Adverse Impact of Climate Change on Mambioko Community Dependent Forest and Local Perception on Vulnerabilities and Responses-Centre Region of Cameroon

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Abstract

Background: Forest ecosystems have important environmental and ecological dimensions which provide livelihoods to Millions of people globally. Forest provides services that are directly link to micro and macro climate, water and soil resources, plants and animals' diversity, food production and food securities and energy resources This study was undertaken to identify and assess climate change vulnerabilities and impacts on the livelihoods of forest dependent communities in Mambioko community forest in the Centre Region of Cameroon.

Methods: Primary data was collected from 120 households; key informants, focus group discussions and was supplemented with secondary data from desk review of relevant literature.

Results: Forest resources were generally perceived by forest dependent communities as declining. Climate Change was observed to have impacted on their major livelihood's activities/resources of forest dependent communities by way of prolonged drought, erratic rainfall pattern, and variability in rainfall intensity. These trends have consequently led to drying of rivers and streams, shift in cropping season, reduced yield, frequent and extreme warm conditions among others. The use of irrigation, crop diversification, household income diversification through alternative livelihood activities and increase in size of cultivated farms are among the different measures being adopted by communities to cope up with the effects of climate change. Using socio-economic indicators, the bimodal agro ecological zone is vulnerable to climate change impact. The zone has relatively higher dependency on climate sensitive livelihood activities/resources, limited diversified income sources and moderate access to climate change information.

Conclusions: This study conclude that in an attempt to help forest dependent communities cope up with climate change impacts, fundamental issues such as non-climate dependent alternative livelihood activities, access to climate, sustainable agricultural practices and sustainable forest resources management are key areas for various multidisciplinary intervention.

1 Background

Forest ecosystems have important environmental and ecological dimensions which provide livelihoods to Millions of people globally. Forest provides services that are directly link to micro and macro climate, water and soil resources, plants and animals' diversity, food production and food securities and energy resources. Nevertheless, the dynamic nature of ecological systems is continuously influence by climate variability. Climate change has the multifaceted potentials to affect the geographical location of ecological systems the species they contain and ability to offer a wide range of benefits on which society depend on for their sustained livelihood generations Climate change is often considered a key threat to the survival of species and the reliability on the forest ecosystems world-wide.

The inherent variability of climate conditions from year to year and from decade to decade makes variability an integral part of climate change (Berz 1999; Hulme et al. 1999) and therefore adaptation to

climate change is inherently adaptation to variability (Downing et al. 1996; Yohe et al. 1996; Smit et al. 1999). Climatic conditions can, however, vary significantly over short periods of time (from season to season or from year to year) and at relatively smaller spatial scales and may bring with them surprises to an otherwise unsuspecting population. Most socio-economic and ecological systems can cope with changes in mean climatic conditions (Smit and Pilifosova 2001), however many systems and communities are vulnerable to changes in events of a frequency and magnitude large enough to fall outside their coping range (Schneider 1997; Rayner and Malone 2001). While small-scale farmers living in areas of high environmental stress in the developing world may be highly capable of adapting to short and long-term climatic and environmental variations (Challinor et al. 2007; Morton 2007), exposure to isolated shocks of natural or man-made origin leads to a degradation of their adaptive capacity and reduces their potential of attaining the goal of sufficiency in food, nutrition and health. Locally specific climate stressors with low predictability are most likely to negatively affect smallholder and subsistence farmers (Morton 2007).

It is believed that the effects of climate change on forests will continue to alter forest in many ways, resulting to change of many services that forest ecosystem provide. In the forest zone of Cameroon recent studies indicated that climate change is already having adverse impact on the livelihood strategies of rural people (Bele et al., 2013). Drought, changing seasons, erratic rainfall patterns, heavy rainfall and strong winds are among the main climate-related disturbances perceived by local people. Although some individuals have developed coping strategies, there is a limit of broader community resilience that can be fostered through such individual's efforts (Bele et al., 2013). While small-scale farmers living in areas of high environmental stress in the developing world may be highly capable of adapting to short and long-term climatic and environmental variations (Challinor et al. 2007) It is important to understand and know the impact of climate change on the livelihoods of the forest dependent communities and the respond of these communities within the context of their adaptation strategies which in future will reduce their vulnerability and enhance their livelihoods activities. The roles play by forest-dependent communities through incentives, motivation and participation in design and the implementation of adaptation strategies. In Cameroon, pronounced seasonality (with the dry season becoming drier and the rainy season becoming wetter) is observed from the country's climate data (Molua 2006; Molua and Lambi 2007). An increase in length of the rainy season may also give rise to other impacts, such as pre-harvest damage of mature crops on farms and post-harvest damage of crops in homes, due to limited resources for preservation and lack of preparedness. Such damages can be seen within the context of income shocks likely having a larger impact on the poor (Kurukulasuriya and Rosenthal 2006).

1.1. Conceptual Frameworks

1.2. Vulnerability and resilience of local livelihoods

Vulnerability has been used in different contexts and has various definitions, which often stems from the different academic backgrounds. Based on the definition of livelihood and sustainable livelihood. Vulnerability can be defined as the susceptibility to circumstances of not being able to sustain a

livelihood (Adger 2006). In the context of climate change, IPCC (2001) defines vulnerability as ‘the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes’. Vulnerability also refers to susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger 2006). Blaikie et al., (1994: p. 9) defines vulnerability as “the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impacts of natural hazard” and Langeweg and Gutierrez-Espeleta (2001), defines it as; “the exposure to hazard by external activity (e.g. the climatic change) and coping capacity of the people to reduce the risk at a particular point of time”. Three key parameters that have been identified as essential for understanding and conceptualizing vulnerability are exposure, sensitivity and adaptive capacity (Kelly and Adger 2000; Adger et al. 2003; Brooks 2003; Downing and Patwardhan 2003; Fussel 2005). Thus, climate change impacts are a function of the exposure to external hazards or harm and the sensitivity of the system (Schroter et al. 2005; Metzger et al. 2006). Invariably, vulnerability of local livelihoods is a function of the impact of climate variability and change, and people’s adaptive capacity to cope with such impacts. In the light of this, vulnerability can be argued to result from loss of resilience. It is under this lens that we also present the concept of resilience. Within the context of socio-ecological system, resilience has been defined as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change (Adger 2000). According to Holling and Gunderson (2002), resilience is the magnitude of disturbance that can be absorbed before the system changes its structure by changes to the variables and processes that control behaviour. Resilience has been used in some cases to characterize the adaptive capacity of a system (Tompkins and Adger 2004; Folke 2006; Fussel and Klein 2006; Gallopin 2006), but also as the flipside, or antonym, of vulnerability. In any case, resilience refers to the internal capacity to respond, which in a sense is the adaptive capacity of a system that makes it less vulnerable. A more resilient local livelihood will obviously be a less vulnerable one. From Fig. 1 resilience can be interpreted on an individual basis as how a particular capital asset interacts with externalities such as shocks, seasonality and change. The aggregate contributions to livelihood in coping with similar situations make it resilient. This is a crucial aspect since the capabilities of individuals or communities in utilising varying combinations of assets following the prevailing circumstances influence the resilience of both the livelihood system and the asset bases. Such resilience in the face of stresses and shocks is key to livelihood adaptations (Davies 1996); invariably, those who are unable to cope (temporal adjustments in the face of change) or adapt (longer-term shifts in livelihood strategies) are inevitably vulnerable and unlikely to achieve a sustainable livelihood (Scoones 1998). Aligning livelihood strategies and natural resource management along new trajectories of climate risks and livelihood adaptation, is important in national policies and programmes geared towards reducing vulnerability of forest dependent-communities (Sonwa et al. 2011a). Private businesses such as logging and mining companies operating in and around communities are relevant in facilitating and building community capacity. Lastly, civil society organizations such as community-based membership organizations and cooperatives offer great opportunities for facilitation and capacity building in local communities (Agrawal, 2008).

This study set out to attain three objectives: to identify major climate sensitive livelihood resources at the household level, examine the level of dependency on climate sensitive livelihoods resources and their perception of climate change impacts on their livelihoods, to examine the socio-economic vulnerability and the available coping and adaptation strategies.

2. Materials And Methods

2.1. Study area Description and Methodology

The site selected for this study (Mambioko) is about 40km away from the chief town of Ngambe-Tikar sub division. It was selected based on the accessibility, number of villages, and dependency of the community on climate sensitive livelihood resources. The study site is covered by a community forests (Mambioko community forest) and it fall in the bi-modal humid forest agro-ecological zone with an annual rainfall range of 1,500–3,000mm and mean temperature of 23°C (Bele et al., 2013), and covered a surface area of 4684 hectares with a population of about 800 inhabitants and a population density of about 7 people per km². They are found in the transition zone between Northwestern Congolian lowland forests and Northern Congolian forest-savanna mosaic. The local economy is based on the exploitation of natural resources including timber agriculture, hunting, fishing and the exploitation of non-timber forest products (NTFPs).

2.2 Methodology

a. Data collection

Secondary data was obtained through desk review of related literature from published and unpublished sources. A survey and primary data collection was collected within five months from February 2018 to July 2018 in villages that constitutes the study area. Primary data was collected through structured questionnaire for conducting interview at household level. In each village, the households were selected based on their availability of individuals, their willingness to participate in the interviews and their estimated numbers as given by the village head and the age chosen that was from 27 years and above was based on their longevity in the study site; experienced in local climatic variability and climatic changes. Additional information was collected from key informants through focus group discussions or village meetings. Tools used include; brainstorming, historical trend analysis diagnosis, visioning, process documentation. Tools which were used include; brainstorming, historical trend analysis diagnosis, visioning, process documentation.

b. Data Analysis

Data were analyzed descriptively using excel spread sheet. Statistics were carried out where necessary to test for the level of significance among variables. Analysis were made at the level of the agro-ecological zone

3. Results And Discussion

3.1 Major climate sensitive livelihood resources.

According to some households during survey, fishing was identified as major climate sensitive livelihood activity and ranked the lowest climate sensitive livelihood activity (1.75%) of the respondents their major livelihood activity was fishing. Hunting was identified as another major climate sensitive livelihood activity (1.7%) of the respondent their major climate sensitive livelihoods activity was hunting, which ranked the second lowest. Others livelihood activities were (non dependent on climate sensitive livelihood activities like business and white collar job). The collection of NTFPs was also another major climate sensitive livelihood activity/resources (61.3%) of the respondents do carried out the collections of NTFP as their major livelihood activity and was ranked the second highest major livelihood activity and agriculture ranked the highest major livelihood activity (100%) of the respondents carried out agriculture as their major livelihood activity. From this study it was observed that, the entire households do carry out different agricultural activities but to some households it is not their major livelihood activities (Figure.3)

3.2. Level of dependency on climate sensitive livelihoods resources

In the study area, respondents ranked their level of dependency on climate sensitive livelihood activities/resources based on the significant contribution climate sensitive livelihood activities/resources (tree products, plant materials and forest product for food and agricultural activities like farming) make to household's income and other household needs (Figure.4). The three-level ranking was used based on the significant role these resources play in livelihoods sustainability. (High dependency = Home consumption and frequent sale of surplus on the local market; Moderate Dependency = Home consumption and occasional sale on the local market; Less dependency = Home consumption only) Generally, (46.7%) of the total respondents were ranked as high level of dependency on forest resources. In this category, respondents described the contribution of climate sensitive livelihood activities/ resources to household's income as very significant. The study showed that level of dependency on fishing was (11.8%) following the field survey which ranked the third lowest dependency, follow by hunting which recorded a percentage of (6.8%) which ranked the second lowest dependency while others activities recorded (3.4%) level of dependency which ranked the lowest dependency while the collections of NTFPs recorded (39.8%) of dependency which ranked the second highest dependency and finally agriculture recorded the (99.2%) level of dependency and was ranked the first highest level of dependency following the survey.(Figure.4)

3.3. Perception on climate change impacts on major livelihoods resources (agriculture and its indicators)

Agriculture is still highly dependent on climate; temperature, light, and water are the main drivers of crop growth. The perception of climate change impact on agriculture was based on the following indicators like pest and diseases, drought, erratic rainfall, prolong, rainfall, low production, changing seasons and strong winds. In this study (74.6%) of the respondents agreed that pest and diseases have been affecting their agricultural activities in the past 10 years especially cocoa. Low production (83.2%) of the respondents agreed that this have been the principal climatic threat to their agricultural activities leading

to food insecurity in these communities. Erratic rainfall as one the indicator, (81.5%) of the respondents believed the climatic stress they are facing on their agricultural activities is erratic rainfall which have change their traditional farming which they use to have in the past. This finding is like another study carry out (Bele et al.,2013). According to the survey (54.2%) of respondents agreed that prolong rainy seasons was affecting their agricultural activities which result to post harvest problem and food insecurity. This finding is similar to the study carried out by ((Yengoh et al., 2010a). In addition, (97.5%) of respondents said strong winds is one of the climatic stress affecting their livelihood activity (agriculture). This finding is like the study carried out by (Bele et al.2013). Following the household survey, (94.1%) of respondents agreed that the increase in climatic events like drought have increase food insecurity in this communities which their livelihoods depend on agriculture. (Figure.5). According this communities, changing seasons (100%) of the respondents is affecting the production calendar which at first was clearly defined but now farmers needs to adapt to unpredicted rainfall and dry season patterns.

Source: Field work,2018

3.4. Respondents perception of climate change impact on fishing and its indicators

Fishing is another activity and a source of income to some households in the study area. According to responses during the survey, (9.8%) of the household agreed that, the drying of water courses due to unreliable rainfall have reduced fishing ground in this communities leading to reduction in the quantities of fish which is caught, for the past 10 years for commercial and for subsistence. In addition, drought (93.2%) of the households agreed that, the principal climatic threat to fishing activity was drought especially during the short rainy seasons reducing food compliments of the households. (Figure.6). Furthermore, household responses (69.5%)agreed that heavy rainfall is the climatic disturbance affecting fishing in this communities especially as the rainy seasons have been come rainier in the past years.

Source: Field work: 2018

5.5 The perception of respondents on the impact of climate change on NTFPs

Forest resources in the form of NTFPs serve as safety nets, sustaining the livelihoods of some forest communities in Mambioko. They play a vital role in income generation and household food security (Nkem et al.2010). The results of this study indicate that the collection and sale of NTFPs is a major livelihood activity and a source of income for households especially in Ngoume and the access to NTFPs is open to the peoples in both community forest settings. They collect NTFPs known as Bush mango (*Irvingia Gabonensis*), Njansang (*Ricinodendron*). NTFPs collection is very strategic in the Mambioko CF, it constitutes about (39.9%) of main livelihood activity and source of income. In this study 91.8% of the household agreed that heavy rainfall prevented the collections of NTFPs especially fuel wood which by is used all the household in Mambioko CF. Households involved in the collection of NTFPs as a main

livelihood activity especially in Bidi the households communicated that the harvesting of fruits from the different tree species is at times poor as a result of poor flowering and fruiting of the tree species. In addition, (94.3%) of the household agreed that drought as one of the climate impacts on climate sensitive activities/resources in these communities. Drought have caused serious problem in collection of some NTFPs species especially njansang which have become very difficult for back to decompose and cracking to remove the nuts. Furthermore (98.1%) of the household indicates that changing seasons is currently affecting the collections of NTFPs due to unpredictable pronounce seasonality like the occurrence of dry Months which have become drier, occurrence less precipitation has reduced the resilience of some plants species due to prolong dry season. Also (84.9%) of the household agreed that erratic rainfall is affecting the collection of NTFPs especially the harvesting of certain fruits in some tree species according some household in Ngoume is very poor due pests and diseases that affect the flowering of this fruits base on their local knowledge.

3.5. Socio-economic vulnerability of respondents in the study site base on six selected indicators

The socio-economic vulnerability in the study site was estimated using six socio-economic indicators. In the estimation, the following assumptions were made:

5.6.1 Household size (HH): Higher household size is associated with higher vulnerability

5.6.2 Level (LE): Lower education level is associated with higher vulnerability

5.6.3 Level of Awareness of Climate change issues (Access to Climate Change information (ACI): Lower access to climate change information is associated with high vulnerability

5.6.4 Dependence on climate sensitive activities/resources (DCO): Higher dependence on climate sensitive occupation is associated with higher vulnerability

5.6.5 Low income (High income is associated with lower vulnerability and lower income is associated with high vulnerability

5.6.6 Poverty is associated with high vulnerability

5.7 Coping and adaptation strategies.

The enabling framework for gaining access to both this knowledge and the resources with which it can be translated into concrete actions that promote adaptation, however, most be provided by governmental and non-governmental institutions at the local, national and international level (Yengoh et al. 2009). At the centre of this communication and collaboration, Vignola et al. (2009) advocate an ecosystem-based framework in which addressing the problems of ecosystem degradation and the conservation of natural capital are the main focus. In this study, (4.2%) of the household used fertilizers in their farms in order to increase yields. The local agriculture system depends on natural temperature, sunshine and rainfall. This implies adjusting and improving (technically, financially and materially) agriculture activities which will

reduce the vulnerability and increase the adaptive capacity of households. The planting of trees to protect winds (5.9%) of the household have planted trees especially around their houses to protect strong winds during torrential rainfall which is accompanied by strong winds in the study site which use to off roof their houses and most households used their traditional methods to protect winds by tying red pieces of cloths round their farms land. Additional (7.6%) of the household have adopted irrigation system of farming during the prolong dry seasons and drought, they moved to swamps areas and opened their new farms where water is available throughout the year the local farmer used watering cane to send water into the farms. They described this irrigation system as “climatic push factor”.

Furthermore 32.8% of household have diversified their crops, sustaining the diversity of crops it is an appropriate adaptation option for food security and livelihood in this communities. This finding is like other studies carried out by (IDRC, 2009). Household in the study area has expressed their willingness to integrate other livelihood activities like food crops and livestock rearing (sheep) have increase their source of income especially small farmers in the study area. This is similar to the findings of (Yengoh et al. 2010). The head master of the Mambioko primary school have initiated beekeeping farming in the Mambioko village though he faced a lot of challenges(financial and technical) This study also show that diversification as an adaptation option at the local levels, cuts across different sectors (environment, forest and wild life, livestock and fisheries, agriculture and rural development, scientific research, finance and commerce), thus it requires the development of inter-sectoral coordination. This finding is supported by that of Yengoh et al (2010), which draw attention to the fact that coordination and collaboration is required between sectors that build the capacity of rural livelihoods.

In this result (69.7%) of household have diversified their occupation in order to reduce their vulnerability to local climate and uncertainty. Engaging in non-climate dependent alternative jobs such as driving, masonry works, sale of assorted goods “provision store”, shoe repairing, painting, sewing or dress making was ranked the second highest among the coping measures described by respondents. Although the dominant occupation is farming and therefore it is expected that most people will give priority to any coping measures that will help sustain their dominant livelihood activity, household members especially the young migrating to urban centres in search for jobs resulting to rural exodus in the study site. Finally, (78.2%) of respondent have increased their farms sizes. According to the household, they increase their farms sizes every beginning of farming season as an adaptation option to local climate variability and uncertainty. The expansion of agricultural land is a coping and adaptation strategy for these forest dependent communities (Figure.8). This supported the findings carried around the same area (Bele et al., 2013a). Increasing the agriculture land to compensate for losses has put more pressure on other natural resources on which the communities depend, resulting in a perverse cycle that could increase their vulnerability even more. Increased climate variability and uncertainty seems to be one of the main disturbances shaping current vulnerability in these communities.

4. Conclusion

This study has investigated the adverse impacts of climate change effect at the household level of forest dependent communities in the case of Mambioko CF in the Centre region of Cameroon. It has also assessed the different coping and adaptation measures being adopted by these communities in the wake of a changing climate. Socio-economic vulnerability levels of this ecological zone have also been determined. Generally, the adverse effects of climate change on key livelihoods activities/ resources and its impacts on livelihoods over the years are already evident. Community perceptions indicate that they are vulnerable to the variation in local climatic conditions and the seasonal calendar, with noted variations in temperature and sunshine, rainfall, and other climate sensitive schedules such as sowing periods and harvesting periods. The secondly vulnerability fear is related to the high level of dependency on climate sensitive livelihoods activities/resources and to some extent the lack of knowledge; widespread poverty and capacity relating to coping strategies.

The communities ranked as highly vulnerable based on the socio-economic vulnerability indicators used. Generally, the high dependency on climate sensitive sectors tends to increase vulnerability to climate change especially, rural communities whose livelihood predominately depends on rain-fed agriculture and forest resources. In the light of this study, addressing the effect of climate change impact at the household level requires reducing the socio-economic vulnerability.

Critical issues such as options of alternative livelihood activities, access to climate, sustainable agricultural practices and agro forestry practices and sustainable forest resource management are key areas to focus. Significant contributions from civil society groups and relevant governmental institutions can play a key role in minimizing the exposure of forest dependent communities to the impact of climate change. This can be done through creating awareness and helping communities to cope and adapt to a changing climate by building on existing coping and adaptation measures while a more scientific approach to ensure sustainable livelihood are being developed.

5. Recommendations

Based in literature and results of this study, the following recommendations could be considered in enhancing the adaptive capacity of the Mambioko local communities:

- a. Community resilience building plans should be work out as it will enhance their adaptive capacity there by reducing their vulnerabilities
- b. The role of national and local government in further analyzing vulnerabilities livelihoods resources of the this communities in order develop adaptive capacity of local communities which cut across different sectors(intersectorial)
- c. The implementation of adaptation strategies requires capacity development of the local communities which INGOs and NGOs can play this role by implementing adaptation through community capacity building or projects.
- d. Setting up mitigation plans in this communities based on local reality will contributes in reducing the vulnerability of the local population

- e. Alternatives livelihoods generation intervention (non dependent on climate) in this communities should be of prime important
- f. Further research is encouraged in the wake of changing cropping patterns in this area.

Abbreviations

CF: Community Forest, NTFPs: Non – Timber Forest Products; IPCC: Intergovernmental Panel on Climate Change

Declarations

Authors Contributions:

All authors were involved in analyzing and editing the paper. All authors read and approved the final manuscript.

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Competing interests

The authors declared that they have no competing interests.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

Ethics approval and consent to participate

This article does not contain any studies with participants performed by any of the authors.

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Informed consent

Informed consent was obtained from individual participant included in the Study.

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Figures

Figure 1

layout map of the study site. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 2

Major climate sensitive livelihoods Resources

Figure 3

Level of dependent on Major climate sensitive livelihoods Resources

Figure 4

Perception of climate change impacts on agriculture and its indicators

Figure 5

perception of climate change impacts on fishing and its indicators

Figure 6

Climate change impact on NTFPs and its indicators

Figure 7

socio-economic vulnerabilities and its indicators

Figure 8

Coping and adaptation strategies and its indicators

Supplementary Files

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