

Securing well-being with the advent of climate hazards

Case of forest-dependent communities in a landscape in the Congo Basin

Case of forest-
dependent
communities

175

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Abstract

Purpose – This paper aims to examine the contribution of forests resource systems to the different aspects of community well-being, the implications of climate variability on the different sources of well-being and further identifies direct and indirect social and policy opportunities relevant for communities to enhance their capabilities in the face of climate variability and change in the Tri-National de la Sangha landscape of Cameroon.

Design/methodology/approach – It illustrates on data collected from focus group discussions and from 151 households randomly selected in three villages to operationalize the conceptual links between community well-being and vulnerability.

Findings – The study shows that vulnerability to climate change interferes with community strategies to achieve well-being, in addition to non-climatic processes which are both internal and external to communities. The study further indicates that healthy forest ecosystems provide opportunities for the local folks to build assets, improve food security, improve health and reduce risks. However, this requires capacity building and the channeling of resources to the local level, in addition to win-win sectoral policy amendments.

Research limitations/implications – Biophysical methods required to complement community perceptions on the suitability of forest resource systems to climate variability.

Practical implications – This paper argues that appropriate strategies which aim at improving well-being needs to capture the role of forest ecosystems, climate change risks and uncertainty and macroeconomic and social processes.

Originality/value – This study contributes to the literature on the relationship between climate risk and the well-being of forest communities. This is relevant for practitioners and policy makers to reflect on the risk of climate change and the rationale for conserving forest resources for community well-being in the post-2015 Millennium Development Goals conclusions.

Keywords Poverty, Vulnerability, Adaptation, Landscape, Cameroon, Congo basin, Forest communities, Forests

Paper type Research paper

1. Introduction

Responding effectively to climate change impacts is a challenge for present and future environmental management and development strategies. Social and ecological systems

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are at risk (Adger *et al.*, 2005) and will continue to suffer if current greenhouse gas emission trends continue. The magnitude and timing of the impacts will vary across geographical regions and across sectors, in addition to the capacity to adapt. In sub-Saharan Africa as in many developing countries, climate change is a constraint to national development efforts, in addition to the already existing environmental problems such as biodiversity loss, land degradation and desertification (IPCC, 2007; MEA, 2005; Stern, 2007). The vulnerability of tropical countries to climate change is explained by the facts that the majority of the livelihoods of the poor and marginalized depend on climate sensitive sectors, such as agriculture, fishing, pastoral practices, energy, forest food, fibre and medicines (Nkem *et al.*, 2007; Heltberg *et al.*, 2009), and many tropical countries face governance and institutional challenges (Osbahe *et al.*, 2008).

The Millennium Ecosystem Assessment (MEA) report highlights that human well-being depends on the exploitation of ecosystem goods and services leading to benefits such as health, security, basic material needs for a good life and good social relations (MEA, 2005). Elements of human well-being are deeply rooted in the Millennium Development Goals (MDGs), especially goal one, eradicating extreme poverty and hunger; goal two, achieving universal primary education; and goal three, promoting gender equality and empowering women. Climate change hinders progress in the achievement of the MDGs (Brooks *et al.*, 2009). Areas of persistent poverty, malnutrition and hunger coincide with areas of high climatic vulnerability (Kreft *et al.*, 2010). Furthermore, ecosystem degradation in addition to climate change is changing development patterns and threatens the bases of household well-being (Hazlewood and Mock, 2010); this requires determination in the MDGs plan of action.

Over 1.6 billion people living in acute poverty depend on forests for part of their livelihood (World Bank, 2004; WRI, 2005). This explains the relevance and connection between forest ecosystems and the MDGs, which has neither been well researched nor established. Furthermore, climate change is a threat to the solutions to eradicate poverty by degrading forests and other forest-related resources on which many households living in poverty depend for their food security and living (Garrity, 2004). There is a need for better understanding of climate risks facing poor natural resource-dependent communities and the potential impacts on household well-being, as efforts are being mobilized globally for adaptation and poverty reduction (Heltberg *et al.*, 2009).

The purpose of this paper is to examine forests resources, community well-being and vulnerability relationships in three villages in the Tri-National de la Sangha (TNS) landscape of Cameroon. More precisely, it examines the contribution of forests and forest-based activities to the different aspects of community well-being, the vulnerability of different sources of well-being to climate variability and further identifies non-climatic factors that exacerbate community vulnerability or enhance their adaptive capabilities in the face of climate variability and change. It is a contribution to the existing literature on climate change vulnerability and adaptation in the Congo Basin region, which is helpful to re-strategize local and national level poverty interventions and to shape the vision of the post-2015 MDG process. The description and analysis will be based on the vulnerability concept developed in the climate change literature (IPCC, 2001) defined by exposure, sensitivity and adaptive capacity. The role of forests, forest resource systems and climate change risks has not been well captured

by present and future national and regional development efforts entrenched in the MDGs. This is crucial for the countries in the Congo Basin region.

The paper is organized as follows. The next section outlines the concepts used to describe the case study. This will be followed by the section which presents the case study area and the methods. Then, the results section will present the findings from the case study area. This will be followed by the analysis and discussion section, in which relevant literature is introduced to provide support to the discussion on the social and political factors that interact with the adaptive capacities of communities in the landscape. This will be followed by a conclusion.

2. Conceptual framework

2.1 Vulnerability

Analysing the different conceptualizations of vulnerability indicates that there is no standard or appropriate framing that fits all contexts and objectives (Kasperson *et al.*, 2005). This is because the notion of vulnerability is used with different policy contexts, referring to different systems exposed to different hazards (Füssel, 2007). In recent climate literature, the IPCC (2001) conceptualization has been dominating climate change analyses – presenting vulnerability as a function of exposure, sensitivity and the adaptive capacity of a system. Exposure is the nature of and degree to which a system experiences environmental and socio-political stresses. Sensitivity is the degree to which a system is affected or modified by perturbations, and adaptive capacity is the ability of a system to evolve to accommodate environmental hazards or policy change and to expand a range of variables in which it can cope (Adger, 2006; Smith and Wandel, 2006).

Vulnerability is produced by environmental factors – climate change and variability and social factors – social relations to resource access, political and economic changes, loss of employment opportunity and weakening social networks (Eriksen *et al.*, 2007; O'Brien *et al.*, 2004; Thornton *et al.*, 2008). According to Kelly and Adger (2000, p. 328), vulnerability denotes “the capacity of individuals and social groups to respond to, that is, to cope with, recover from or adapt to any external stress placed on their livelihoods and well-being”.

2.2 Human well-being

Human well-being in this paper is based on the MEA (2005) conceptualization which is presented as the various aspects required for living a decent life encompassing good health, security, basic material needs and good social relations. Eriksen *et al.* (2007) describe well-being as the process of reducing poverty, interpreting poverty as the deprivation of well-being or deprivation of basic capabilities. They further describe poverty as a multifaceted phenomenon that includes the lack of income, food, clothing, shelter, basic skills and poor health, lack of the sense of community solidarity, a feeling of insecurity in the face of natural disaster and the lack of the ability of people to influence their own situations. These same elements are also highlighted by Heltberg *et al.* (2009) as the outcome of inadequate household well-being. This study is not measuring the different elements of well-being in its strict sense but rather how household resources are allocated to the different elements of well-being. For example, food security is described simply as the direct and indirect contribution of different

production systems and resources to household food consumption designated in this study as nutrition (Arnold *et al.*, 2011).

2.3 Linking well-being and vulnerability

The link between well-being and vulnerability is represented in the shaded area in Figure 1. The linkage will be operationalized in this case study, looking at the interference of vulnerability (climatic and non-climatic) on current methods of securing well-being and the potential options to leverage strategies of secure well-being in the face of climatic stresses. The constituents of well-being are used to describe the capacity of households to cope with external hazards such as climate change (Kelly and Adger, 2000). A better capacity to secure well-being also implies a better capacity to adjust to changing situations. In vulnerability literature, the determinants of adaptive capacity [income, food security, access to resources, social networks and collective action and knowledge and education (Brooks and Adger, 2005; Klein and Smith, 2003)] are similar to the direct and indirect components of well-being in the MEA (2005) study.

3. Study area and methodology

3.1 Study area

The research findings presented here are drawn from data collected in 2012 from three villages (Mboy II, Nampella and Djalobekoe) in the Cameroon part of the TNS landscape located in Yokadouma sub-division, East region of Cameroon (Figure 2). The TNS covers a total surface area of 44,000 km² comprising three contiguous national parks – the Nouabalé-Ndoki (Republic of Congo), Lobéké (Cameroon) and Dzanga-Sangha (Central Africa Republic). It has a population of about 200,000 inhabitants and an estimated population density of 5 inhabitants per km². The climate is generally humid with an average annual precipitation rate of 1,460 to 1,600 mm and a short dry season period from January to March. The local economy is based on the exploitation of natural resources including timber, tourism, mining (diamond, gold, aluminium, etc), agriculture, hunting, fishing and the exploitation of non-timber forest products (NTFPs) (CBFP, 2006). The study area is one of the five pilot project sites that were selected to host projects that integrate climate change adaptation and mitigation in the Congo basin. This study is part of the vulnerability assessment component, which was to

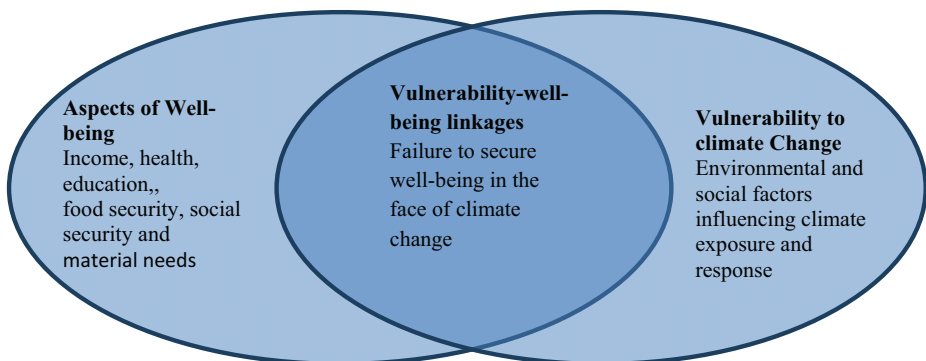
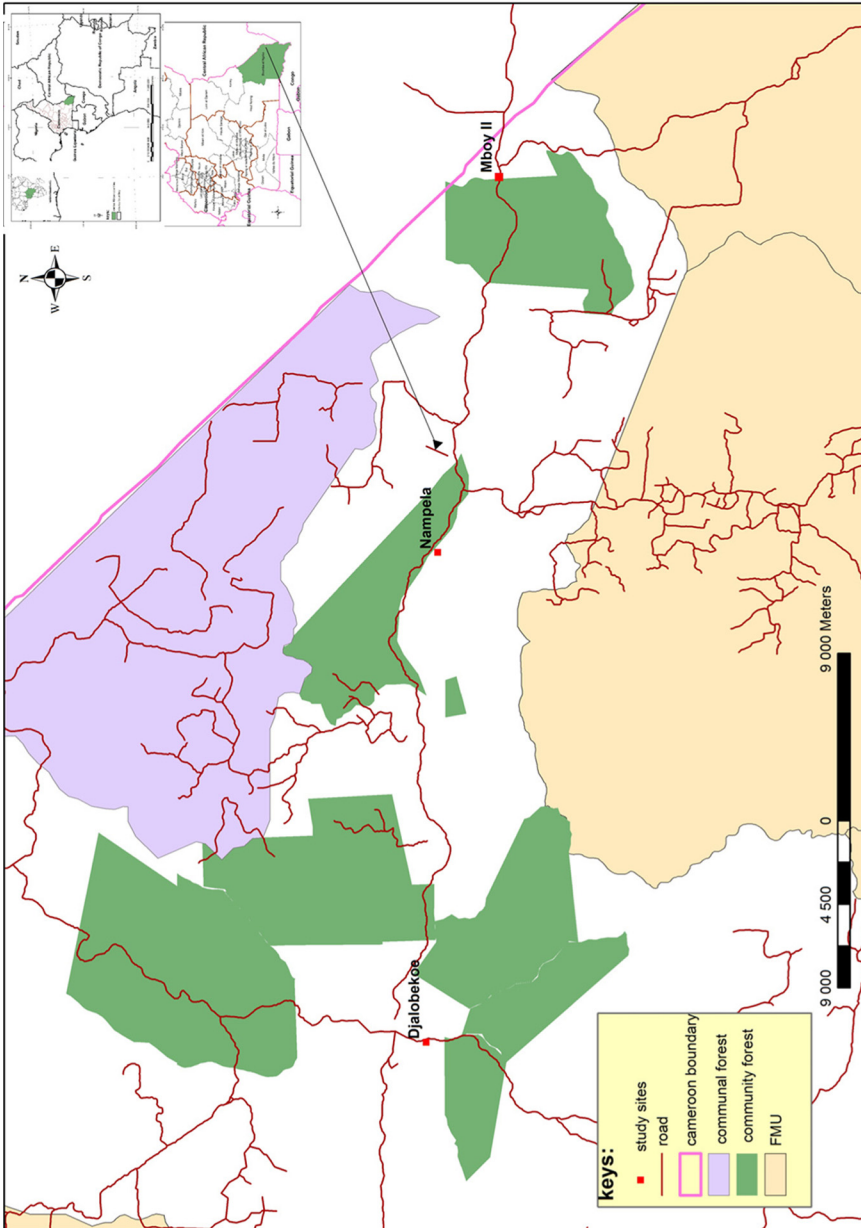


Figure 1. Vulnerability–well-being linkages with the shaded area showing the overlap between the elements of well-being and vulnerability

Source: Adapted from Eriksen *et al.* (2007)



Source: Created by authors

Figure 2.
Map showing the
three villages
involved in the study
in the TNS
landscapes

understand the adaptive capacity of forest communities, to design appropriate adaptation strategies.

3.2 Methodology

3.2.1 Data collection. Table I shows the types of information which are of relevance to this paper and the data collection techniques that were used during data collection. A survey was conducted on 151 households selected randomly from the three villages – Mboy II, Nampella and Djalobekoe. Focus group discussions were carried out involving a mix of men and women, and the group was made up of 24 participants of whom eight came from each village, and women constituted 25 per cent of each of the village groups. Focus group participants were purposefully selected (Limb and Dwyer, 2001), and the village chiefs helped in selecting the participants. The three villages share homogenous social, cultural and local economic characteristics. In situations where gender sensitivity appeared to influence discussions, participants were divided into homogenous groups of men and women. During the pebble voting exercise, group members were asked to distribute the pebbles in relation to the questions showing community dynamics, and the number of pebbles allocated was validated by all group members. For example, groups were asked to vote on how community members usually allocate income to the different aspects of well-being.

3.2.2 Data analysis. Household data relevant for this paper were extracted from the excel project data base. Frequency and proportions were analysed to identify dominant responses between households. We analysed the sensitivity of income to different climatic hazards in the study area by applying the propensity score matching (using the matching package of the “R” statistic software) on two sub-groups from the household survey. We assume that the group that observed climate variability was a more sensitive group and the other group less so.

The scores of the pebble voting were converted to percentages which present the relative differences in perception of group members concerning issues of the community in general. For example, with 100 pebbles representing total income, allocating ten pebbles to education indicates 10/100 (10 per cent), which implies that the group

Type of information	Data collection technique
Community production and resource systems	Household survey FGD* brainstorming and pebble voting
Contribution of production and resource systems to income	FGD, brainstorming and pebble voting Household survey
Distribution of income to the elements of well-being in the communities	FGD, brainstorming and pebble voting Household survey
Climate-related disturbances experience at the household and community level	FGD, brainstorming, historical trend analysis, vulnerability-exposure matrix and vulnerability profiling Household survey
Social networks and collective action	FGD, social network analysis and coping strategy analysis

Table I.
Data collection tools
used in the three
villages

Note: FGD: Focus group discussion

members perceive that community members usually allocate 10 per cent of their income for educational purposes.

We constructed a disturbance-impact matrix by using the description of the villagers to evaluate the differentiated effect of climate-related threats on different activities and resources. We use qualitative scales (1 to 3) and signs (+ and –) to provide an idea of the magnitude of the impact and the type of potential impact.

The study acknowledges the shortcomings and uncertainties in climate change vulnerability studies and specific effects of climatic threats on ecosystems and people at the local level. Notwithstanding such uncertainties, local perception can provide opportunities to build on the complementarities between local and scientific knowledge (Bele *et al.*, 2013b).

4. Findings

4.1 Contribution of forest-based activities to community well-being

Communities in the TNS use different forest-based activities and other strategies to provide for their well-being. The activities in the area include forest-based agriculture, the collection of NTFPs, hunting, fishing and livestock. According to the survey, 45 per cent of households indicated agriculture as their main activity, followed by the collection of NTFPs and hunting with 14 and 13 per cent, respectively. Furthermore, agriculture also constitutes the main source of income, followed by hunting and the collection of NTFPs (Table II). Forests play a vital role in the livelihood systems in the villages by providing resources and services for subsistence and cash purposes. Furthermore, they also play a role as safety nets, as villagers use timber and NTFPs to diversify their income and livelihood base. According to the focus group participants, a greater part of livelihood activities and resources such as hunting, collection of NTFPs, timber harvesting, medicinal plants, fishing, etc., depend on the primary and secondary forests.

Households are involved in the production of different cash-generating crops such as cocoa, plantain and palm oil, with different levels of contribution to average household income. In addition, focus group discussion results indicate that communities are also engaged in subsistence crops (cassava, groundnuts, maize and cocoyam) which also contribute to household income and nutrition. These activities contribute to community well-being principally through the income which is generated by households, which is later on distributed to the different aspects of well-being. Aspects of well-being relate to household nutrition, health, education, investment in production systems and savings,

Activities	Household (<i>N</i> = 151)	(%)
Agriculture	149	98.68
Hunting	50	33.11
Fishing	32	21.19
Livestock	18	11.92
Artisanal mining	10	6.62
Collection of NTFPs	42	27.81
Wage	4	2.65
Business	26	17.22

Source: 2012 survey

Table II.
Contribution of livelihood activities to household income in Mboya II, Nampella and Djalobekoe

material needs such as clothing, construction and household utensils, etc. (Table III). Table III shows the results of the pebble voting on the perception of how households in the communities usually distribute income to the various aspects of well-being.

4.1.1 Group differentiation in securing income. Results from the pebble voting in the women's focus group indicate that women make less income from cash crops (10 per cent) such as cocoa, coffee and pepper and more from annual products (25 per cent) such as plantain and cassava, followed by fish (20 per cent) – mostly shrimps, and NTFPs (15 per cent) such as njangsang (*Ricinodendron heudelotii*), Mpeke (*Irvingia gabonensis*) and Rondelle (*Scorodophloeus zenkeri* Olom). On the other hand, men make more of their total income from cash crops (30 per cent) such as cocoa, coffee and palm oil, followed by annual products (30 per cent) such as cassava, plantain, maize, groundnuts and livestock (15 per cent) such as goats, chickens and pigs. Though the collection of NTFP is seasonal, it is more relevant to women. They put in more time (10 per cent) than men (3 per cent) in the collection process.

Discussions in men's and women's groups which were followed by pebble voting indicate that men and women allocate income differently. Table III shows the differences between men and women in relation to the distribution of income to the different aspects of well-being. Following pebble voting in the women's focus group, perceptions of existing allocation of income by women is represented by education (29 per cent), food and health (15 and 12 per cent, respectively) and household utensils (10 per cent). For men, they allocate income in the order of re-investment in production systems (20 per cent), education (15 per cent) and construction (10 per cent).

4.2 Vulnerability of community sources of well-being to multiple climatic threats

Historical trend analyses indicate that communities have experienced multiple climate-related disturbances. The disturbances relate to shift in seasons, droughts, diarrhea epidemic, caterpillar invasions, strong winds and drying water sources. The perception and explanation provided by the villagers point to the fact that the disturbances are interrelated. For example, changes in dry and rainy season patterns at times lead to water scarcity. During these periods, communities are obliged to use river water sources which increase the chances of a diarrhea epidemic. Changes in seasons

Aspects of community well-being	Income allocation by men (%)	Income allocation by women (%)
Education	15	29
Clothing	8	4
Health	7	12
Nutrition	4	14
Utensils/equipments	8	10
Construction	10	8
Production	22	8
Dowry	5	5
Savings	8	3
Church	4	2
Travel	3	4
Leisure	6	-

Table III.
Distribution of
income to the
different aspects of
well-being by men
and women in Mboy
II, Nampella and
Djalobekoe

Source: Pebble voting exercise, 2012

appear to be the main climate-related disturbances affecting the villages, some of which according to the survey are prolonged dry seasons (54 per cent respondents), prolonged wet season (46 per cent) and dry spells in wet seasons (42 per cent) and intense rainfall (42 per cent). Changes in weather patterns reported by the villagers are in accordance with the records of local weather stations in the area, the Intergovernmental Panel on Climate Change (IPCC) prediction for the region and other studies reported in the humid forest zones of Cameroon (Bele *et al.*, 2013a, 2013b; IPCC, 2007).

Table IV presents the disturbance-impact matrix generated from the focus group discussions in relation to the effects of climate-related threats on the activities and resources that support household and community well-being.

According to the discussions that accompanied the construction of the disturbance-impact matrix, agriculture systems suffer the most from changing seasons. There is distortion in the agricultural calendar in relation to the preparation of agriculture fields, planting, field maintenance and harvesting. Villagers are still struggling to master the “arrival” and “departure” of the wet and dry seasons, and they relate the changing seasons to other crop maintenance problems such as pests and weeds. The production cycle of crops has been altered with assumptions that it has subsequent impacts on crop production. On the other hand, villagers declare that some crops and NTFPs have benefited from changing seasonal patterns.

The perceptions on the impacts of changing seasons on crop production were generally negative (Table IV). The observations from the focus group discussions corroborate the findings from household surveys on the impacts of changing wet and dry seasons on agriculture. More than 74 per cent of respondents indicated negative impacts of seasonal changes on agriculture, followed by 50 per cent of respondents indicating a decline in income from agriculture; meanwhile, about 38 per cent respondents indicated post-harvest storage problems as a result of changing seasons. Agriculture is the main source of income, and such income is very vital for providing for the requirements of well-being such as health, education, basic material needs, investment and food security. This implies that a decline in agricultural production is a big blow to the well-being of forest-based livelihoods. The impacts of climate change on people’s livelihoods in the three villages in the TNS landscape are in accordance with the

Strategies/resources	Intense droughts	Changing seasons	Pest invasion	Strong winds
Agriculture	-3	-3	-3	-3
Hunting	-	+3	-	-
Fishing	-	-2	-	-
Livestock	-	+2	-	-
Forests	-3	-	-	-1
Gardens	-3	-3	-3	-3
NTFPs	-2	-1	-2	-2
Cocoa	-3	-3	-3	-2
Cassava	-2	+3	-	-2
Maize	-	-3	-	-3

Note: Level of magnitude range from ‘1’ = low to ‘3’ = high and potential impacts which can be ‘-’ negative or ‘+’ positive. - = no response.

Source: Vulnerability-exposure matrix exercise, 2012

Table IV.
Disturbance-impact matrix for activities and resources that support well-being in the study area

IPCC predictions for Africa related to changing seasons and decrease in agricultural production (IPCC, 2007).

Results from the propensity matching score analysis of the sensitivity of household income to short rainy seasons, pockets of droughts during rainy seasons and torrential/intense rainfall indicate that households more sensitive to short rainy season have 11 per cent less income than less sensitive households, households more sensitive to pockets of drought in rainy seasons have 9 per cent less income than less sensitive households and households more sensitive to torrential rains have 4 per cent less income than less sensitive households (Table V).

4.3 Non-climatic drivers of vulnerability in local forest communities

Historical trend analysis from the focus group discussion indicated declining quantities of bushmeat and NTFPs over the past decades. The decline was attributed to forest cover change in the area, with claims that forest cover change destroys the habitats of many animals. Participants in the focus group assert that in the 1970s, primary forest which is relevant for hunting and the collection of NTFPs used to be around villages, but presently, villagers are required to walk more than 5 km to access primary forest. For NTFPs such as Bush Mango (*Irvingia gabonensis*) which have been over exploited in the past decades, villagers are expected to walk for over 30 km. Participants highlighted that hunting has become time-consuming and competitive. A hunter claimed that in the 1970s, it was possible to return home with ten animals after a day's hunting, as opposed to five animals caught after two days hunting at present. Forest cover change was attributed to deforestation caused by the expansion of agriculture activities, the presence of logging concessions and mining activities, all of which are further exacerbated by population pressure.

Social networks and collective action reduce vulnerability through the enhancement of adaptive capacity (Adger, 2003). They describe the ability of community members to act collectively, which involves the interdependence of community members through their relationship with each other, with the institutions in which they reside and the resources on which they depend (Adger, 2003; Crona and Bodin, 2009). There is lack of collective action to take care of existing social infrastructure in the study area. Health centres, schools and markets are in a state of disrepair, with no maintenance and upkeep. Bore holes constructed by the state have been destroyed and abandoned. On the other hand, social networks and collective action through associations were positive in the study area. The historical trend analysis shows that the creation of groups and associations in the study area has experienced an increase. Three major collective

Table V.
Results of propensity matching score analysis comparing the sensitivity of household income to local climatic hazards

Climatic variation	Sensitive households Δ ATT	
	Estimation (%)	Err.type
Torrential rains	-4.50***	0.013
Pockets of drought in rainy seasons	-9.30***	0.047
Shortening of the rainy season	-11.2***	0.002

Notes: Significance code: ***significant at 1%; **significant at 5%, (Δ^{ATT} , ATT for "average treatment effect on the treated")

Source: Field survey 2012

actions characterize the different common initiative groups created in the area. Some groups are involved in the collective improvement of agriculture production systems, while others are involved in the combined marketing of agriculture and forest products through cooperatives, and lastly, community members belong to groups and associations that provide material and financial aid to members during difficult periods. These are constituents of well-being (MEA, 2005) and are also relevant in facilitating the adjustment of communities to changes.

5. Analysis and discussion

5.1 Dependence of well-being on forest-based activities and resources

The MEA (2005) report asserts that ecosystem services provide and support different constituents of well-being including security (security from disasters and personal safety), basic material needs (income, food and shelter), health (strength and feeling well) and good social relations (social cohesion, mutual respect and ability to help others). In the case study, the constituents of well-being that benefit from forest resources and forest production systems are (Figure 3) health, education, nutrition, clothing, investment and production, construction, support for village infrastructure, equipment, savings, recreation and family donations. Men and women have dissimilar priorities in terms of distributing resources to the different elements of their well-being.

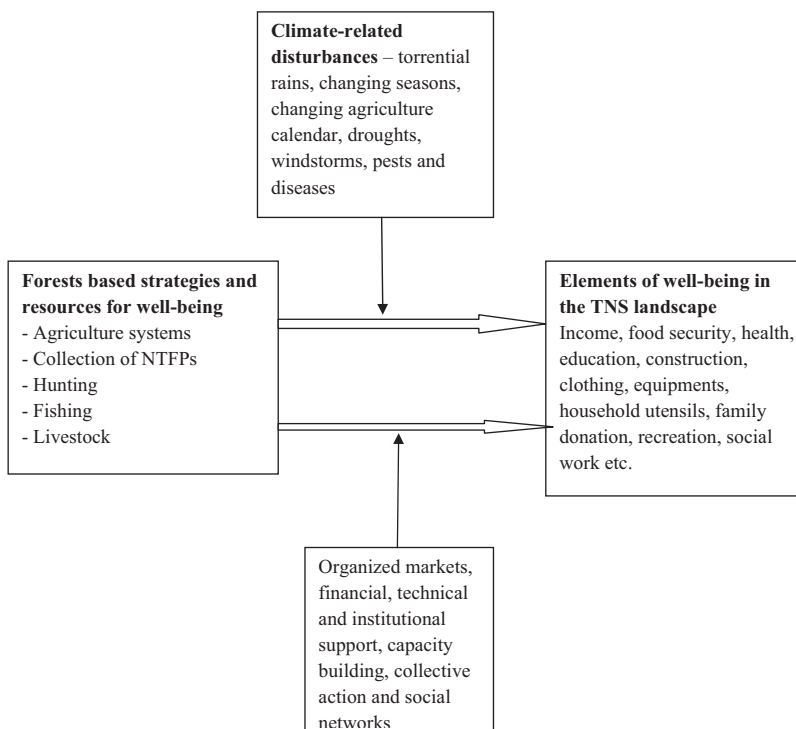


Figure 3.
The state of well-being and vulnerability relationships in the TNS landscapes

Source: Field survey 2012 and secondary information

Understanding the dependence and relationships of people to forest and forest-related resources allows the appraisal of ecological, social and economic changes (Byron and Arnold, 1999). The dependence of community well-being on forest ecosystems services is direct and indirect (Nkem *et al.*, 2012). In the study area, direct benefits from forest relates to income from the sales of NTFPs and direct household consumption. In India (Gunatilake *et al.*, 1993), the Brazilian Amazon (Pattanayak and Sills, 2001) and South Africa (Shackleton and Shackleton, 2004), NTFPs contribute both to household subsistence and income, though annual income generated by NTFPs is much lower than income generated from indirect forest resources such as agriculture. Wildlife also provides direct benefits to income and food consumption. Protein from bushmeat is vital for food security and livelihoods in rural forest communities in the tropics (Nasi *et al.*, 2011). Other findings in the humid forest zone of Cameroon indicate that communities depend on forest for food, fuel wood and medicinal plants, and they also generate income from the trade in NTFPs (Nkem *et al.*, 2010). However, market access also limits better income from the sales of forest products. Nkem *et al.* (2010) assert that in times of difficulty such as climate variability and change, better markets for NTFPs can act as safety nets for households, especially for NTFPs in which their direct consumption has limited contribution for household food security.

Agriculture dominates the indirect contribution of forests to the well-being in the study area. Agricultural production includes food crops (cassava, groundnuts, plantains, cocoyam, maize and potatoes) and cash crops (cocoa, oil palm, etc.). Forests are the entry points in the agriculture cycle through the conversion of primary and secondary forests to agroforestry and farmlands. Apart from agriculture, households are also involved in livestock and fishing activities which contribute both to household food security and income. The degree of dependency of livelihoods on the indirect contribution of forests is high as compared to direct contributions (Nkem *et al.*, 2012), especially for men. In the context of the case study, achieving well-being which is linked to the MDGs occurs within the confines of forest resources and forest-related activities. Climatic hazards will have impacts on the well-being of communities following their pattern of dependency on livelihood strategies that cross the path of climate variability and change (Nkem *et al.*, 2012).

5.2 Linking climatic hazards and community strategies to secure well-being

Communities in the study area highlighted a series of climatic-related observations for the past 10-15 years. Observations were dominated by changes in wet and dry seasons over the years, in addition to droughts, windstorms, torrential rains, rising temperatures, etc. There is limited understanding on the magnitude of the changes in local climatic scenarios in the landscape. Observations were related to uncertainty, irregularity and periodic changes. In a study in southern Cameroon, villagers describe this situation as “Climate accident” (Chia *et al.*, 2013). However, the inherent variations of climate from season to season and from year to year make variability a fundamental part of climate change (Hulme *et al.*, 1999; Berz, 1999). Research has underscored the vulnerability to climate variability and change of sectors, such as food, energy and water (Sonwa *et al.*, 2012), and the livelihood strategies of forest-dependent communities (Bele *et al.*, 2013a, 2013b; Nkem *et al.*, 2012; Chia *et al.*, 2013) in other forest areas in the region.

Climate-related variations observed in the landscape are also accompanied by irregularities in the agro-ecological systems. Ecological change can disrupt the flow and dependability of the supply of ecosystem services that people receive from nature. These changes can in turn increase the vulnerability of people and ecosystems to further changes (Cumming *et al.*, 2005). The irregularities and changing seasons have greatly influenced local climate sensitive activities and resources. Agriculture systems which provide the greatest support to communities in terms of well-being appear to be the most affected. Nkem *et al.* (2012) state that agriculture is considered the most vulnerable livelihood activity in some parts of the humid forest area of Cameroon. In the case study, plant growth and production cycle in general have been distorted including surprises in the timing of field preparation, sowing period, pests, weed control, harvesting and post-harvest loss management. Agriculture and plant growth depend on supporting services such as primary production, nutrient cycling and soil formation. The facilitation of these different services depends on an ensemble of biophysical factors including rainfall and temperature change. In South Western Cameroon, variation in rainfall is having impacts on agriculture and food security (Molua, 2002). Most studies using different crop models show that crop production will be negatively impacted by climate change in Africa (Challinor *et al.*, 2007), and these impacts will vary between crops, demanding specific policy and research attention (Lobell *et al.*, 2008). In Columbia, temperature (changing by an average 2.1°C) and rainfall (by an average 100 mm) reduces the suitability of crops which are relevant for food security and the income of smallholder farmers (Eitzinger *et al.*, 2014).

Locally, decrease in agricultural output due to climate variability can lead to the expansion of agriculture fields into primary forest to compensate for the lost yield (Chia *et al.*, 2013). This may lead to biodiversity loss, deteriorating the very ecosystem services that support agricultural systems (Hannah *et al.*, 2013). In Morogoro, Tanzania, climatic and other hazards for agricultural systems incited agriculture-dependent households to intensify agriculture, increase farm sizes and diversify livelihoods as a response. The response strategies used by communities have depleted natural resources such as forest, water and soil with subsequent impacts on communities' ability to adapt to future climatic stressors (Paavola, 2008). Furthermore, the destruction of primary forest will reduce wildlife which is relevant for income and household food security through hunting.

The impact of climate change on agriculture is a significant development challenge in ensuring food security and well-being in general (Jones and Thornton, 2003). Climate change represent risks (changes in temperature, increase or decrease in precipitation, changing weather patterns, droughts and floods patterns) to poor people and contributes to the failure to secure well-being (Eriksen and O'Brien, 2007; IPCC, 2007). Climate change impacts influence resource flows which are critical for the well-being in forest landscapes. Sonwa *et al.* (2012) indicated that climate variability is a threat to the flow of ecosystem goods and services (food, fuel, freshwater and medicinal plants, etc.) which are relevant for the well-being of forest-dependent communities.

The vulnerability of tropical forests to climate change is a function of exposure (increase in temperature, changes in precipitation and seasonal patterns) and sensitivity changes in disturbance regimes (fires, pests and diseases), changes in tree level processes (productivity) and changes in site conditions (soil conditions) (Locatelli *et al.*, 2008). These different interventions in the forest ecosystem are likely to modify the

direct and indirect forest ecosystem services. Despite these numerous threats, forests remain a gateway for forest-dependent communities to adjust to climate change and variability (Haore, 2007; Justice *et al.*, 2001; Nkem *et al.*, 2010, 2012), which can be better facilitated by social, political and institutional factors.

5.3 Non-climatic influence on community efforts to achieve well-being in the face of climate hazards

Apart from climate change impacts, vulnerability is generated by other factors and processes which determine household and community ability to adjust and continue a normal way of life in the presence of unavoidable climate change impacts (Thornton *et al.*, 2008). Social, political and economic processes and arrangements can buttress or ruin the ability of households and groups to achieve well-being in the face of climate change (Heltberg *et al.*, 2009). Understanding the degree of overlap between poverty, conservation and macroeconomic processes is an unconditional necessity for human well-being and ecological sustainability (Fisher and Christopher, 2007).

The TNS landscape land-use dynamics are characterized by protected areas, mining concessions and forest management units or concessions with their creation and management rooted in macroeconomic policies. The population in the TNS landscape is increasing, driven by the presence of mining and logging activities. Concessions have limited forest agricultural expansion, and conflicts abound with the population increase. According to Bele *et al.* (2013a, 2013b) and Chia *et al.* (2013), agricultural expansion is a coping strategy for forest communities in the advent of climate change. This approach enables households to maintain or increase crop production which is relevant for their well-being. Furthermore, mining and logging activities also threaten habitat and wildlife, with subsequent impacts on household food and income. Investments for economic development purposes such as mining and logging activities that cross the path of the strategies for sustaining community livelihoods should be organized, taking into consideration the potential impacts of climate change on the marginal livelihood sources and strategies.

Markets are relevant in complementing the role of forest goods and services for healthcare, nutrition and economic well-being for the local population. Forest products serve as safety nets for forest communities in the Congo Basin region. However, the complexity in the market chain leaves communities with returns lower than the value of their commodities. Organized markets will increase commodity value and revenue flows which have potentials of enhancing the welfare of local communities (Nkem *et al.*, 2010). In some communities around Bogota, Columbia, it was evaluated that farmers having access to organized markets have better adaptive capacity to changing crop production as a result of climate change (Eitzinger *et al.*, 2014).

The concern on climate change is vital in shaping future development endeavours especially with the fact that climate change impacts local poverty reduction strategies, demanding local adaptation interventions. Local institutions are pivotal for local adaptation in that they structure climate change impacts and vulnerability, and they act as a means to convey resources to facilitate adaptation (Agrawal, 2008). Studies in the humid forests zone of Cameroon on climate change impacts and adaptation indicate that diversification, post-harvest crop management, etc., are practices that need to be encouraged for adaptation (Bele *et al.*, 2013a; Nkem *et al.*, 2012). Nonetheless, external financial, information, technology,

leadership and policy interventions are needed to support and build local adaptive capacity. Public, private and civil society institutions are important in assisting households and groups in communities to access external flows. Public institutions might include local governments and local agencies such as agricultural research and extension services. 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).

6. Conclusion

The MDGs will be expiring by 2015, and discussions are ongoing at the national, regional and international levels on the new agenda for post-2015 MDGs. MDGs are a response to the intractable problems of environment and development. Solutions to such problems require the convergence of natural or forest resource management, climate change and poverty reduction strategies.

This paper has provided an understanding of the linkages between forest and forest production systems, vulnerability to climate change and well-being in a landscape. It has demonstrated the crucial role of forests as social–ecological systems in supporting the well-being of forest-dependent communities. Forest-based activities and forest resources provide for income, food security, health, education and other material needs which are relevant for the well-being of forest communities. However, climate-related disturbances have implications for forest-based activities and resources; this reduces the potential of forest ecosystems to provide the goods and services which are important for local communities experiencing growing populations.

There is an overlap between well-being, biodiversity conservation and extra-sectoral processes in the landscape, and understanding these relationships is relevant to design win–win solutions. This implies that in a collaborative manner, adaptation strategies for local communities must take into consideration the risk for biodiversity loss; biodiversity conservation strategies and macroeconomic policies on the other hand should take into consideration the vulnerability of local communities to climate change.

Despite the growing disagreement over climate predictions by humans, regions like sub-Saharan Africa still need to prepare. This implies that future national and global poverty reduction and development initiatives need to take into account climate change uncertainty, risks and impacts. Proper management of forest ecosystems, capacity building, technical and material support to forest communities through viable arrangements will provide opportunities for forest-dependent communities to enhance their existing adaptive capacities amidst the threats of climate change. However, studies need to go beyond household and community perceptions to include biophysical analysis, which is relevant for the design of interventions in terms of research and extension. This context is crucial for countries of the Congo Basin region.

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Further reading

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