

Perceptions of and adaptation to environmental change in forest-adjacent communities in three African nations

N.D. GROSS-CAMP^{1,2}, R. FEW² and A. MARTIN²

^{1,2}University College London, Department of Anthropology, 14 Taviton Street, London, WC1H 0BW

²University of East Anglia, School of International Development, Norwich, NR4 7TJ

Email: n.gross-camp@ucl.ac.uk

SUMMARY

Semi-structured interviews were used to explore how rural communities near forests are responding to environmental change in three African nations – Cameroon, Equatorial Guinea and Rwanda. The study first recounts people’s perception of environmental change – what are the issues of greatest concern identified by local communities? Second, it explores people’s responses to identified environmental problems and in particular the role of forests in these processes. Finally, it concludes with a discussion of changing land management practices, and how their implementation may affect the future adaptation strategies of such communities. Results suggest that people’s current and potential responses and adaptation to environmental change are influenced by the availability and access to forests and forest resources, and the degree to which their livelihood strategies have diversified away from forest dependence. Thus we conclude that forest policies such as REDD+ will need to be responsive to diverse forest-based adaptation needs, rather than assuming a ‘one size fits all’ relationship between forest conservation and adaptation to climate change.

Keywords: adaptation, Cameroon, climate change, Equatorial Guinea, Rwanda, tropical forest

Perceptions et adaptation aux changements de l’environnement par les communautés limitrophes de la forêt dans trois pays Africains

N.D. GROSS-CAMP, R. FEW et A. MARTIN

Les entretiens semi-structurés ont été utilisés pour explorer la façon dont les communautés rurales à proximité des forêts réagissent aux changements de l’environnement dans trois pays africains – le Cameroun, la Guinée équatoriale et le Rwanda. Premièrement l’étude relate la perception des gens du changement environnemental – Quels sont les problèmes les plus préoccupants identifiés par les communautés locales? Deuxièmement il explore les réactions des gens aux problèmes environnementaux identifiés et en particulier le rôle des forêts dans ces processus. Enfin, il conclut par une discussion sur l’évolution des pratiques de gestion des terres, et comment leur mise en œuvre peut affecter les futures stratégies d’adaptation de ces communautés. Les résultats suggèrent que les réponses actuelles et potentielles et de l’adaptation des gens aux changements environnementaux sont influencés par la disponibilité et l’accès aux forêts et les ressources forestières, et la mesure dans laquelle leurs stratégies de subsistance ont diversifié loin de la dépendance de la forêt. Nous en concluons donc que les politiques forestières tels que REDD + devront être adaptés aux besoins d’adaptation forestières diverses, plutôt que d’assumer un ‘one size fits all’ relation entre la conservation des forêts et l’adaptation au changement climatique.

Percepciones de, y adaptación a, cambio ambiental en comunidades adyacentes a bosques en tres Naciones Africanas

N.D. GROSS-CAMP, R. FEW y A. MARTIN

Se utilizaron entrevistas semi-estructuradas para explorar como comunidades rurales cerca de bosques están respondiendo al cambio ambiental en tres Naciones Africanas: Camerón, Guinea Ecuatorial y Ruanda. El estudio primero recuenta las percepciones locales de cambio ambiental – cuales son los temas de mayor preocupación para las comunidades locales? Segundo, explora las respuestas a problemas ambientales identificados, con especial atención al rol que juegan los bosques en estos procesos. Finalmente, concluye con una discusión de cambios en las prácticas de uso de la tierra, y como estos cambios pueden afectar las estrategias adaptativas de las comunidades locales. Los resultados sugieren que las respuestas y la adaptación actual y potencial de la comunidades al cambio ambiental, es influenciada por la disponibilidad y el acceso a los bosques y sus recursos, y el grado en el cual sus modos de vida se han diversificado de la dependencia de los bosques. Por lo tanto, concluimos que políticas forestales como REDD+ tendrán que ser sensibles a esta necesaria diversidad en las respuestas adaptativas al uso del bosque, en lugar de asumir “una solución única” a la relación conservación y adaptación de cambio de clima.

INTRODUCTION

The contribution of forests to human well-being is reflected in estimates that roughly 1.6 billion people depend on forests for part of their livelihood (WB 2004). In particular tropical forests play a considerable role in the livelihoods of the rural poor through their provision of food (Wilkie and Carpenter 1999, Nasi *et al.* 2008), fuel (UNEP 2006), and medicines (Ndoye *et al.* 1998, Colfer *et al.* 2006, Colfer 2008, Sonwa *et al.* 2012). These ecosystem goods or provisioning ecosystem services often contribute a large percentage of a household's income with fuel wood sometimes forming the single most important component (Cavendish 2000, Angelsen *et al.* 2011, Belcher *et al.* 2011). Furthermore, forests have been recognised for their contribution to people's livelihoods and identity through regulating and cultural ecosystem services (MEA 2005). Forests are also considered 'safety nets' for poor households providing goods during times of agricultural shortfalls or other such unpredicted shocks (Sunderlin *et al.* 2000, Pattanayak and Sills 2001, McSweeney 2003, Takasaki *et al.* 2004, Belcher 2005, Akinnifesi *et al.* 2006, Shackleton *et al.* 2007, WB 2007, Nkem *et al.* 2010, Vira and Kontoleon 2013). For example, Fisher & Shively (2003) found that rural households in Malawi rely on forest products during food shortages and that such reliance is proportionately higher in poorer households. Reliance on forest products is particularly evident in Africa (Ambrose-Oji 2003, Ndoye and Tieguhong 2004, Ruiz-Perez *et al.* 2004, Sunderland and Ndoye 2004, Shackleton *et al.* 2008), home to the second largest remaining intact tropical forest in the world – the Congo Basin (Mayaux *et al.* 2004, FAO 2005, Hoare 2007).

We should not however conclude that all forest-dependent people have the same forest-based livelihood needs, or that all will be best served by the same policy prescriptions. For example, it is often assumed that all forest-adjacent communities will benefit from access to local forests, because the poor tend to have higher forest dependency and forest access has an equalising effect. However, such assumptions do not hold universally and in some cases, policies that sustain forest dependence can reinforce a form of poverty trap (Byron and Arnold 1999, Zenteno *et al.* 2013). We have therefore learned that if the objective is to lift people out of poverty, different communities (and different groups within those communities) might not all benefit from the same interventions. But what if our objective is not poverty alleviation per se, but to enhance the ability of communities to adapt to environmental change? Recent research on the relationship between forest-based mitigation and adaptation suggests in broad terms that managing forests for global climate change mitigation will at the same time enhance prospects for local adaptation to environmental change. But given what we have learned about the relationship between forests and poverty, it is important that we now begin to empirically explore these relationships in different livelihood contexts.

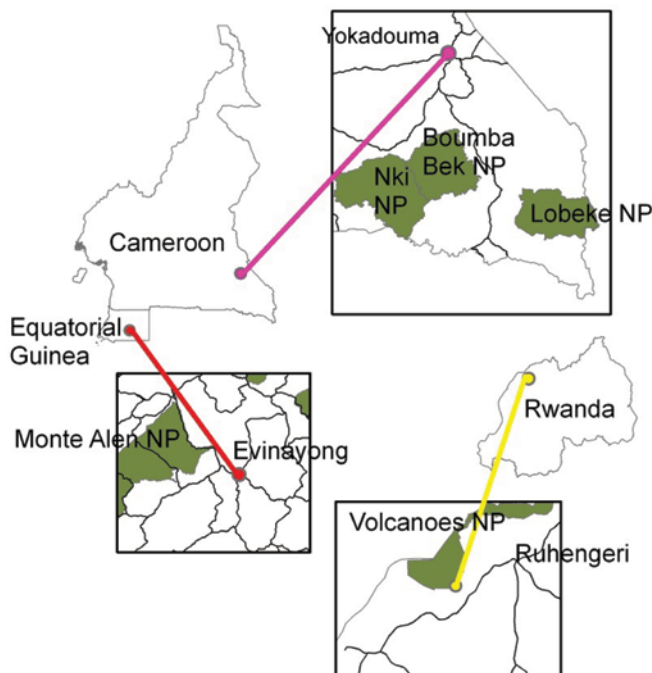
The focus in this paper is on exploring the role (and potential role) of forests in adaptation to climate-induced environ-

mental change, of which the effects of global climate change are likely to be an increasingly important driver. It is now beyond doubt that the earth's climate is changing, that significant impacts are already recorded, and that the problem is being accelerated by continued growth in greenhouse gas emissions (IPCC 2014). This is of critical importance for Africa where it is anticipated countries will suffer a disproportionately large share of the negative impacts of global climate change (Slingo *et al.* 2005, IPCC 2007, UNDP 2007, Fisher *et al.* 2010). In particular rural people in developing nations are considered vulnerable to environmental changes due to poverty, low levels of education and health, lack of technology and infrastructure, and poor food security (Huntingford *et al.* 2005, Thomas and Twyman 2005). Adaptation refers to activities that reduce the vulnerability of people, societies and ecosystems facing the effects of environmental change. Empirical work on adaptation tends to focus on the ways in which people have responded to past and contemporary climatic stresses (including hydro-meteorological hazards) in an effort to describe how rural households might adapt to future climate change. In this paper we describe how communities living near forests respond to environmental change in three study locations, Cameroon, Equatorial Guinea and Rwanda. We begin by recounting people's perceived experiences of environmental change – what are the issues of greatest concern as identified by local communities? Second, we explore people's responses to identified environmental problems (how are people adapting to the identified changes?) and in particular the role of forests in these processes. Finally, we conclude with a discussion of changing land (and in particular, forest) management practices – both real and prospective – in the focal countries, and how their implementation may affect the future adaptation strategies of such communities.

STUDY SITES

Our study forms a part of the COBAM project implemented by CIFOR and partners (additional information may be viewed at: <http://www1.cifor.org/cobam/publications.html>). The countries in which our study takes place, Cameroon, Equatorial Guinea and Rwanda, were selected for their proximity to the Congo Basin landscape as well as their ability to capture a variety of forest livelihood and management practices. The Congo Basin covers approximately 228 million hectares (Hoare 2007) and represents 20% of the world's remaining forests (Mayaux *et al.* 2004). Furthermore these forests are home to roughly 30 million forest-based indigenous people that are largely concentrated around forest peripheries (CBFP 2006). We selected two villages in each country based on their location near to forest and the presence of rural, subsistence-based communities. In Cameroon we also selected sites near officially established community forests. The study sites in each country coincide with three of the regional landscapes prioritized under the Congo Basin Ecosystems Conservation Support Programme (PACEBCo):

FIGURE 1 Location of respective communities in study countries



the Tri-National de la Sangha (TNS) in Cameroon, Monte Alen-Mont Cristal (MAC) in Equatorial Guinea and the Virungas in Rwanda (Figure 1). The villages selected in Rwanda were located adjacent to the strictly protected Volcanoes National Park, home to the highly endangered mountain gorilla. Communities in Equatorial Guinea were similarly located near but not adjacent to the Monte Alen National Park. Human population pressures vary considerably with the highest densities occurring in Rwanda with up to 820 people per km² in the Virunga landscape, compared with 5 people/km² in the TNS landscape and 16 people/km² country wide in Equatorial Guinea. The Rwandan sites are characterised by a steep landscape and, in the National Park, by dense, montane forest (ASL 680–4000 m). In contrast the TNS and MAC landscapes are predominantly lowland forests ranging from 300 up to 1250 m ASL.

METHODS

We conducted semi-structured interviews with approximately 20 households in two villages in each country (N=121), and a single group interview with community leaders in each village (N=6). Villages included Djalobekue and Mang, part of a group of villages managing the Mpiemog and Morikoualye community forests in eastern Cameroon, and located less than 40 km from the urban centre of Yokadouma. In Rwanda the villages of Kamiro and Masasa were selected, located in the Districts of Burera (Northern Province) and Nyabihu (Western Province), respectively. Lastly, the villages of Atom and Kukumankok in Equatorial Guinea are located on the eastern side of Monte Alen National Park near the

urban centre of Evinayong. Households were randomly selected in Rwanda and Equatorial Guinea where no major ethnographic distinctions were present in the sample population, whereas in Cameroon five (of 20) households from the Baka – an indigenous, ethnic minority, were intentionally included from each village. Although there are Batwa peoples (part of the Pygmies people, similar to that of the Cameroonian Baka) in parts of Rwanda, there were no such families in our study villages. In Equatorial Guinea households were from a single ethnic group, Fang, and the different clans were reported (by the respective leaders of the clans) to have little difference between them in terms of culture or livelihoods. The average age of a household since its formation across all countries was 27 ± 1 years, range 5–73, and median of 23 years. In each country, interviews were conducted by two native speakers of the relevant local language – Kinyarwanda in Rwanda, Fang in Equatorial Guinea and Mbimou in Cameroon – over a period from July 2012 to March 2013. Interviewers were trained over a period of 4–5 days immediately followed by a period of intensive data collection. Transcripts were then translated into English for analysis. We utilised NVivo v.9.2 (QSR 2011) to help manage, code and analyse transcript content.

Group interviews explored perceptions of environmental change by first generating a list of the main types of environmental change (and specific events, if applicable) experienced by the community. From this comprehensive list, the group then selected the top 4 items in order of importance and described the change in greater detail, e.g. importance of the change identified, the characteristics of the change – when it began, frequency, etc., and who in the community is affected by it.

Semi-structured interviews of households explored perceptions of access to and availability of land, forest products including firewood, weather patterns (i.e. rainfall and wind storms), temperature, and subjective wellbeing. Typically the head of household was interviewed, spouse of the head, or both. Households were asked to describe the direction and degree of change using the year of their household's formation as a baseline (e.g. marriage or establishment of own house, degree of independence from parents). Once an initial exploration of trends was completed, the respondent was asked to select 1–2 environmental changes or forest-related issues to explore in greater detail. It is in this second section that we attempted to capture people's responses or adaptations to the identified environmental changes as well as any constraints that they may experience. Additionally, respondents were asked a series of questions about forest use and management; we draw on this section of the interview to explore peoples' future options and the ways in which they may be constrained by current initiatives.

We rely on local reporting of changes experienced in weather and other environmental change. Local perceptions of climate change have been found to only partly correspond with meteorological data. For example Osbahr and colleagues (2011) find local descriptions of temperature trends to better match weather station data than their descriptions of rainfall trends. But local knowledge of climatic change is nonetheless

considered most relevant to this study of adaptation because research in Africa has found that rural people develop adaptive strategies based on their own farming experiences (Bryan *et al.* 2009, Mertz *et al.* 2011) and that perception of climate change is a factor in these strategies (Mertz *et al.* 2009, Nielson and Reenberg 2010).

RESULTS

All communities are characterised by agricultural production predominantly for subsistence with some cash crops including e.g. cocoa (Cameroon and Equatorial Guinea) and pyrethrum (Rwanda). Many households engage in secondary activities such as livestock rearing, fishing, wage labour, and small business. In the Rwanda sites, there is very little use of products from non-plantation forests, whereas in the Cameroon and Equatorial Guinea sites access to the forest remains relatively unconstrained and there is widespread collection of meat, wood, fruits and other materials. In Rwanda, a few households (n=10) described the collection of firewood from the park but indicated that this was increasingly difficult due to enforcement. Instead, the majority of households rely on local (plantation) forests for their fuel wood needs.

Perceptions of environmental change

Group discussions in all three sites ranked increasing uncertainty in predicting weather patterns as one of the top four environmental changes affecting their communities. Ultimately the group described an increase in food insecurity as a result of such changing weather patterns. The second issue mentioned in all but Mang village (Cameroon) was that of crop failure due to pests, disease or reduction in soil fertility. Equatorial Guinea was the only country to describe the issue of crop raiding, expressed as the top issue of concern in Kukumankok and second in Atom, as well as animal disease affecting chickens. In the village of Mang (Cameroon), human disease was selected as the third greatest environmental problem, referring principally to changes in mosquito vector abundance – though the perceived mechanism for this change was not made clear.

In the household interviews eight major environmental change issues were identified (Figure 2). Households self-selected one to two ‘major’ issues to discuss in further detail based on a preceding discussion on trends (see methods). Greater uncertainty in predictability and intensity of weather patterns (n=90), and crop failure as a result of pests, plant disease, or reduction in soil fertility (n=48, of 202 coded quotes) were the most commonly reported environmental challenges facing households in all sites.

The majority of households described a change in the temperature (65%) and/ or rainfall (43%). Changing weather patterns and in particular changing temperature and rainfall patterns can impact on livelihoods in multiple ways, e.g. due to threats to food production and greater health risks from diseases transmitted in food and water (IPCC 2014). The majority of Rwandan households described an increase in both temperature and rainfall, Cameroonian households described the temperature as colder, whilst only few Equatorial Guinean households described changing weather patterns. In line with previous studies in tropical Africa (Osbah *et al.* 2011), several households across all sites also observed greater variability and in particular changing and less predictable seasons.

We are experiencing a change in the seasons; there is rain when it is not usually expected and drought when it is normal to have rain (Equatorial Guinea, Atom 01)

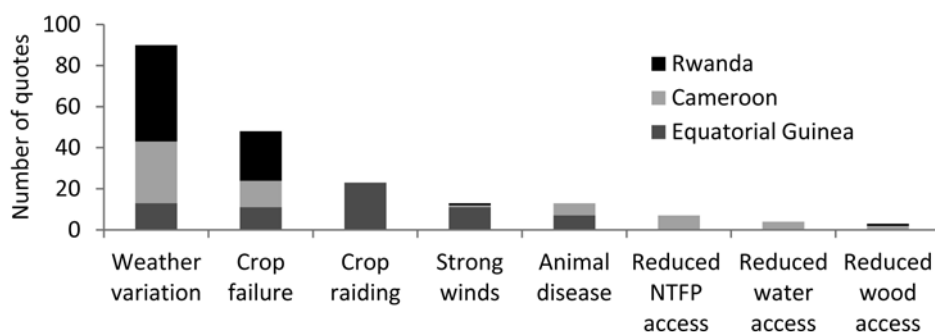
Rains fall during the dry season, and those rains come usually with heavy winds (Cameroon, Djalobekue 04)

The wet and dry seasons have mixed and their start and end is no longer easily predicted (Rwanda, Kamiro 11)

Shifting weather patterns resulted in a disruption of cultivation patterns and ultimately households’ ability to produce sufficient quantities of food (i.e. crop failure).

It was when we were sowing corn and peanut. I sowed like everybody, but after that we had a burning sun for three weeks. All the corn that germinated got burned. I replanted twice, thinking that things will change,

FIGURE 2 Summary of the top environmental changes identified by household interviews (202 quotes were coded in the interviews – approximately 2 per household interview)



and I had the same result. All got burned (Cameroon, Djalobekue 09)

In the Cameroon sites, respondents reported the most diverse set of changes compared to the other countries, with concerns also expressed about loss of access to forest and water resources and animal diseases. In Equatorial Guinea the issue of strong winds, resulting in damage to crops or other property, as well as crop raiding of agricultural fields by forest animals were quite important. In particular, crop raiding appears to be a major concern for the village of Kukumankok where 83% of the 23 mentions in respondent's interviews were recorded. In Rwanda, respondents reported a smaller range of issues due to environmental change, largely restricted to concerns with crop production being affected by weather variability.

Adaptation and forests

Here we focus on household responses to environmental change, in particular comparing the ways in which households from different sites respond and the role that the forest plays in their responses.

As predominantly subsistence communities much of the discussion with groups and individual households revolved around a reduction in crop production and their efforts to reduce such loss. Historically households have coped with fluctuations in food production by planting different crop varieties, shifting sowing-harvesting times, adding or modifying chemical and organic inputs, diversifying income to compensate for losses and most dramatically migrating to 'better' areas (see for discussion Maddison 2006, Thomas *et al.* 2007).

Whilst respondents in the Rwandan sites reported the least variety of environmental concerns, it is interesting to note that they also reported the highest variety of adaptations (Table 1). Increasing chemical and organic inputs was described by 71% of Rwandan households as a means of combatting plant disease and increasing yield. Responses suggest that households were acting largely in response to suggestions made by gov-

ernmental agronomists or copying neighbours and that they often lacked an understanding of the properties and uses of respective inputs. For example, several households described the use of fertilisers to combat pests. Rwandans also described considerable efforts to create waterways to channel rain water away from houses, to reduce vulnerability to crop damage as well as to store water for later use.

We have tried to do communal activities of bringing back the soil in place that were damaged, we dug holes in our fields, we made stones fences around our fields and we have planted some plants that fight against erosion (Rwanda, Kamiro 12)

Furthermore the Rwanda sites were the only ones to describe assistance from governmental initiatives or local cooperatives, or taking a government supported loan to purchase materials to cultivate a second time. The presence of informal institutions in Rwanda contrasts greatly with other countries; cooperatives and communal work (*umuganda*) were mentioned in over half (57%) of the Rwandan households as assisting, supporting or enabling adaptive strategies, with no mention of such organisations in our sites in Cameroon or Equatorial Guinea.

Though they are less able to draw direct benefit from the forest resources, Rwandan households still recognise the indirect value of the forest and the potential it has to reduce or offset livelihood impacts of environmental change. For example, there is a strong recognition of the importance of forest in preventing or reducing soil erosion, regulation of temperature and rainfall, and providing income through a revenue sharing program.

It [the forest] has benefit to protect us [from] the soil erosion because if the forest is not there, water destroys our crops and homes, (Rwanda, Masasa 06)

One direct use is provision of water during the dry season:

TABLE 1 Household responses to identified environmental changes

	Cameroon	Rwanda	Equatorial Guinea
Use of inputs fertilisers or pesticides		X	
Erosion control (ie digging holes or planting trees or grass)		X	
Water storage		X	
Clear new plot (in forest)	X		X
Altering planting schedule	X	X	
Renting/selling assets (eg land and livestock)	X	X	
Sharing surplus with neighbours		X	
Employment (farm labour)		X	
Small loans/organisational support		X	
Reduce expenditures	X	X	

It has always been hard to find water in the dry season, we fetch from the forest [Volcanoes National Park] (Rwanda, Kamiro 13)

By contrast, households' use of forest products, regardless of environmental shocks, is widespread in Cameroon and Equatorial Guinea (78 and 100%). There was no indication that households utilise the forest differently during times of environmental stress with the exception of being able to clear land for agricultural production (this is not an option in the densely populated and highly constrained landscape of Rwanda). Interestingly, however, the ability to find and access these forest products is perceived to be reducing. All but a single household in Cameroon described a reduction in wild meat with 85% describing a reduction in non-timber forest products (NTFPs) due to changes in human behaviour and population density, but also environmental change.

It [the reduction in wild meat] is caused by the hunting with guns. And also, in the past we were killing animals just for consumption; today, they kill them to sell (Cameroon, Djalobekue 08)

It [NTFP collection] is more difficult to find now. One has to go very far in the forest to harvest them. The situation is gradually getting worse. Before nobody was interested in NTFP and we were not using them much in the village. Now that they are sold [commercially], everybody is interested in them and everybody is harvesting them in great quantities. That is the why they are more and more rare (Cameroon, Mang 13)

[NTFPs are reducing] [b]ecause trees are producing less than before. There are years that they produce nothing. It is because of the perturbation of seasons and the strong winds. They produce well and when the wind comes all the fruits fall (Cameroon, Mang 03)

Similar sentiments were echoed from Equatorial Guinean households where 56% of households described a reduction of wild meat, specifically of larger, hunter-preferred animals like duikers. The decline in these species is paralleled with a perceived increase in crop loss due to raiding by smaller species as well as a shift in hunting practices (described in greater detail below).

Despite the benefits of the forest, people equally indicated that it had costs. For example, crop loss due to raiding activities of animals from the forest was raised by households in all countries, including 43% in Cameroon, 59% in Equatorial Guinea, and 79% in Rwanda¹. Similar to the decreases in meat and NTFP access, increasing incidences of crop raiding are considered to be the result of overhunting and clearing of the forest for agricultural production.

The cause [of increased crop raiding incidence] is the fact that there has been a lot of hunting and exploitation of the forest in that area (Equatorial Guinea, Atom 01)

To see animals [to hunt] one has to go beyond 50 km. But rodents can be found beside the farms, approximately 2 km from the village (Cameroon, Djalobekue 09)

Although not directly the result of climatic change, it is likely that these more localised anthropogenic pressures will further intensify the impacts of environmental change and, subsequently, rural communities' ability to cope with such change. In Equatorial Guinea, for example, households described the need to travel much further into the forest to find wild meat, spending more time away from home, whilst also balancing the need to protect their crops from raiding (forest) animals. Notably several households described a shift in their hunting practices to accommodate these changes by creating a series of small animal traps around their fields that are then consumed or sold.

There has been a change in the type of hunting and traps because nowadays I do not hunt for commercial reasons, but to protect my crops (Equatorial Guinea, Atom 09)

[T]he only hunting that I carry out is to protect my crops. This change has been gradual as there are not very many animals left, this is due to various slaughters which have caused various species to become extinct, therefore I prefer to just make traps around my plots (Equatorial Guinea, Atom 12)

Finally, people in Cameroon and Equatorial Guinea seem to have a much stronger cultural attachment to the forest. For example a household in Cameroon described the forest as 'the mother of everything' (Mang 11) with another stating, 'If you take out the forest, we will die. I do not know how to explain this to you. We draw all from the forest, even the moral satisfaction' (Djalobekue 02). Similarly, households in Equatorial Guinea explained, 'everything I have is from the forest' and 'my life is in the forest, I cannot live without it.' In particular, the identity with the forest appeared strongest in the Baka households where one respondent explained, 'When we live out of the forest, everything goes wrong for us' (Cameroon, Djalobekue 14) and another that 'The forest is our god. The Baka is nothing without the forest. It represents everything for us' (Cameroon, Mang 20). These quotes suggest that, for some groups of people, the contribution of forests to wellbeing is perhaps beyond economic contributions to farming, hunting and gathering, and, in seeking policies that will enhance communities' ability to adapt, the cultural context must also be considered.

¹ The percentages reported here differ from those reported earlier where households were asked to describe 1–2 of the most important environmental issues concerning them. Here we report people's response to a question concerning the value, both positive and negative, of the forest to their household.

Forest management and adaptation strategies

Forest management interventions will effect different adaptation possibilities in different ways. For example, strictly preservationist management may result in a landscape in which forest-based contributions to adaptation are largely confined to regulating ecosystem services, and where farmers look beyond the forest for improved livelihood security. This is the situation in the Rwanda sites where communities live next to a heavily enforced protected area that prohibits all human activity. Rwandan households are broadly aware of the authority responsible for the forest's management (RDB) and generally accept and tolerate the authority. Despite household's acceptance of such restrictions there is evidence that this management is relatively 'new' with some household's describing former use of the park and an indication of how forced diversification away from forest dependence has affected income and food security.

During the past years when there was poverty, we entered into the forest for collecting bamboo and if these were sold we find some money to buy food. We put our beehives into the forest. Nowadays, all these actions are not allowed to be made in the park (Rwanda, Masasa 02)

A further two households described the loss of land during the park's creation with one recounting a more penetrating loss:

There at the entrance of the park; it was the land of the community; RDB [governmental management authority] took 6 meters of our lands when they constructed that entrance. It seems that those 6 meters for all lands of the community are too much. We had enough harvest on that land, but nowadays it's no longer the case. [Park guards say that trees are the property of the community, but if someone is caught there collecting grasses of the livestock or firewood, she is automatically getting punishments. We have not access on those resources, but they always say that these are your property. They don't remember that time when they took our lands; I'm telling you the truth, no one among the community is paid for those activities (Rwanda, Masasa 08)

This statement is indicative of Rwandan's former use of the forest and perhaps more critically, is insightful into present day perceptions of the park and its associated management authority that influences and (or) constrains people's responses to environmental induced change. Land confiscation by the Rwandan government in park formation and its associated impacts is explicitly acknowledged in the country's Biodiversity Policy (GoR 2011) that states,

In the creation of protected areas many communities were forcibly removed without adequate compensation. Furthermore, a "fences and fines" approach resulted in people being denied access to resources upon which they depended. Aggravating these circumstances is the fact that protected areas have remained inaccessible to the

majority of the people, and are perceived to provide few benefits to them. These imbalances are well recognized, and are in some instances being redressed by conservation and other agencies.

Specifically the Batwa were negatively impacted by Rwandan park formation and, to date, have received little if any compensation or recognition for their displacement. Although our interviews did not capture any members of this population, we consider the repercussions of such treatment on the Batwa's ability to adapt to be rather significant as has been suggested by other studies on Pygmies people (e.g. Nkem *et al.* 2013 Baka, Bagyeli or Bakola and Medzan in Cameroon). The Batwa are traditionally forest-based peoples and, with increasing exclusion from forests compounded by active discrimination against them as a people, these communities have been highly constrained in their ability to adapt to less forest-based livelihood strategies. We will return to this issue again in the discussion.

Turning to our other study sites, Cameroon and Equatorial Guinea have similar de facto management practices whereby the forest is informally managed by village or clan leaders. Primary and secondary forests are distinguished with the latter being informally owned through family inheritance or based on initial efforts to 'clear' the plot for farming. In Cameroon, the Mpiemong Community Forest (CF) is 5500 ha in size and shared between four villages including Mang. The Morikoualye CF is 5000 ha in size and shared between seven villages including Djalobekue. These areas are legally recognised by the Cameroonian government and yet only 28% of interviewed households understood that there was a community forest with a further 18% describing active exclusion in their ability to contribute to the formation of community forest regulations and general access. In particular a Baka household described greater limitations on access to the forest that suggests 'free access' does not exist for all village occupants.

People from the village and the whites prevent us from having access to resources in the virgin forest. [Whites for the Bakas refer to all those that are neither Bakas nor from the village.] The fact is that we are prevented from entering the forest to collect the products that we can sell to live here in the village. Without that law [suggesting active removal from their preferred home in the forest], no Baka would have been found here in the village. We would have been all in the forest. So with that law, we are chased away from the milieu where we live with ease. I have no idea of what you call community forest. I do not really know what it is (Cameroon, Mang 20)

The present structure of management practice – formal in Rwanda and informal in Cameroon and Equatorial Guinea may be modified under new management practices with the potential to exacerbate or reduce some of the inequitable access currently experienced by the Baka and loss of land in Rwanda.

Finally we explored current land use management practices and how possible changes in such practices would be re-

ceived by households. In Cameroon and Equatorial Guinea there is generally good access by households to the forest and its associated products. There are also several logging concessions where management and access differs, though hunting remains possible. We asked households how they would be affected by an expansion of these concessions to which there was an almost unanimous positive response in Equatorial Guinea, with Cameroon being more divided – 35% responded positively in contrast to 60% negative. Equatorial Guineans responded positively with the exception of two households based on the expectation that they (or someone in their household) would receive employment and subsequent increase in income and quality of life. The two households that responded negatively cautioned against short-term benefits and long term, negative consequences:

Even if young people got jobs I do not support it [expansion of the logging concessions] because young people do not realise the importance of the forests because exploitation is temporary and for me the forest is very important. I do not like the thought of a timber company arriving to work in the forest. (Equatorial Guinea, Atom 09)

It would not be good, I hate exploitation, it causes a rise in heat. (Equatorial Guinea, Kukumankok 19)

In Cameroon similar concerns were echoed if logging concessions were expanded citing a loss of available land, and loss of forests and associated resources for the present and future generations. People in support of logging concession expansion stated their promise to increase jobs, income and thus, material well-being. Such responses suggest that households are responding to an interest in obtaining greater financial security but tempered by their concern for maintaining their access to land and in particular, forests. This likely represents a trade-off that may become more divisive as forests decrease and (or) become less accessible to locals, e.g. due to increased management and/ or protection.

In Rwanda there are no logging concessions in or around the park, though there are a multitude of activities in the area to reduce soil erosion and efforts to increase agricultural efficiency. Recall that Rwanda's landscape differs from that of Equatorial Guinea and Cameroon in its being at higher altitudes with more variable topography. Soil erosion is a major issue over much of the Rwandan landscape as is agricultural efficiency on plots that are, on average, less than 0.76 hectares per household (ROR 2010). We focused in particular on the conversion of farmland to agroforestry and governmental control of crops being planted based on the potential and demonstrated impacts of these activities on household's ability to adapt to environmental change.

The majority of households in Rwanda felt that agroforestry would help their households based on its ability to reduce soil erosion, creation of a natural wind block for sensitive crops, lack of impact on crop production, and utility of wood source. The few that were less confident in agroforestry's utility were concerned about the compatibility of trees with their crops, worried that the trees remained the property

of the community (as opposed to the government, see quote from Rwanda Masasa 08 above describing loss of access to 'public' trees), preference to plant grass that similarly reduced soil erosion and provided fodder for livestock, and concern that land size constraints would make it difficult to meet household food needs (i.e. competing space of trees and food crops).

In 2007 the government of Rwanda initiated the Crop Intensification Programme (CIP; MINAGRI 2008) that mandates the types of crops that may be grown in a given region and growing season (there are two main growing seasons in the year). There are a total of six approved crops through the CIP including wheat, rice, potatoes, beans, maize and cassava; these crops comprised only 30% of the total national production in 2008 (NISR 2010) representing a severe reduction in the kinds of crops households are able to produce. In addition the way in which household's plant crops has been changed from a mixed- to mono-cropping culture. Fifty-seven percent (n=24) of Rwandan households in our study reported that this programme resulted in hardship, predominantly hunger due to smaller crop yields, increased reliance on the production of a single crop and consequences of its failure. Furthermore even the people that 'accepted' the programme did so with serious reservations.

We have to accept it, but the remaining problem is when the authorities enforce the community to plant one crop. This crop may not grow well and causes some problems including hunger (Rwanda, Kamiro 09)

People's reservations are perhaps well founded given that the government reserves the right 'to repossess the land if the owner or holder of the land rights has failed to use it in accordance with the law,' (ROR 2004) and will surely influence what and how people plant in the foreseeable future.

DISCUSSION

Our results corroborate the findings of many other studies from developing nations and more specifically sub-Saharan Africa that indicate households are struggling with environmental change impacts and in particular more erratic and intense weather patterns that directly affect crop yields and cause hunger (Maddison 2006, Fisher *et al.* 2010, Nkem *et al.* 2010, Sonwa *et al.* 2012, Nkem *et al.* 2013). Households in our study sites were relatively limited in their response to environmental induced changes, predominantly responding to short term shocks (e.g. drought/ flood events or crop pest outbreaks) and being more reactive than strategic (see for discussion of this tendency Ellis 2000, Smit 2000, Wunder *et al.* 2014). The Rwandan sites contrasted with other sites, with a greater range of non-forest based adaptation strategies. This reflects relatively recent tightening of forest exclusion policies and provides a clear indication of how policy can define and change the role that forests play in adaptation to climate change. The way in which such forest policies play out for adaptive strategies is of course linked to an evolving constel-

lation of other policies and institutions. In Rwanda, the national emphasis on modernising agriculture through institutional support for accelerated uptake of purchased inputs is an important part of this constellation of drivers. Whilst this is an example of a nationwide factor it is difficult to generalise to the country level with some distinctions likely being more a result of context-specific factors pertaining to a selected village than applicable country-wide. For example, the selection of Rwandan villages next to a strictly protected area and absence of such in Equatorial Guinea and Cameroon, is clearly critical to both perceptions of major environmental changes and the range of available adaptations to these. Despite these reservations we offer a few generalised insights based on our research on the way households in these countries may adapt to environmental change in the future as well as how interventions, like REDD+, may influence such adaptations.

A major distinguishing characteristic between the study countries is access to forest and its associated products. In Cameroon and Equatorial Guinea, households have a more direct relationship with the forest, clearing it to create agricultural lands, collecting NTFPs, and a deep value or connection to the forest particularly reflected by the Baka households. In contrast, Rwandans are more distant or indirect users, recognising the forest's value in regulating climate and provision of water during the dry season, but otherwise restricted in their ability to obtain other items or access it. Furthermore, our interactions with Rwandans and familiarity with its history suggests that this mentality and emotional divorce from the forest is relatively recent with deep wounds only being superficially 'healed.' Specifically, in the 1990s the formation of the Volcanoes National Park resulted in a dramatic reduction in access to the forest for thousands of people and in particular forced displacement of households, many of which were Batwa. These households were moved without consultation or compensation (Huggins 2009). There were no Batwa households represented within our sample, though displacement was raised by two non-Batwa households and is indicative of the tensions between those that were displaced, the current park authority, and the effect on their livelihoods. Similarly, the content of the Baka's response in Cameroon to the value of the forest and suggestion of active discrimination by non-Baka (i.e. exclusion from the community forest), suggests that the ethnic minorities in these regions may face particular challenges, above and beyond that of non-Pygmy people, in adaptation to environmental change. Insecurity of land tenure, marginalization and disempowerment are likely to inhibit the capabilities to make active decisions on land use and livelihoods that underlie the idea of adaptive capacity (Ribot 2010, McDowell and Hess 2012). The significance of this are particularly relevant within the context of forest governance interventions.

Our findings suggest that different communities, and different groups within those communities, have different forest requirements for responding to environmental change. This means that even if forest policies were to play out on level playing fields, the impact on different locations would vary. Given that playing fields are rarely level, we also know that

there are forms of discrimination that lead to the material and cultural needs of some groups being marginalised, and contrasting experiences of policy – even within locations. Given that policy can play out differently in different places, and among different groups within those places, any attempt to use policy levers to enhance forest-based adaptation to climate change will require acute sensitivity to local conditions and to the ways in which forest access, authority and cultural attachment shape the experiences of different people. Currently popular forest conservation policies include extension of protected area networks (Leadley *et al.* 2014) and REDD+. Notably, both are increasingly seeking to ensure, amongst other things, that forest management interventions do not make local people more vulnerable to livelihood insecurities. For example, several conservation organisations have advocated 'ecosystem-based adaptation' as a means of achieving synergies between forest preservation and local adaptation, whilst the UN REDD+ process has introduced social 'safeguards'. If safeguards are to work, it is important to understand that one policy is unlikely to fit all and that safeguards must be premised on a local understanding of specific adaption needs.

Cameroon and Equatorial Guinea are also distinct from Rwanda in their recognition of community forests. There are no such forests currently present in Equatorial Guinea although the government has established a law recognising communities' rights to manage forest through the creation of a title '*bosques comunales*.' The benefits of these areas and ability to support communities' adaptive capacity are not yet clear but may be a vital step in ensuring that local people are able to capture benefits from programmes like REDD+.

Overall our data suggests that the forest *can* be both a short term coping mechanism (e.g. during crises of crop failure, clearing of new agricultural lands) and long term insurance (e.g. regulation of climate) against the impacts of environmental change. The degree to which this is possible appears to be driven by the availability and access to forest, as well as the rate of forest degradation and deforestation. Equally important there are likely to be trade-offs that may strain people's future ability to adapt (Few *et al.* 2014). For example, Equatorial Guinean households described a shift in hunting practices from the hunting of large ungulates and primates to one that traps predominantly smaller rodent species around agricultural fields. The implication is that former hunting practices of larger animals are no longer possible due to a decline in these species. Furthermore, people implied that crop raiding had become worse and so trapping around plots served a dual purpose – to prevent crop loss and as a meat source. Although beyond the scope of our study, the decrease in the size and type of animals being hunted is likely indicative of species depletion due to intensive hunting practices (Fa *et al.* 2000), the longer term impacts of which we have only a cursory ecological understanding.

Finally, our study demonstrates the difficulties of generalization about the potential role of forests in supporting adaptation and the importance of context in predicting forest's ability to contribute or constrain people's ability to adapt to environmental change. Rwanda is a country with very little

remaining forest cover, a relatively recent history of forced exclusion from these forests, and increasing centralisation of agricultural production, i.e. CIP. In contrast, Cameroon and Equatorial Guinea have large tracts of forest under customary management, increasing trend of community managed forests, presence of extractive industries (i.e. timber and mining), and relatively little intervention or support from formal institutions. The interplay of these factors affects people's ability to adapt and perhaps most critically determines the role that the forest plays in this process.

ACKNOWLEDGEMENTS

We are very grateful to all those who have helped to make this study possible. In Rwanda the work was facilitated by ARECO, and in particular: Dancille Mukakamari, Jean-Pierre Mugabo, Emmanuel Dufitumukza. Field data collection was greatly assisted by Assumpta Uzamukunda and Laura Rurangwe. In Cameroon the work was supported by CIFOR (Yaounde), in particular Anne-Marie Tiani, Charlotte Pavageau and Flore Ndong; by Stockholm Environment Institute (Oxford), in particular Tahia Devisscher and by ROSE, in particular Gerard Sindemo. Field assistance was provided by Chrislain Kenfack and Sylvie Asso. In Equatorial Guinea the work was supported by INDEFOR, in particular Fidel Esono Mba, Diosdado Obiang Mbomio and Juan Abeso; and by SEI, Monica Coll Besa. Field assistance was provided by Angeles Mang Eyene and Alfonso Mikue. This work was part of the COBAM project and supported by a grant through the African Development Bank.

LITERATURE CITED

- AKINNIFESI, F., WAIBEL, H. and MITHOFER, D. 2006. The role of food from natural resources in reducing vulnerability to poverty: a case study from Zimbabwe. *Proceedings of the German Development Economics Conference*. Berlin, Germany, Research Committee Development Economics.
- AMBROSE-OJI, B. 2003. The contribution of NTFPs to the livelihoods of the 'forest poor': evidence from the tropical forest zone of south-west Cameroon. *International Forestry Review* **5**(2): 106–117.
- ANGELSEN, A., WUNDER, S., BABIGUMIRA, R., BELCHER, B., BORNER, J. and SMITH-HALL, C. 2011. Environmental incomes and rural livelihoods: a global-comparative assessment. *4th Wye Global Conference* Rio de Janeiro.
- BELCHER, B. 2005. Forest product markets, forests and poverty alleviation. *International Forestry Review* **7**(2): 82–89.
- BELCHER, B., DEWI, S. and ACHDIAWAN, R. 2011. Livelihood strategies under different access and natural asset levels in Jharkhand, India. *Poverty and Environment Network Symposium*. University of East Anglia, Norwich.
- BRYAN, E., DERESSA, T.T., GBETIBOUO, G.A. and RINGLER, C. 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science & Policy* **12**(4): 413–426.
- BYRON, N. and ARNOLD, M. 1999. What futures for the people of the tropical forest? *World Development* **27**(5): 789–805.
- CAVENDISH, W. 2000. Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. *World Development* **28**(11): 1979–2003.
- CBFP. 2006. Forest and climate briefing of the G8 meeting, June 2007, Congo Basin Forest Partnership.
- COLFER, C.J.P., Ed. 2008. *Human health and forests: a global overview of the issues, practice and policy*. London, Earthscan.
- COLFER, C.J.P., SHEIL, D. and KISHI, M. 2006. Forests and human health: assessing the evidence. *CIFOR Occasional Paper*. Bogor, Indonesia, CIFOR.
- ELLIS, F. 2000. *Rural livelihoods and diversity in developing countries*. Oxford, UK, Oxford University Press.
- FA, J.E., GARCIA YUSTE, J.E. and CASTELO, R. 2000. Bushmeat markets on Bioko Island as a measure of hunting pressure. *Conservation Biology* **14**(6): 1602–1613.
- FAO. 2005. State of the world's forests. Rome, Food and Agriculture Organization of the United Nations.
- FEW, R., GROSS-CAMP, N. and MARTIN, A. 2014. Vulnerability, adaptation and mitigation in the forests of the Congo Basin: a critical investigation. *DEV working paper series*. Norwich, UK, University of East Anglia.
- FISHER, M., CHAUDHURY, M. and MCCUSKER, B. 2010. Do forests help rural households adapt to climate variability? Evidence from Southern Malawi. *World Development* **38**(9): 1241–1250.
- FISHER, M. and SHIVELY, G. 2003. Do tropical forests provide a safety net? Income shocks and forest extraction in Malawi. *Agricultural Economics Association Meeting* Montreal, Canada.
- GOR. 2011. Rwanda Biodiversity Policy. Rwanda, Republic of Rwanda.
- HOARE, A.L. 2007. *Clouds on the horizon: the Congo Basin forests and climate change*. London, The Rainforest Foundation.
- HUGGINS, C. 2009. No 4 Historical and contemporary land laws and their impact on indigenous peoples' land rights in Rwanda. *Land rights and the forest peoples of Africa: historical, legal and anthropological perspectives*. Moreton-in Marsh, UK, Forest Peoples Programme.
- HUNTINGFORD, C., LAMBERT, F.H., GASH, J.H.C., TAYLOR, C.M. and CHALLINOR, A.J. 2005. Aspects of climate change prediction relevant to crop productivity. *Philos Trans Royal Soc B* **360**(1463): 1999–2009.
- IPCC. 2007. Impacts, adaptation, and vulnerability. *Fourth assessment report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. v. d. Linden and C.E. Hanson. Cambridge University Press, Cambridge, UK and New York, NY, USA.

- . 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. *Fifth assessment report of the Intergovernmental Panel on Climate Change*. C.B. Field, V.R. Barros, D.J. Dokken *et al.* Cambridge University Press, Cambridge, UK and New York, NY, USA.
- LEADLEY, P.W., KRUG, C.B., ALKEMADE, R., PEREIRA, H.M., SUMAILA, U.R., WALPOLE, M., MARQUES, A., NEWBOLD, T., TEH, L.S.L., VAN KOLCK, J., BELLARD, C., JANUCHOWSKI-HARTLEY, S.R. and MUMBY, P.J. 2014. Progress towards the Aichi Biodiversity Targets: an assessment of biodiversity trends, policy scenarios and key actions. *Technical Series 78*. Montreal, Canada, Secretariat of the Convention on Biological Diversity: 500.
- MADDISON, D. 2006. The perception of and adaptation to climate change in Africa. *discussion paper no. 10*. South Africa, Centre for Environmental Economics and Policy in Africa.
- MAYAUX, P., BARTHOLOME, E., FRITZ, S. and BELWARD, A. 2004. A new land-cover map of Africa for the year 2000. *Journal of Biogeography* **31**: 861–877.
- MCDOWELL, J. and HESS, J. 2012. Accessing adaptation: multiple stressors on livelihoods in the Bolivian highlands under a changing climate. *Global Environmental Change* **22**: 342–353.
- MCSWEENEY, K. 2003. Tropical forests as safety nets? The relative importance of forest product sale as smallholder insurance, eastern Honduras. *International Conference on Rural Livelihoods, Forests and Biodiversity*. Bonn, Germany.
- MEA. 2005. Millennium Ecosystem Assessment. *Ecosystems and human well-being: Biodiversity synthesis*. Washington, DC, World Resources Institute.
- MERTZ, O., MBOW, C., REENBERG, A. and DIOUF, A. 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in Rural Sahel. *Environmental Management* **43**(5): 804–816.
- MERTZ, O., MBOW, C., REENBERG, A., GENESIO, L., LAMBIN, E.F., D'HAEN, S., ZOROM, M., RASMUSSEN, K., DIALLO, D., BARBIER, B., MOUSSA, I.B., DIOUF, A., NIELSEN, J.O. and SANDHOLT, I. 2011. Adaptation strategies and climate vulnerability in the Sudano-Sahelian region of West Africa. *Atmospheric Science Letters* **12**(1): 104–108.
- MINAGRI. 2008. Strategic Plan for the Transformation of Agriculture in Rwanda (SPAT II). *Final Report*. Kigali, Rwandan Ministry of Agriculture: pp 127.
- NASI, R., BROWN, D., WILKIE, D., BENNETT, E., TUTIN, C., VAN TOL, G. and CHRISTOPHERSEN, T. 2008. Conservation and use of wildlife-based resources: the bushmeat crisis. *Technical Series 33*, Secretariat of the Convention on Biological Diversity, Montreal, and CIFOR, Bogor, Indonesia.
- NDOYE, O., MANUEL, R.P. and EYEBE, A. 1998. Non-wood forest products and potential forest resource degradation in central Africa: the role of research in providing a balance between welfare improvement and forest conservation. *Non-wood forest products of Central Africa*. T.C.H. Sunderland, L.E. Clark and P. Vantomme. Rome, Current Research Issues and Prospects for Conservation and Development, FAO: 183–206.
- NDOYE, O. and TIEGUHONG, J.C. 2004. Forest resources and rural livelihoods: the conflict between timber and non-timber forest products in the Congo Basin. *Scandinavian Journal of Forest Research* **19**(4): 36–44.
- NIELSON, J.O. and REENBERG, A. 2010. Temporality and the problem with singling out climate as a current driver of change in a small West African village. *Journal of Arid Environments* **74**(4): 464–474.
- NISR. 2010. National Agricultural Survey 2008, National Institute of Statistics of Rwanda, Republic of Rwanda: p. 249.
- NKEM, J., KALAME, F.B., IDINOBA, M., SOMORIN, O.A., NDOYE, P. and AWONO, A. 2010. Shaping forest safety nets with markets: adaptation to climate change under changing roles of tropical forests in Congo Basin. *Environmental Science & Policy* **13**: 498–508.
- NKEM, J.N., SOMORIN, O.A., JUM, C., IDINOBA, M., BELE, Y.M. and SONWA, D.J. 2013. Profiling climate change vulnerability of forest indigenous communities in the Congo Basin. *Mitigation and Adaptation Strategies Global Change* **18**: 513–533.
- OSBAHR, H., DOWWARD, P., STERN, R. and COOPER, S. 2011. Supporting agricultural innovation in Uganda to respond to climate risk: linking climate change and variability with farmer perceptions. *Experimental Agriculture* **47**: 293–316.
- PATTANAYAK, S.K. and SILLS, E. 2001. Do tropical forests provide natural insurance? The microeconomics of non-timber forest products collection in the Brazilian Amazon. *Land Economics* **77**: 595–612.
- QSR. 2011. NVivo version 9.2, QSR International.
- RIBOT, J.C. 2010. Vulnerability does not fall from the sky: toward multiscale, pro-poor climate policy. *Social dimensions of climate change: equity and vulnerability in a warming world*. R. Mearns and A. Norton. Washington, DC, The International Bank for Reconstruction and Development, The World Bank: 47–74.
- ROR. 2004. National Land Policy. Kigali, Republic of Rwanda.
- . 2010. National Agricultural Survey 2008. Republic of Rwanda, Kigali, National Institute of Statistics.
- RUIZ-PEREZ, M., BELCHER, B., ACHDIWAN, R., ALEXIADES, M., AUBERTIN, C., CABALLERO, J., CAMPBELL, B., CLEMENT, C., CUNNINGHAM, T., FANTINI, A., DE FORESTA, H., FERNANDEZ, C.G., GAUTAM, K.H., MARTINEZ, P.H., DE JONG, W., KUSTERS, K., KUTTY, M.G., LOPEZ, C., FU, M., ALFARO, M.A.M., RAGHAVAN NAIR, T.K., NDOYE, O., OCAMPO, R., RAI, N., RICKER, M., SCHRECKENBERG, K., SHACKLETON, S., SHANLEY, P., SUNDERLAND, T. and YOUNG, Y.-C. 2004. Markets drive the specialization strategies of forest peoples. *Ecology and Society* **9**(2).
- SHACKLETON, C., SHACKLETON, S.E., BUITEN, E. and BIRD, E. 2007. The importance of dry woodlands and

- forests in rural livelihoods and poverty alleviation in South Africa. *Forest Policy and Economics* **9**(5): 558–577.
- SHACKLETON, S., CAMPBELL, B.M., LOTZ-SISITKA, H. and SHACKLETON, C. 2008. Links between the local trade in natural products, livelihoods and poverty alleviation in a semiarid region of South Africa. *World Development* **36**: 505–526.
- SLINGO, J.M., CHALLINOR, A.J., HOSKINS, B.J. and WHEELER, T.R. 2005. Introduction: food crops in a changing climate. *Philos Trans Royal Soc B* **360**(1463): 1983–1989.
- SMIT, B. 2000. An anatomy of adaptation to climate change and variability. *Climate Change* **45**(1): 223–251.
- SONWA, D.J., SOMORIN, O.A., JUM, C., BELE, M.Y. and NKEM, J. 2012. Vulnerability, forest-related sectors and climate change adaptation: the case of Cameroon. *Forest Policy and Economics* **23**: 1–9.
- SUNDERLAND, T.C.H. and NDOYE, O., Eds. 2004. *Forest Products, Livelihoods and Conservation: Case studies of non-timber forest product systems*. Forest Product Systems. Bogor, Indonesia, CIFOR.
- SUNDERLIN, W.D., RESOSUDARMO, I.A.P., RIANTO, E. and ANGLESEN, A. 2000. The effect of Indonesia's economic crisis on small farmers and natural forest cover in the outer islands. *CIFOR Occasional Paper No. 28*. Bogor, Indonesia, CIFOR.
- TAKASAKI, Y., BARHAM, B.L. and COOMES, O.T. 2004. Coping strategies in tropical forests: floods, illnesses, and resource extraction. *Environment and Development Economics* **9**: 203–224.
- THOMAS, D.S.G. and TWYMAN, C. 2005. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change* **15**(2): 115–124.
- THOMAS, D.S.G., TWYMAN, C., HENNY, O. and HEWITSON, B. 2007. Adaptation to climate change and variability: Farmer responses to intra-seasonal precipitation trends in South Africa. *Climatic Change* **83**: 301–322.
- UNDP. 2007. Human Development Report 2007/2008 fighting climate change: Human solidarity in a divided world. New York, United Nations Development Programme.
- UNEP. 2006. Africa Environment Outlook – Our environment, our wealth, United Nations Environment Programme.
- VIRA, B. and KONTOLEON, A. 2013. Dependence of the poor on biodiversity. *Biodiversity conservation and poverty alleviation*. D. Roe, J. Elliott, C. Sandbrook and M. Walpole. Oxford, Wiley-Blackwell.
- WB. 2004. Sustaining forests: a development strategy. Washington, DC, The World Bank.
- . 2007. Poverty and environment: understanding linkages at the household level. Washington DC, World Bank.
- WILKIE, D. and CARPENTER, J.F. 1999. Bush meat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity and Conservation* **8**: 927–955.
- WUNDER, S., BORNER, J., SHIVELY, G. and WYMAN, M. 2014. Safety nets, gap filling and forests: a global-comparative perspective. *World Development in press*.
- ZENTENO, M., ZUIDEMA, P.A., DE JONG, W. and BOOT, R.G.A. 2013. Livelihood strategies and forest dependence: new insights from Bolivian forest communities. *Forest Policy and Economics* **26**: 12–21.