Linking Land Tenure and Use for Shared Prosperity

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 23-27, 2015

THE EFFECT OF DEFORESTATION RATE ON LAND TENURE IN CENTRAL AFRICA

Pauline GILLET[1], Laurène FEINTRENIE[2], Elisabet CODINA LLAVINA[1], Charlotte LEHNEBACH[1], Cédric VERMEULEN[1]

Département BIOSE, Laboratoire de Foresterie des Régions Tropicales et Subtropicales, Gembloux Agro-Bio Tech, Université de Liège. Passage des Déportés 2, 5030 Gembloux, Belgique

[2]Unité de Recherche Biens et Services des Ecosystèmes Forestiers tropicaux (UR B&SEF), Département Environnement et Sociétés, CIRAD- Direction Régionale d'Afrique Centrale, BP 2572, rue Joseph Essono Balla, Yaoundé, Cameroun

pgillet@ulg.ac.be

Paper prepared for presentation at the
"2015 WORLD BANK CONFERENCE ON LAND AND POVERTY"
The World Bank - Washington DC, March 23-27, 2015

Abstract

The CoForTips project aims at the promotion of better management of the forest of the Congo Basin by presenting to the policy makers plausible scenarios of social and ecological systems evolution. In this paper, we focused on the impact of deforestation on land tenure mutation in Central Africa. Land tenure defines the level of ownership and management experienced by the local population on defined areas (Le Roy et al., 1996). We assume that the rules acting on objects of land tenure evolve from loose land control to privatization and the ability to dispose of resources when we progress on the forest transition curve designed by Mather (1992). We demonstrate that individual land tenure increases along with the deforestation process, and continue along with the reforestation process where this one is a consequence of agricultural plantations on deforested lands. We then draw a theoretical land tenure evolution with variation of population density in relation to forest cover that could be used as an indicator of SES shifting more sensitive than the evolution of forest cover to appreciate forest transition at the SES level and predict the presence and intensity of tipping points.

Key Words:

Central Africa, CoForTips project, forest transition curve, land tenure theory, Socio-ecological system

Introduction

Forests of the Congo Basin are among the best preserved areas of the globe. Currently, the erosion of biodiversity is low compared to other African areas and areas of Asia and tropical America (Sanderson et al., 2002). According to the projections of the impacts of global change on biodiversity proposed by Leadley et al. (2010) the conversion of large areas of forests to answer economic purposes outside the forestry sector in territories with a different assignment (such as mines or large scale plantations) is expected. The effects of this pressure on biodiversity and associated ecosystem services could be considerable.

The process of deforestation due to increasing demographic pressure has been described by Mather (1992) as the forest transition. The forest transition curve shows the relationship between forest cover and time. Time can be replaced by the rise in population density or the economic development (Barbier et al., 2010). According to Angelsen (2008), the forest transition curve can be divided in three phases: initially, the area is characterized by a high percentage of forest cover with a low deforestation rate, the low population density involving a low impact on forest resources. Then the deforestation rate increases, the forest is partially degraded and under pressure of conversion to other land uses. Finally, only small surfaces of degraded forest remain once the transition is completed. Ultimate stage sees a trend of plantation of useful trees on deforested land, conducting to an increase in tree cover (Figure 1). Mather's forest transition theory is based on historical facts. Most significant factors implying the forest-area transition are trends of population growth and in resources values and perceptions. Population growth has been associated with expansion of agricultural area. When population growth slows down and technical revolutions transform the way to produce, the pressures to expand agricultural area weaken. The increase in urban population changes the perceived value of forests from a source of timber and potential farmland to an aesthetic and recreational resource (Colson et al., 2009).

The forest transition participates in a complex phenomenon of change of a socio-ecological system (SES). This is the result of a joint development between economy, culture, technology, ecology and institutional development at different scales (Marten, 2005). This concept can be applied to forest landscapes and then express the conversion of forest cover in an alternative cover (agriculture, large-scale planting or urbanization). It is difficult to separate the forest ecosystem of the social issues associated. This so called forested SES deals with a particular group of actors who have an impact on a particular lot of resources allocated to a particular set of institutions (Janssen et al., 2007). The tipping point of the forested SES is the critical point in an evolving situation that makes it switch to a new situation irreversible development (Repenning et al., 2001). In connection with the identification of tipping points, it is possible to define

resilience landscapes or systems that persist in a changing context, evolving, but without losing the basic functional parameters that define the system (Holling, 1973).

Researches conducted in forested SES demonstrate the value of modeling to develop biodiversity evolution scenarios. Nepstad et al. (2008) modeled the possible evolution of the conversion of the Amazon rainforest. Scenarios developed by Nepstad et al. (2008) suggest the imminent approach of a tipping point resulting in the conversion of some parts of the Amazon rainforest to savannah. This transformation is due to the combined effect of different factors either socio-economic or biophysical such as the expansion of agriculture, climate change or changes in the fire regime causing deforestation. Hirota et al. (2011) have built a resilience curve of tropical forest cover in South America, Australia and Africa. Based on this curve, Hirota et al. concluded that the forest cover should follow the same trends in all the tropics. Climate change would push the ecosystem to another attraction basin which is another stable state. Specifically, the disruption of rainfall patterns would result in a decrease of forest resilience with a switch over to a savanna landscape. This transition would be fastened by human disturbances such as deforestation or fire (Hirota et al., 2011).

If a deterministic relationship between population trends and forest area is assumed, huge areas of native forests will disappear before the forest transition takes place. On the other hand, as in many European cases, there might be a forest transition relatively early, leading to the subsistence of large native forests areas linked with changes in resource perceptions and increasing rates of reforestation or afforestation in tropical countries (Mather & Needle, 1998).

Despite the amount of study about forest transition (Barbier et al., 2010; Rudel et al., 2005; Rudel et al., 2002), property aspects linked to this transition have not been treated. To understand the evolution of SES in the forest transition context, we have used land tenure theory developed by Le Roy et al. (1996) to measure levels of ownership and co-management of the customary territory. It allows to "report a scale of things and property control modes (the land tenure objects), as well as relations between people who control these things (the land tenure subjects)" (Le Roy et al., 1996). Land management means, "the exercise of power (...) recognized to the man who, through an act of appropriation of space, reserved more or less exclusively this space" (Le Roy et al., 1996).

We applied the land tenure theory to classify the rules of access to different resources and different spaces, according to their ownership and co-management modalities in three study sites distributed on the forest transition curve. We observed the translation of the majority of land tenure objects from a loose land control with an undefined management entity, to strict land tenure with a precise distribution of land

in a society oriented toward the individual rather than group. We demonstrate that this process of formalization and individualization of land tenure can be linked to the forest transition curve.

Method

This research is based on surveys, participatory observations, interviews and group discussions that were conducted between June 2013 and May 2014 with more than 200 villagers from 8 villages of Central Africa. The villages are located in three research sites in Cameroon and Gabon. We compared the land tenure table obtained with results coming from the literature namely Vermeulen & Carrière (2001a) and Vermeulen et al. (2011) to bring out a theoretical land tenure evolution with variation of population density in relation to forest cover.

Study sites

The three study sites where chosen according to their position on the forest transition curve (Figure 1). The first one is located in north-east Gabon; it is characterized by a low population density (1.6 inhabitants/km²). The studied socio-ecological system is made of three surrounding villages in the influence sphere of Makokou, inhabited mostly by natives of the ethnic group *Bakota*. Villagers' incomes are generated mostly from the exploitation of natural resources such as slash and burn agriculture, hunting, fishing and gathering. The low population density combined with a low agricultural impact explains the location of this site on the Mather's curve (Figure 1).

The second study site consists of three villages located in the Eastern Province of Cameroon. The population density is about 6.3 inhabitants/km², majoritarian ethnic groups are indigenous: *Badjoué* (33.5%), *Ndjem* (17.96%) and *Baka* pygmies (12.1%), the remaining population is made of ethnic group from across the country. One of these villages hosts the base camp of a logging company. The income level is higher than in the first site and depends mostly on the salaries coming from the logging company. Slash and burn agriculture is mostly practiced to overcome family food needs. Forest cover located around the villages of this site is being degraded due to the rise in population density which explains its intermediary position on the forest transition curve (Figure 1).

The third study site is 100 km north of Yaoundé (the Cameroon Capital city) at the interface between forest and savannah in a densely populated area (71 inhabitants/km²). The population is made exclusively of ethnic natives *Yambassa*. Agriculture is the main source of income; products are sold on local markets to traders of the capital city and to cocoa cooperatives. This area is characterized by a mosaic of agricultural land with small patches of remnant forest. Current landscape dynamics consist in an increase

in the tree covers due to the expansion of cocoa agroforestry plantations in savannahs. This dynamic explains the position of this site on the forest transition curve (Figure 1).

Figure 1.

Land tenure approach

The land tenure approach is commonly used to structure the policies of conservation and management of local cultural concepts. Regulation of the relations of man to land is illustrated in a table returning correlations of the three types of data that characterize traditional African law and constitute tenure: (i) status, (ii) usage patterns of the place by allocation at preferential uses and (iii) localities or objects of land tenure (see Figure 2). This matrix model crosses types of land control (on horizontal axis) to the modalities of use (on the vertical axis). Land control types are associated with the legal status of resources. Modalities of use are understood as the categories of people who get the control on the resource, from the widest collective (public) to individual management (private).

The horizontal axis is made of five appropriation levels. The *undifferentiated* appropriation tenure is the right to *access* it gives allowance to enter a defined area. The *priority* appropriation level gives right to access and to *extract*, it allows taking away or harvesting the product of a particular resource. The *specialized* level gives right to access, extract and *manage*, it gives allowance to regulate internal patterns of use or to transform the resource through improvements or negligence. The *exclusive* level right to access, extract, manage and *exclude*, it allows one to decide who have rights of access and how these rights can be obtained, lost or transferred. Last, the *absolute* level gives right to *alienate*, it is a property right under civil law such as the right to sell or rent a property.

The vertical axis reports co-management modes: *public* is what is common to all, groups and individuals, *extern* reflects what is common to some groups, *intern-extern* is common to two groups, *intern* is common to one group or community and *private* is proper to a person or entity (institution).

We used the methodology developed by Le Roy et al. (1996) to identify objects on which land tenure is determined by local populations. To do so we conducted a spatial occupancy study to identify the different areas designed by the populations using participatory mapping (Larzillière et al., 2013a) and semi-structured interviews. We then determined the land control being exerted on these objects. The resulting land tenure grid was later validated in focus groups of representatives of the villages (women and men of different ethnic groups, young and old people, hunters, fishermen, farmers and local elites).

The objects of land tenure rules are, within the framework of this study, the different spaces and resources around which gravitate the villagers. More than anything, there is a strong relationship between the resource and the place in which it is located. Indeed, to remove a resource, it is necessary to have access to the area in which it is located (Vermeulen & Carrière, 2001b). "Resource tenure primarily involves the land tenure of outer space" (Barrière & Barrière, 1996). This is why the study of land tenure focuses on agricultural resources (crops and trees planted) and forest resources (non-timber forest products, timber resources). All of these resources will be put in relation to the location in which they are found: forest, river, field, village or the edge of road.

We located geographically the various land uses associated with these spaces. Hunting can be located in dense forest area or in secondary forest, while trapping is often located around of the agricultural fields. Fishing technics depends on the size of rivers; fishing by the woman takes place in small rivers while fishing by men occurs often in large rivers. These areas can be at a distance of several hours walk from the village, the people then build fishing camps that are used year after year. Non Timber Forest Products (NTFP) can be harvested in the forest, plantation or village; the relative land control change according to the type of land cover. Finally crop plots and plantations are characterized by a specific type of control.

Results

Land tenure and forest transition in our study sites

Figure 2 brings together the possible regulation of human relationships with land and resources by land tenure for the first study site (*Bakota* villages near Makokou north-west Gabon). Are accessible to all: (i) areas distant of the village such as large rivers (which often determine boundaries of the village territory by their difficulty to be crossed) in which fishing is allowed to all, (ii) hunting areas when not occupied and (iii) fuel wood. Non-timber forest products that have fallen onto the ground can be picked up. NTFP can be collected by several groups (in this case it comes to lineages) in the forest. Cassava leaves can be picked by the same persons in the fields. The gun hunting areas are accessible by natives of these different lineages. Women's fishing takes place in small rivers by groups of women and children based on affinities. Less important NTFP are defined as not subject to sale, they are not valued or present in small quantities in the village.

Men's fishing zones take mostly place in river of greater importance between men of the same lineage. The fishing camps are constructed by a person, his presence prohibits access to this camp for others, and he has the right to exclude. During his absence lineage members can enjoy this hut.

Fields and young fallows are subject to an exclusive private tenure. Non-timber forest products in trade or being particularly important located in the fields can only be used by the person cultivating the field. Trapping areas are often located in edge of the fields and are thus private.

We note that most of the land tenure objects are located in the upper right quadrant indicating a loose control with undefined land management entities except for agricultural tenure which are mostly private. This situation typically characterizes relatively undisturbed and little deforested SES of Central Africa.

Figure 2.

In order to facilitate the understanding of information we have compiled land tenure tables from the three study sites in a single table (Figure 3). The charts in the different boxes represent the number of items associated with the land control present for each site. We see that the external co-management entity (common to several groups) is allowed to extract the products located on three different land tenure objects in the site characterized by the lowest degraded forest cover (site 1), whereas the same co-management does only apply to one object in the site under transition (site 2) and on no object in the site under afforestation (site 3). We can also observed that people representing the private management entity exercise their power to exclude on five objects in the first site against three in the second and only one in the third one. This trend is reversed for the next box illustrating the concept of private ownership. In this case, there are a large number of land tenure objects that can be alienated by persons in the case of sites with the lowest forest cover (site 3) as the first site contains no objects presenting the private ownership criteria.

By looking at the location of most of the land tenure objects for each study site (illustrated by the different circles) we can see the translation of the majority of land tenure objects from a loose land control with an undefined management entity exercising low ownership control in the little disturbed forests, to strict land tenure with a precise distribution of land in a society oriented toward the individual in the deforested area. Even in the less deforested study site some land tenure objects like fields, plantations and home gardens are located in the exclusive private land tenure box, they are managed exclusively by the nuclear family.

When superimposing the forest transition curve to the land tenure table, we can see the location of the study sites on Mather's forest transition curve (Figure 3). The position of each site on the transition curve (represented with the arrows) is precisely located in the circle representing the majority of land tenure object for this particular place. It figures out the relationship between the displacement of land tenure systems and the location of the study site on the Mather's forest transition curve.

Figure 3.

In the little disturbed forest cover site (site 1), the availability of resources is not hampered by the proximity of other villages or degraded environment. Land tenure objects have a low degree of ownership and are managed by entities poorly defined which makes sense in an ecosystem perceived as "intact" and therefore with "abundant" space entities. In the second study site located at the second stage of Mather's forest transition curve (in transition, with on-going deforestation), most resource areas are located in the center of the land control table, which reflects improved management of land. The availability of resources begins to be influenced by the proximity of other villages and by the logging company and environment begins to deteriorate; various elements have a fairly high degree of ownership managed by more specific entities. In the third study site characterized by a highly degraded forest cover and under afforestation, the co-management arrangements are generally internal to the family or private. The limiting factor of production is land, which appears to be the main reason to this appropriation of space; other causes may be related to the economic importance of agriculture leading to the complete privatization of the agricultural land with the possibility of alienation. At this point, land becomes a marketable commodity.

Land tenure and forest transition: can we generalize to Central Africa?

These results are confirmed by an application of the same approach on data coming from Vermeulen and Carrière (2001) and from Vermeulen et al. (2011).

In the first paper, the authors applied the land tenure theory to land management by three ethnic groups located in Cameroon: *Badjoué* (Eastern region), *Mvae* and *Ntumu* (both groups in the South-West region). Forest cover of the *Badjoué*'s area is placed on the forest transition curve between our first and our second study site (Figure 4). Agricultural products come from slash and burn complemented by hunting, fishing, gathering and a cash tree production. *Mvae* and *Ntumu* come from an area characterized by Letouzey (1985) as lowland wet evergreen littoral and semi-deciduous types. According to Biwolé (2014), soil contains large quantities of charcoals and potsherd witnesses of a common past human occupancy. Forest cover of this study site, although little affected by deforestation at present time, has been disturbed by past and current human occupancy. Figure 4 shows the charts representing the number of objects corresponding to each land tenure for each site and the location of the majority of land tenure objects represented by the circles. Grey circle stands for both *Mvaé* and *Ntumu* due to the comparable land tenure applied.

Vermeulen et al. (2011) studied land issues linked to anthropic pressure coming from the proximity of Kinshasa in *Batandu* villages in the province of Bas-Congo, in the Democratic Republic of Congo. Nearly the entire space has been cleared for agricultural crops exerted on short rotations (of about three years) due to a manifest land saturation and wood energy production. Marien et al. (2013) have used remote sensing images to reconstruct the recent evolution of land use in this region. They show a decrease in the wood volume of over 75% in 17 years. Short fallow length does not allow regeneration of woody species and forested ecosystems have almost entirely disappeared. The number of objects of land tenure has therefore declined sharply. Gatherings are anecdotal and come from artificial woodlands, restored for the production of charcoal and agricultural production. Fishing and hunting are still practiced in traditional ways but have not been productive for many years, games comes down to very small prey available in very small quantities. This study site is located at the bottom of the forest transition curve (dotted arrow on Figure 4) this arrow is located in the dotted circle representing the majority of land tenure objects (Figure 4).

Figure 4.

Building on these 7 study sites we tried to come up with a theory that would link land tenure evolution in relationship with variation in population density and in forest cover.

According to the study sites, we notice that with the exception of exclusive private land tenure which mainly concern the fields and other plantations, many land tenure objects are located in the upper left corner of the land potential table, reflecting a low degree of ownership and poorly defined management entities (Figure 3: site 1). The four study sites located on the decreasing phase of the curve (Figure 3, site 2 and Figure 4: *Badjoués*, *Mvae* and *Ntumu*) have a more diffuse distribution of land tenure objects. The site with the lowest forest cover (Figure 4: *Batandu*) is characterized by the disappearance of a large number of resource areas resulting in a reduction in the number of land tenure objects. These are located in the lower right corner showing a strong ownership of the space. In the site under afforestation (Figure 3: Site 3), the number of land tenure objects is higher than in the previous site but their position in the table does not change.

When representing these results in a table in three dimensions taking as a basis the land potential table together with population density and forest cover, we get Figure 5. It reflects the high number of land tenure exercised in sites with the highest forest cover density and the lowest population density located in the upper left corner showing the low degree of ownership. In the case of the lowest forest cover and the most densely populated areas, the high peak shows the high number of land tenure objects reflecting the

strong ownership. The lowest peak represents sites where forest covers decreases and a population density increases, land tenure objects are still many and are more spread in the table.

According to Hirota (2011), tipping points are unstable situations where the current state goes from one basin of attraction to another. In our case, we are assuming that when the number of land tenure objects identified in land tenure is high, the harder it will be to push the system to a new basin of attraction represented by a different type of land control. Here, conversely to Hirota et al. (2011) we postulate that tipping points from which the SES moves to another attraction basin are in the valleys between peaks shown on figure 2 and are conditioned with a population density threshold. The position of land tenure in the land tenure table could be used as an indicator of SES shifting more sensitive than the evolution of forest cover to appreciate forest transition at the SES level and predict the presence and intensity of tipping points. The determination of these thresholds requires further study.

Figure 5.

Historical evolution

This land tenure evolution can also be seen as a historical evolution. Vermeulen & Karsenty (2001) demonstrated the change of land tenure systems over time for villages in Center-South Cameroon region. Despite the limited historical data available, it is possible to trace the migratory evolution as well as the social structure and the evolution of the land and terroir associated with it (Figure 6).

Before 1890, groups were highly mobile. Villages were organized as lineage societies with large autonomous family units practicing slash and burn agriculture and moving 2 to 3 times in a lifetime over short distances. Since 1890, residential units settled gradually down. The introduction of cocoa gradually induced the permanent settlement of the populations and agriculture took over hunting as a major source of income. The proliferation of Christian missions in the early 20th century caused the concentration of population in their surroundings. Another consequence was the religious split of some villages which induced the gradual disappearance of collective hunting practices related to animist rites and the appearance of right to the land. French colonization and cocoa national policy lead to abandonment of isolated villages resulting in a range of autonomous family units and a right on cocoa and on fallow land through inheritance. From 1950, the villages are set by the colonial administration which restricts the villages to a space defined along the road. These are composed of family units presenting a coherent and minimal organization. Shifting cultivation stabilizes around villages and massive use of traps decreases the amount of bushmeat around the villages. Currently, several factors such as the falling price of cocoa, revenues from the exploitation of natural resources such as wildlife and unemployment in the city has

forced the return of part of the population leading to a depletion of farmland near the village and a hunting right all over the finage. This historical evolution shows the transition of regulation of human relationships with land and resources as expressed in Figure 6.

Figure 6.

Discussion

Reforestation

Would reforestation induce a decrease in the level of appropriation of some objects of land tenure? Makala EU project "Sustainable management of the fuelwood resource in Central Africa" undertook to quantify the fuelwood demands from Kinshasa and Kisangani (in DRC) and curb the degradation of the environment and the difficulty to meet the demand for domestic energy (Marien et al., 2013). In this context of very advanced deforestation in *Batandu* villages and in the case of a project with a high level of participation (Larzillière et al., 2013b), choices made by the lineages in terms of reforestation were mostly oriented towards individual reforestation (Dubiez et al., 2013) except for a few enrichment operated for the benefit of lineages (Peltier et al., 2013).

Our third study site located north of Yaoundé is an example of spontaneous afforestation through agroforestry happening beyond any support program and resulting in a continued land privatization (private- absolute land tenure). Savannas with public priority land tenure are transformed into private individual plantations and sometime received a land title.

In Europa, after a massive deforestation period in the benefit of agriculture expansion, some agricultural lands were abandoned and returned, spontaneously or through planting, to the forest area (Cornu, 2003). In this context of afforestation of the least productive agricultural land, de-privatization does not occur; instead most of these lands (subjects- to absolute private land tenure) are sold. These examples demonstrate the absence of de-privatization of forest lands where afforestation is underway.

In contrast, in the particular case of China, forests have been subject to several types of land tenure. Indeed before 1949, most of the forests were owned and managed by households (private- absolute land tenure). From the 50s, private lands (regardless of their agricultural or forestry function) were expropriated. Private property was eliminated in favor of communal management. Two types of forest properties appeared: collective management (extern-exclusive land tenure) and state properties (public-exclusive land tenure). In the early 1980s, the decentralization of forest management has resulted in

dissociation between the rights of use (private-priority land tenure) and collective property (extern-absolute land tenure) (Liu & Yuan, 2007). China does not seem to fit in the theory linking land tenure and forest transition.

Conclusion and perspectives

The level of agricultural expansion leads to a drastic reduction of land available to individual occupancy, leading to hardening of land tenure rules. This evolution ends in private land ownership and its commercialization. We demonstrate that individual land tenure increases along with the deforestation process, and continue along with the reforestation process where this one is a consequence of agricultural plantations on deforested lands.

Destruction of customary relationship between man and resource in Central Africa is still ongoing. Deforestation and increased population density, two interconnected variables, contribute together to this destruction. They augur profound changes of forested SES from village to national scales towards land tenure forms that can lead to better management of certain commercial value resources like agriculture or mining at the expense of all other resources. This process would not be in favor of maintaining ecosystem services and biodiversity, especially large fauna.

Acknowledgement

For valuable discussion and comments we are very grateful to all of our co-authors. CoForTips is part of Biodiversa 2012 call for projects and is co-funded by ERA-Net Biodiversa with national donors: ANR (France), BELSPO (Belgium) and FWF (Austria). We thank Anaïs Gorel for the suggestions throughout the study and for comments on the manuscript. We thank DACEFI project and the logging company for their welcome and the villagers of La Scierie, Massaha, Nzé Vatican, Mindourou, Ampel, Medjoh, Guéfigué and Guéboba for welcoming the research team and answering our interviews.

References

Angelsen, A. (2008). How do we set the reference levels for REDD payments. In *Moving ahead with REDD: issues, options and implications* (pp. 53–64).

Barbier, E., Burgess, J., & Grainger, A. (2010). The forest transition: Towards a more comprehensive theoretical framework. *Land Use Policy*, *27*(2), 98–107.

Barrière, O., & Barrière, C. (1996). Approches environnementales. Systèmes fonciers dans le delta intérieur du Niger: de l'implosion du droit traditionnel à la recherche d'un droit propice à la sécurisation foncière. In *La sécurisation foncière en Afrique - Pour une gestion viable des ressources renouvelables* (Karthala). Paris: Le Roy E., Karsenty A., Bertrand A.

Biwolé, A. (2014). New data on the recent history of the littoral forests of southern Cameroon: an insight into the role of historical human disturbances on the current forest composition. *Plant Ecology and Evolution*.

Colson, V., Lejeune, P., & Rondeux, J. (2009). La fonction récréative de la forêt wallonne: Evaluation et pistes de réflexion pour son intégration optimale dans l'aménagement intégré des massifs. *Forêt Wallonne*, (101).

Dubiez, E., Freycon, V., Yamba Yamba, T., Mvolo, B., & Louppe, D. (2013). Perception locale des sols et de leur évolution chez les populations Batandu. In *Quand la ville mange la forêt. Les défis de bois-énergie en Afrique Centrale* (Quae Editions, pp. 107–117). France.

Hirota, M., Holmgren, M., Van Nes, E. H., & Scheffer, M. (2011). Global Resilience of Tropical Forest and Savanna to Critical Transitions. *Science*, *334*(6053), 232–235.

Holling, C. (1973). Resilience and Stability of Ecological Systems. *Annual Review of Ecological and Systematics*, *4*, 1–23.

Janssen, M., Anderies, J., & Ostrom, E. (2007). Robustness of Social-Ecological Systems to Spatial and Temporal Variability. *Society & Natural Resources*, *20*(4), 307–322.

Larzillière, A., Vermeulen, C., Dubiez, E., Yamba Yamba, T., Diowo, S., & Mumbere, G. (2013a). La maquette interactive, un outil novateur de participation. *Bois et Forêts Des Tropiques*, (315).

Larzillière, A., Vermeulen, C., Dubiez, E., Yamba Yamba, T., Diowo, S., & Mumbere, G. (2013b). Une démarche participative pour un partage des connaissances. In *Quand la ville mange la forêt. Les défis de bois-énergie en Afrique Centrale* (Quae Editions, pp. 77–87). France.

Leadley, P., Pereira, H. M., Alkemade, R., Fernandez-Manjarrés, J. F., Proença, V., Scharlemann, J. P. W., & Wapole, M. J. (2010). *Biodiversity scenarios: projections of 21 century change in biodiversity and associated ecosystem services* (Technical series No. 50) (p. 132). Montreal: Secretariat of the convention on Biological Diversity.

Le Roy, E., Karsenty, A., & Bertrand, A. (1996). *La sécurisation foncière en Afrique. Pour une gestion viable des ressources renouvelales* (Le Roy E., Karsenty A., Bertrand A.). Paris, Karthala.

Letouzey, R. (1985). Notice de la carte phytogéographique du Cameroun au 1/500 000. Toulouse.

Liu, J., & Yuan, J. (2007). Le boom de la Chine dans la gestion familiale des forêts. *Unasylva*, *58*(228).

Marien, J.-N., Louppe, D., Dubiez, E., & Larzillière, A. (2013). *Quand la ville mange la forêt: Les défis du bois énergie en Afrique centrale*. France: Quae Editions.

Marten, G. (2005). Environmental tipping points: a new paradigm for restoring ecological security. *Journal of Policy Studies (Japan)*, *20*, 75–87.

Mather, A. S., & Needle, C. L. (1998). The forest transition: a theoretical basis. *Area*, *30*(2), 117–124.

Nepstad, D. C., Stickler, C. M., Filho, B. S., & Merry, F. (2008). Interactions among Amazon land use, forests and climate: prospects for a near-term forest tipping point. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1498), 1737–1746.

Peltier, R., Marquant, B., Gigaud, M., Proces, P., Diowo, S., Dubiez, E., … Marien, J.-N. (2013). La régénération naturelle assistée, un outil pour rendre les jachères plus productives. In *Quand la ville mange la forêt. Les défis de bois-énergie en Afrique Centrale* (Quae Editions, pp. 119–135). France.

Repenning, N., Goncalves, P., & Black, L. (2001). Past the Tipping Point: the persistence of firefighting in product development. *California Management Review*, *43*(4), 44.

Rudel, T., Bates, D., & Machinguiashi, R. (2002). A Tropical Forest Transition? Agricultural Change, Out-migration, and Secondary Forests in the Ecuadorian Amazon. *Annals of the Association of American Geographers*, *92*(1), 87–102.

Rudel, T., Coomes, O., Moran, E., Achard, F., Angelsen, Z., Xu, J., & Lambin, E. (2005). Forest transitions: towards a global understanding of land use change. *Global Environmental Change*, *15*(1), 23–31.

Sanderson, E., Jaiteh, M., Levy, M., Redford, K., Wannebo, A., & Woolmer, G. (2002). The Human footprint and the Last of the Wild. *BioScience*, *52*(10).

Vermeulen, C., & Carrière, S. (2001a). Stratégies de gestion des ressources naturelles fondées sur les maîtrises foncières coutumières. In *La forêt des hommes- Terroirs villageois en forêt tropicale africaine* (Les presses agronomiques de Gembloux). Belgique.

Vermeulen, C., & Carrière, S. (2001b). Système foncier et forestier coutumier chez les Badjoués. In *La forêt des hommes- Terroirs villageois en forêt tropicale africaine* (Les presses agronomiques de Gembloux). Belgique.

Vermeulen, C., Dubiez, E., Proces, P., Diowo Mukumary, S., Yamba Yamba, T., Mutambwe, S., … Doucet, J.-L. (2011). Enjeux fonciers, exploitation des ressources naturelles et forêts des communautés locales en périphérie de Kinshasa, RDC. *Biotechnol. Agron. Soc. Environ.*, *15*(4), 535–544.

Vermeulen, C., & Karsenty, A. (2001). Place et légitimité des terroirs villageois dans la conservation. In *La forêt des hommes- Terroirs villageois en forêt tropicale africaine* (Les presses agronomiques de Gembloux). Belgique.

Figures

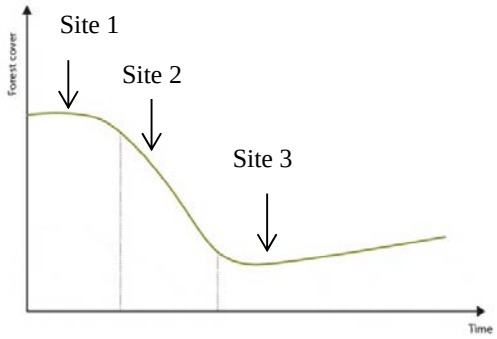

Figure 1. Forest transition curve and the position of the three study sites.

	Undifferentiated *(Access)*	***Priority*** *(Access and extraction)*	***Specialised*** *(Access, extraction and Management)*	***Exclusive*** *(Access, extraction, management and Exclusion)*	***Absolute*** *(Right to use and dispose thus alienate)*
Public	- Big rivers - Fuel wood - Hunting areas	- NTFP on the ground - fishing in big rivers			
Extern		- All NTFP in forest - Cassava leaves - Gun hunting areas			
Intern-Extern					
Intern (group)		- Women fishing area - Non important NTFP in fields			
Intern (lineage)		- Men fishing area		- Hunting camp	
Private				- Fields - Young fallow - Important NTFP in fields - Trapping zones	

Figure 2. Possible regulation of human relationships with land and resources by land tenure. Case of Bakota from North-east Gabon. Source: Field data collected by the first author in 2013.

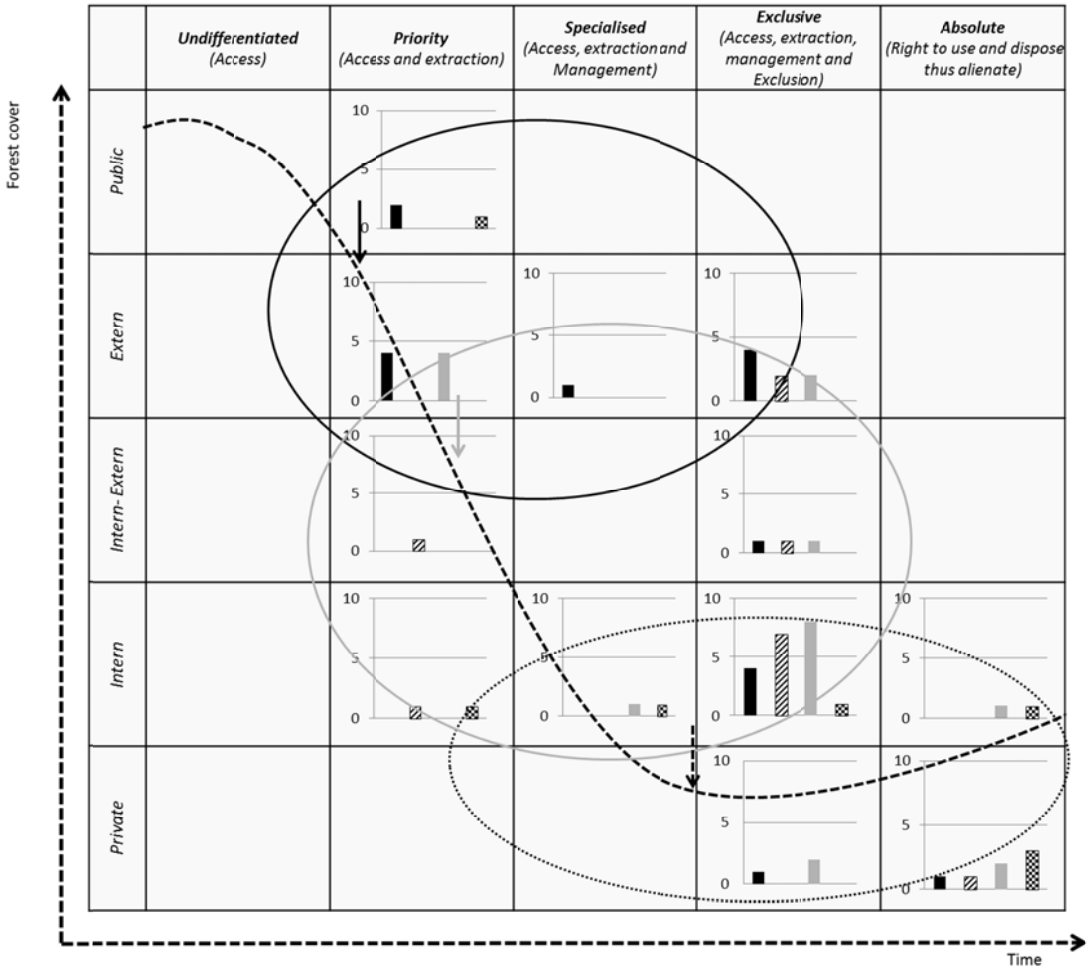

Figure 3. Land tenure table gathering the land tenure objects defined on the three study sites.

Plots illustrate the number of objects that are concerned by a particular land control for each site. (Black: study site 1, hatched: study site 2, grey: study site 3). Circles represent location of the majority of land tenure objects for each site (black: site 1, hatched: site 2, grey: site 3). The dotted curve stands for Mather's forest transition curve (forest cover in relationship with time) and arrows are location of the study sites on this curve (black: site 1, hatched: site 2; grey: site 3).

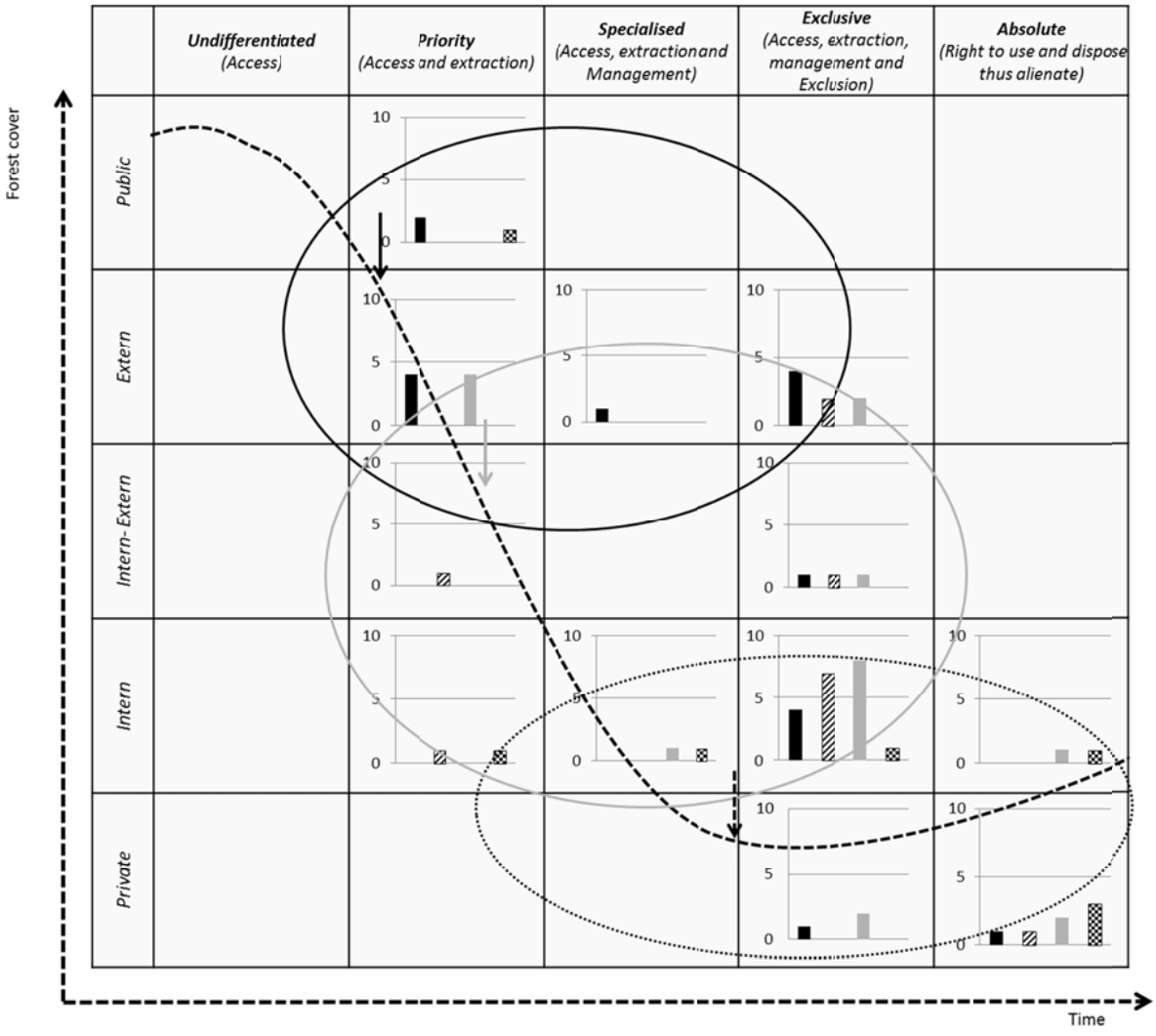

Figure 4. Land tenure table gathering the land tenure objects defined by Vermeulen and Carrière (2001) and by Vermeulen (2011).

Plots illustrate the number of objects that are concerned by a particular land control for each site. (Black: Badjoués, hatched: Mvaé, grey: Ntumu, checked: Batandu). Circles represent location of the majority of land tenure object for the three sites (black: Badjoués, grey: Mvaé and Ntumu, dotted: Batandu). The dotted curve stands for Mather's forest transition curve (forest cover in relationship with time) and arrows are location of the study sites on this curve (black: Badjoués, grey: Mvaé and Ntumu, dotted: Batandu).

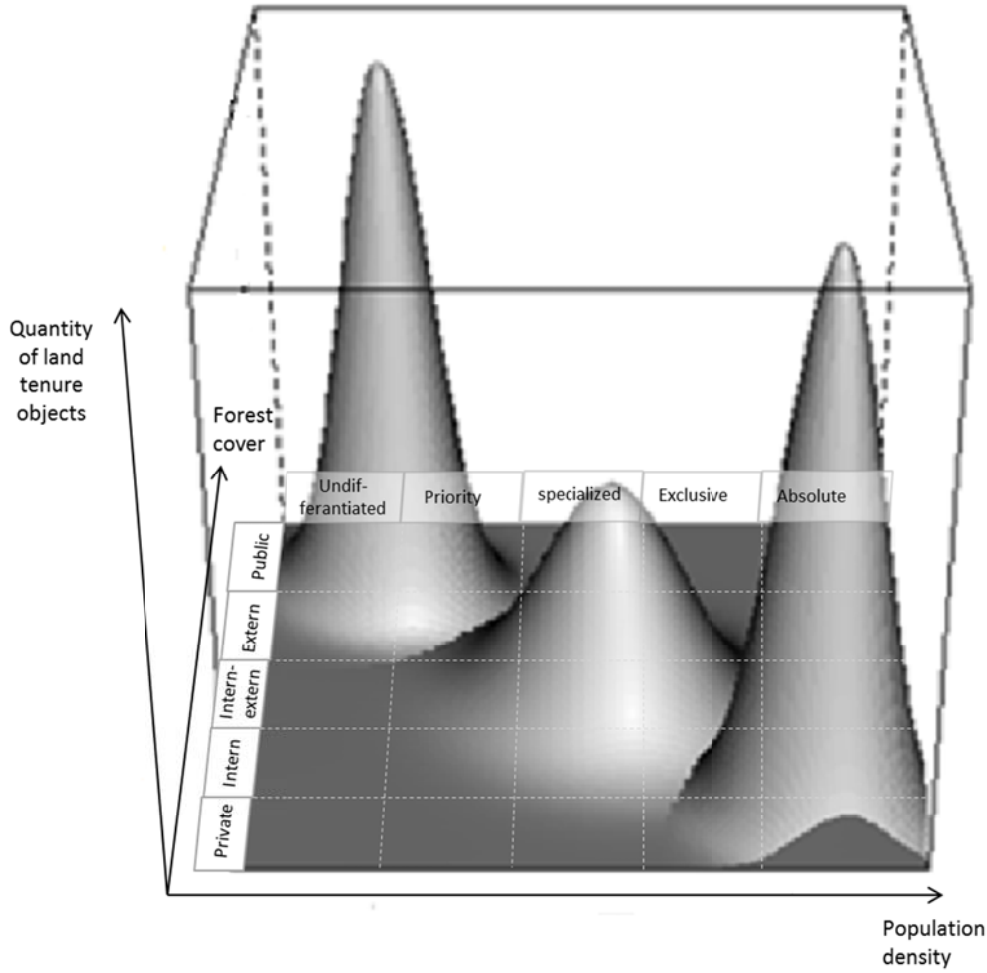

Figure 5. Theoretical land tenure evolution with variation of population density in relation to forest cover.

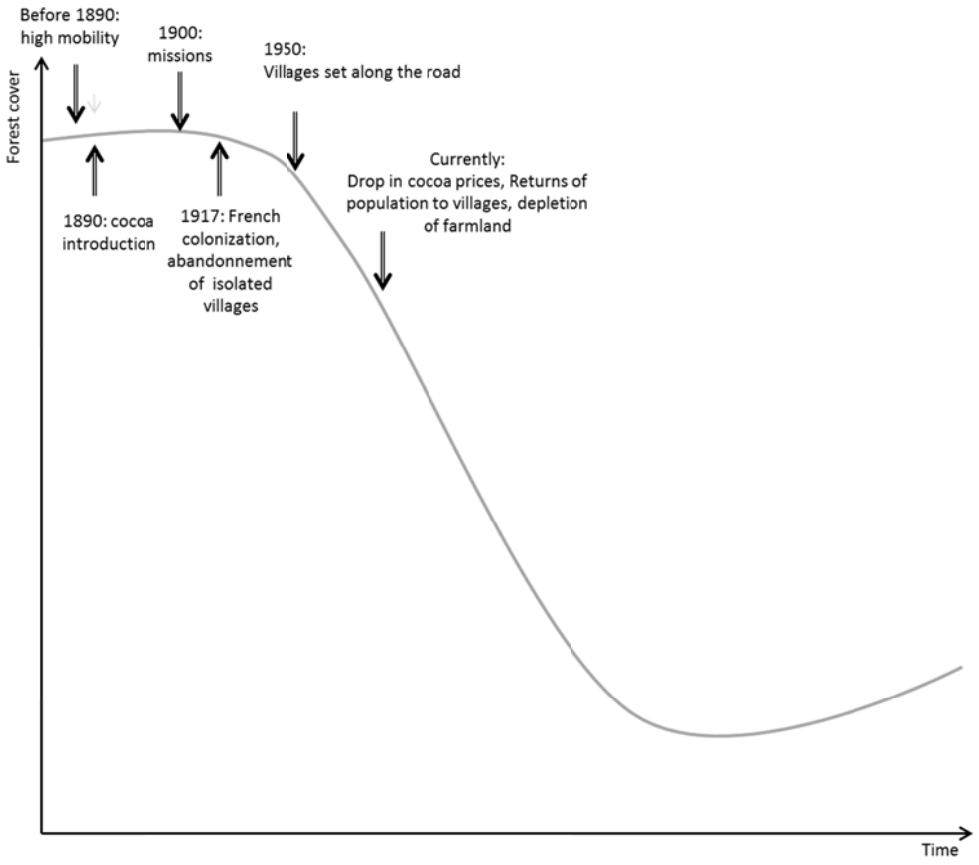

Figure 6. Forest cover evolution of villages in Center-South Cameroun. (source: Vermeulen and Karsenty, 2001)