD could help prioritize areas with high deforestation risk and high carbon content (Kanninen et al., 2007).

Local perception on the vulnerability of forest goods

Among West African communities, forest / tree products are very important to the livelihoods of the people because of their many benefits. The loss of several important plant and animal species as indicated by the local communities is linked to land use changes and the loss of the forest cover. This indicates the vulnerability of forest ecosystems and its continual provision of goods and services on which communities and national economies depend is threatened.

In some communities in Dori region in Northern Burkina Faso, the local communities highlighted the significant reduction in the availability of NTFPs, high variability in their productivity and in some villages such as the Djomga and Gnalalaye villages, a complete extinction of some valuable NTFPs producing tree species like the *Adansonia digitata, Diospyros mespiliformis* and *Anogeissus leiocarpus.* This situation according to the local communities started from the years of drought in the region. And the subsequent recurrent droughts in combination with anthropogenic pressures resulted to poor tree regeneration, tree dieback and mortality with consequential negative effects on the availability of NTFPs (Idinoba et al., 2009).

The emergence of insect pest on the shea trees since the 1980s as observed by the people is a major threat to the shea tree. Pestilences are increasing in number and reducing the productivity of the trees in West Africa. According to the communities interviewed insect pests especially the gunus *Salebria* seems to emerge with the aggravation of the changing climatic conditions. Such attack has been documented by other studies (Lamien et al., 2008; Lucier et al., 2009), and could be explain by the increasing light intensity and warmer conditions (Barbosa and Wagner 1989; Currano et al., 2008). Although the community in Ghana perceived changes to be mainly human induced, they also see a clear link in the observable differences in weather conditions in the past and now and the fact that species/ herbs they have been using are already scarce. While local knowledge may not always be scientifically approved, local communities have understood and observed changes in their environment for generations and in most instances have been able to adapt to varying degrees. Therefore, their knowledge forms a relevant source of information on historically baseline and sustainable forest management practices which can be a useful resource in the preparation of planned adaptation.

Existing and planned adaptation strategies

Communities have always coped with changes and will continue to cope, but the sustainability of such existing coping strategies remain an issue since the projected changes in climate over the coming years are far more severe than any the communities have been accustomed to in the past. Some of the adaptive steps taken so far in West African region are as follows: The government and some private initiated programme of reforestation and afforestation in Burkina Faso aims at the ecological zonation of tree species following south-wards shift in rainfall pattern over the years to facilitate the evolution of forest ecosystem under current changes in climatic conditions. Farmers have learnt to preserve and protect particular useful tree species such as *Vitellaria paradoxa, Parkia biglobosa, Mangifera indica, Adansonia digitata* on their farmlands to ensure continuous supply of NTFP while some research institutions like the Forest Research Institute of Ghana, Institut de l'Environnement et de Recherches Agricoles and Centre National de Semences Forestières in Burkina Faso and other NGOs are increasingly domesticating and im- proving adaptive and resistant genetic varieties of useful tree species (Idinoba et al., 2009).

Traditional or local laws are put in place to regulate the exploitation of forest products, for example in some parts of Burkina Faso, at the beginning of rainy season when almost all the fruit trees are bearing fruits, the chief of the land makes sacrifices to signal departure for gathering shea nuts. The people are permitted only to collect fruits that have fallen off the shea nut tree and it is forbidden to climb the tree to gather the fruits. Any contravener of this rule runs the risk of loosing all that he has already collected, being banned from further collection, paying a fine or will be made to undergo the performance of a ritual. This is to prevent the collection of immature fruits, which is prohibited. In some communities too, a tree is planted when a male child is delivered. In all the studies areas, local bye-laws and rules are also being enforced in some communities to prevent the reckless use of fire in hunting and land preparation, especially in the savanna and Sahel areas, in such communities, there are community fire protection groups that help in extinguishing any detected fires and also arrest the culprit. These measures notwithstanding, the lack of alternative means of livelihood has led to over exploitation of forest products by majority of the population almost everywhere in the study zone. This calls for appropriate policy responses on the management, development and recognition by decision makers of the role of NTFPs for adaptation of communities (Kalame et al., 2009). Since adaptation is a dynamic process it will require planning and participation of all stakeholders at local, district and national levels with continuous monitoring and evaluation for further improvements which is currently lacking in the region. With the increasing current trends and projection of increased temperatures and variable rainfall for West Africa the exposure of forest to changing climate will increase, while at the same time, humans and sectors that depend on the forest ecosystem will most likely not decrease their dependence and interference on useful forest products for livelihoods or autonomous / spontaneous adaptation which leads to further sensitivity of forest ecosystems to changes. An ecosystem-based adaptation approach may be more suitable as it addresses vulnerability and planned adaptation of ecosystems at multi-sectoral and multi- scale levels involving various governance structures and existing local knowledge to reduce vulnerability of ecosystems, people and economic sectors to environmental changes.

Conclusion

Current and projected LULC changes for the region are on the rise and this point to the need for adequate and appropriate policies to address the drivers of deforestation and degradation to enhance the natural resource-dependent development agenda of most countries in Africa. Climatic and non-climatic drivers are responsible for changes in forest cover, productivity, distribution and availability of forest goods in the study areas. Although human activities appear to be dominant, climate variability and change also plays a role. The extent of the impacts of human and climatic forces on the land cover changes are however complex and not clear. This study shows relevance to both adaptation and mitigation activities. Local communities observe changes in their environment which are similar to other documented studies. Their knowledge and observations help them to adapt, which can forms a relevant source of information useful for planned adaptation. Information generated in this study on changes in forest areas is an important component of monitoring, reporting and verifying (MRV) deforestation and degradation under REDD schemes. Appropriate policy framework for forest ecosystem management using an ecosystem-based approach will reduce vulnerability and provide benefits for adaptation and/or mitigation.

ACKNOWLEDGEMENTS

This document has been produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of the authors and can under no circumstances be regarded as reflecting the position of the European Union. We acknowledge the useful contributions of Chantal Agbahungba, Placide Hien and Kologo Oumarou and the various anonymous reviewers.

REFERENCES

Antwi LB (1999). What we have: Our Forest Heritage. Proceedings, Workshop for Media Personnel on Forestry and Wildlife Reporting. IRNR-UST, pp. 6-11 June.

Barbosa P, Wagner MR (1989). Introduction to forest and shade tree insects. Acad. Press, Inc, San Diego.

Biringer J (2003). Forest ecosystems threatened by climate change: promoting long term forest: Hansen LJ, Biringer JL, Hoffman JR (eds) Buying time: a user’s manual for building resistance and resilience to climate change in natural systems. WWF, Berlin, Germany, pp. 41-69.

Brovkin V (2002). Climate-vegetation interaction. J. Phys. 12:57-72.

Currano ED, Wilf P, Wing SL, Labandeira CC, Lovelock EC, Royer DL (2008). Sharply increased insect herbivory during the Paleaocene-Eocene thermal maximum. Proc. Nat. Acad. Sci. United States Am., 105(6): 1960-1964.

DNM (Direction Nationale de la Météorologie) (2007). Programme d'Action National d'Adaptation aux Changements Climatiques (PANA). Ministère de l’Equipement et des Transports, Mali.

ECF (European Climate Forum) and Potsdam Institute (2004). What is dangerous climate change? Initial Results of a Symposium on Key Vulnerable Regions, Climate Change and Article 2 of the UNFCCC, Buenos Aires. Beijing, p. 39. http://www.european-climate-forum.net/.

EPA (2000). 1st National Communication of Ghana to the United Nation Framework Convention on Climate Change. Environmental Protection Agency, UNFCCC.

EarthTrends (2003). Country Profiles. http://earthtrends.wri.org.

FAO (2001). Global Forest Fire Assessment 1990-2001 - FRA WP 55. The Forest Resources Assessment Programme, Food and Agricultural Organisation (FAO). Rome. http://www.fao.org/docrep/006/AD653E/ad653e00.HTM.

FAOAGL (2003). Land Degradation Severity. Terrastat online database. http://www.fao.org/ag/agl/agll/terrastat/#terrastatdb.

FAO (2007). State of the World's Forest 2007. Food Agric. Organization. Rome, Italy. [www.fao.org]

Gonzalez P (2001). Desertification and a shift of forest species in the West African Sahel. Climate Res., 17: 217-228.

Idinoba M, Kalame FB, Nkem J, Blay D, Coulibaly Y (2009). Climate change and non-wood forest products: vulnerability and adaptation in West Africa. Unasylva, 60(1-2): 231-232.

IPCC (2003). Good practices guidance for land use, land-use change and forestry (GPLULUCF). Penman J, Gytarsky M, Krug T, Kruger D, Pipartti R, Buendia L, Miwa K, Ngara T, Tanabe K, Wagner F (eds), IPCC-IGES, Kanagawa. <http://wwwipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.html (12> March 2008).

Kalame FB, Nkem J, Idinoba M, Kanninen M (2009). Matching national forest policies and management practices for climate change adaptation in Burkina Faso and Ghana. Mitigation Adaptation Strategies Global Change, 14: 135-151.

Kanninen M, Murdiyarso D, Seymour F, Angelsen A, Wunder S, German L (2007). Do trees grow on money? The implications of deforestation research for policies to promote REDD. Center Int. For. Res. (CIFOR), Bogor, Indonesia.

Lamien N, Tigabu M, Dabiré R, Guinko S, Oden PC (2008). Insect (*Salebria* sp.) infestation and impact on Vitellaria paradoxa C.F. Gaertn. Fruit production in agroforestry parklands. Agrofor. Syst., 72(1) 15-22.

Locatelli B, Kanninen M, Brockhaus M, Colfer CJP, Murdiyarso D, Santoso H (2008). Facing an uncertain future: How forest and people can adapt to climate change. Forest Perspectives no. 5 CIFOR, Bogor, Indonesia.

Lucier A, Ayres M, Karnosky D, Thompson I, Loehle C, Percy K, Sohngen B (2009). Forest responses and vulnerability to recent climate change pages 29-52 in Seppälä, R., Buck. A. and Katila, P. (eds). 2009. Adaptation of forest and people to climate change. A global assessment report. IUFRO World Series, Helsinki, 22: 224.

Leemans RE (2004). Another reason for concern: regional and global impact on ecosystems for different levels of climate change. Global Environ. Change, 14: 219-228.

McClean CJ, Lovett JC, Küper L., Hannah JH, Sommer W, Barthlott M, Termansen GF (2005). African plant diversity and climate change. Ann. Mo. Bot. Gard., 92 : 139-152.

Murdiyarso D, Skutsch M, Guariguata M, Kanninen M, Luttrell C, Verweij P, Martins OS (2008). in Angelsen, A. (ed.) 2008. Moving ahead with REDD : Issues, opyions and impications. CIFOR, Bogor, Indonesia.

Reij C (1983). L'évolution de la lutte anti erosive en Haute Volta depuis l'indépedence: vers une plus grande participation de la population. Vrije Universiteit, Amsterdam: Amsterdam Inst. Environ. studies.

Seppälä R, Buck A, Katila P (eds). (2009). Adaptation of forest and people to climate change. A global assessment report. IUFRO World Series, Helsinki, 22: 224.

SP/CONEDD (2007). Communication Nationale du Burkina Faso pour le Convention Cadre des Nations Unies sur les Changements Climatiques (UNFCCC). Ouagadougou, Secrétariat Permanent du Conseil National pour la Gestion de l'Environnement: 132.

UNEP (2008). "Africa: Atlas of Our Changing Environment." Division of Early Warning and Assessment (DEWA), United Nations Environment Programme (UNEP). Nairobi, Kenya. pp. 182-187.

Volney WJA, Fleming RA (2000). Climate change and impacts of boreal forest insects. Agric. Ecosyst. Environ. 82: 283-294 doi:10.1016/S0167-8809(00)00232-2.