Land Use Management by Smallholders' Households as a Promising Way for Synergies Between the Rio Conventions: Case Study in Semi-Arid Areas of Cameroon

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V. A. Kemeuze, D. J. Sonwa, P. M. Mapongmetsem, L. Verchot, Evariste Fongnzossie, and B. A. Nkongmeneck

Abstract

Land use management by smallholders' households in dry landscapes can be an important entry point for contending desertification, climate change mitigation and biodiversity conservation. Strategies employed by these households to address land use problems can bring together efforts of the three Rio conventions. Identifying the typology of the current land use can lead to understand how biomass can be managed toward climate change mitigation efforts such as Clean Development Mechanism and Reduce Emissions from Deforestation and Forest Degradation including conservation, sustainable management of forests and enhancement of forest carbon stocks. From this perspective, a survey of 598 households in six divisions in the Far North Cameroon was conducted using a semi-structured questionnaire.

This study reveals six main land uses, some of which overlap: cropped field (managed by 95% of local households), grassland (34%), settlements (28%) and forest lands (76%) that significantly contribute to local livelihoods. Non-timber forest products, fuelwoods, timbers and fodders are the main products provided by these land uses. Besides the products, some management practices including agroforestry, urban and peri-urban forestry and forest plantation have been

V. A. Kemeuze (✉)
ECO Consult Sepp & Busacker Partnerschaft, Oberaula, Germany
e-mail: victor.kemeuze@eco-consult.com

D. J. Sonwa · L. Verchot
Center for International Forestry Research (CIFOR), (Messa) Yaounde, Cameroon
e-mail: D.Sonwa@cgiar.org

P. M. Mapongmetsem
Department of Biological Sciences, University of Ngaoundere, Ngaoundere, Cameroon

E. Fongnzossie · B. A. Nkongmeneck
Higher Teacher's Training School, The University of Douala, Douala, Cameroon

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identified to contribute to combat desertification and conserve biodiversity and climate change mitigation and adaptation in this semi-arid area of Cameroon.

Keywords

Land use change · Household characterization · Biodiversity conservation · Climate change · Rio Convention

6.1 Introduction

Human activities in the land use, land use change and forestry (LULUCF) sectors are recognized among the main causes of land degradation, biodiversity loss and climate change. Land use refers to the total of human's activities and inputs undertaken in a certain land cover type, while land use change refers to a transformation in terms of use or management of land by humans, which is accompanied by a change in land cover (IPCC 2000). Several studies have showed the links between land use change, biodiversity loss, climate change and desertification (Pando-Moreno et al. 2004; de Chazal and Rounsevell 2009; Oliver and Morecroft 2014; Foley et al. 2005).

The LULUCF sector has an important place in the Convention on Biological Diversity. Decisions adopted by the conference of the parties to the convention on biological diversity at its fifth meeting, held in Nairobi, considered land use change as a proximate cause of biodiversity loss (CBD 2000). Gonzalez et al. (2012) detected significant 1960–2000 species richness decline of 21% across the Sahel in which northern Cameroon is a part. This issue has also been identified by the Cameroon National Biodiversity Strategies and Action Plan (NBSAP) which attributed biodiversity loss to forest and savanna conversion to industrial farming systems and urban development (Republic of Cameroon 2012).

Land use change and climate change are interlinked (Teixeira et al. 2006; IPCC 2013). The first national inventory of greenhouse gas (GHG) emission published in Cameroon's "Initial National Communication" to the United Nations Framework Convention on Climate Change (UNFCCC) (MINEP 2006), by the Environment and Forest Minister, highlights the key role of LULUCF activities in climate change. This inventory clearly established that the highest levels of GHG emissions are associated with the agriculture and land use change. Agriculture and land use change are responsible respectively of 38% (16,435 $GgECO_2$) and 50% (22,186 $GgECO_2$) of total GHG emission in the country (MINEP 2006).

The Secretariat of the United Nations Convention to Combat Desertification (UNCCD) (1994) recognized land use as the direct factor of land degradation in Africa and worldwide. The article 9 of the UNCCD recommends to each affected African country party to "identify and analyze the constraints, needs and gaps affecting development and sustainable land use and recommend practical measures to avoid duplication by making full use of relevant ongoing efforts and promote implementation of results".

Compared to the humid area of the country belonging to the Congo Basin, the implementation of national environmental policies and programmes developed to address such problems until now have been happening in the context of limited information in land use management. Cameroon like other countries of Central Africa is covered by humid and dry landscapes. Unfortunately, because of the high interest in preserving the Congo Basin forests, much of the research and conservation activities have so far been focused in the southern part of the country and very little information exists in the northern dry landscape. It remained somewhat poorly understood the links between human activities and environmental dynamics in semi-arid areas of Cameroon.

Land use management by smallholders' households can be an important entry point to reduce desertification, mitigate climate change and conserve biodiversity. According to the Secretariat of the United Nations Convention to Combat Desertification (UNCCD) (1994), LULUCF activities can play an important role in reducing net GHG emissions to the atmosphere through conservation of existing carbon pools, sequestration by increasing the size of carbon pools and substitution of fossil fuel energy by use of modern biomass. Sustainable land use can also address human activities such as overexploitation of plants and trampling of soils that exacerbates dryland vulnerability (Millennium Ecosystem Assessment 2005). Thus, the implementation of land use, land use change and forestry activities can be potential synergies between existing multilateral environmental agreements.

Recent research studies highlighted some indigenous strategies that have been practised in the Sahel and elsewhere in Africa. Some of them describe mitigation and adaptation strategies that have enabled local population to reduce their vulnerability to climate variability and change (Nyong et al. 2007; Egeru 2012; Kpadonou et al. 2012), while others underlined traditional practices in biodiversity conservation and measures to combat desertification (Oke and Jamala 2013; Fraser et al. 2006; Hens 2006; McNeely and Scroth 2006). The present study will (i) identify and characterize the main land use in the semi-arid area of Cameroon and (ii) analyse the management of plant resource in those land use (ii) and their role in biodiversity conservation, mitigating climate change and desertification.

6.2 Study Area, Data Collection, and Data Analysis

6.2.1 Study Area

The Far North Region of Cameroon lies between 9°40′ and 13°05′ north and 12°15′ and 16°45′ east. It covers 34,263 square kilometre (Tabopda Wafo 2008) and represents 7.21% of the total country land area. This region is bordered to the north and the east by the Republic of Chad, to the west by the Federal Republic of Nigeria and to the south by the North Region of Cameroon (Fig. 6.1). The Far North Region is one of the most populated regions of the country with 3.709691 million, which represents 17.4% of Cameroon's overall population and a density of 90.8 inhabitants per square kilometre (Mbarga 2010).

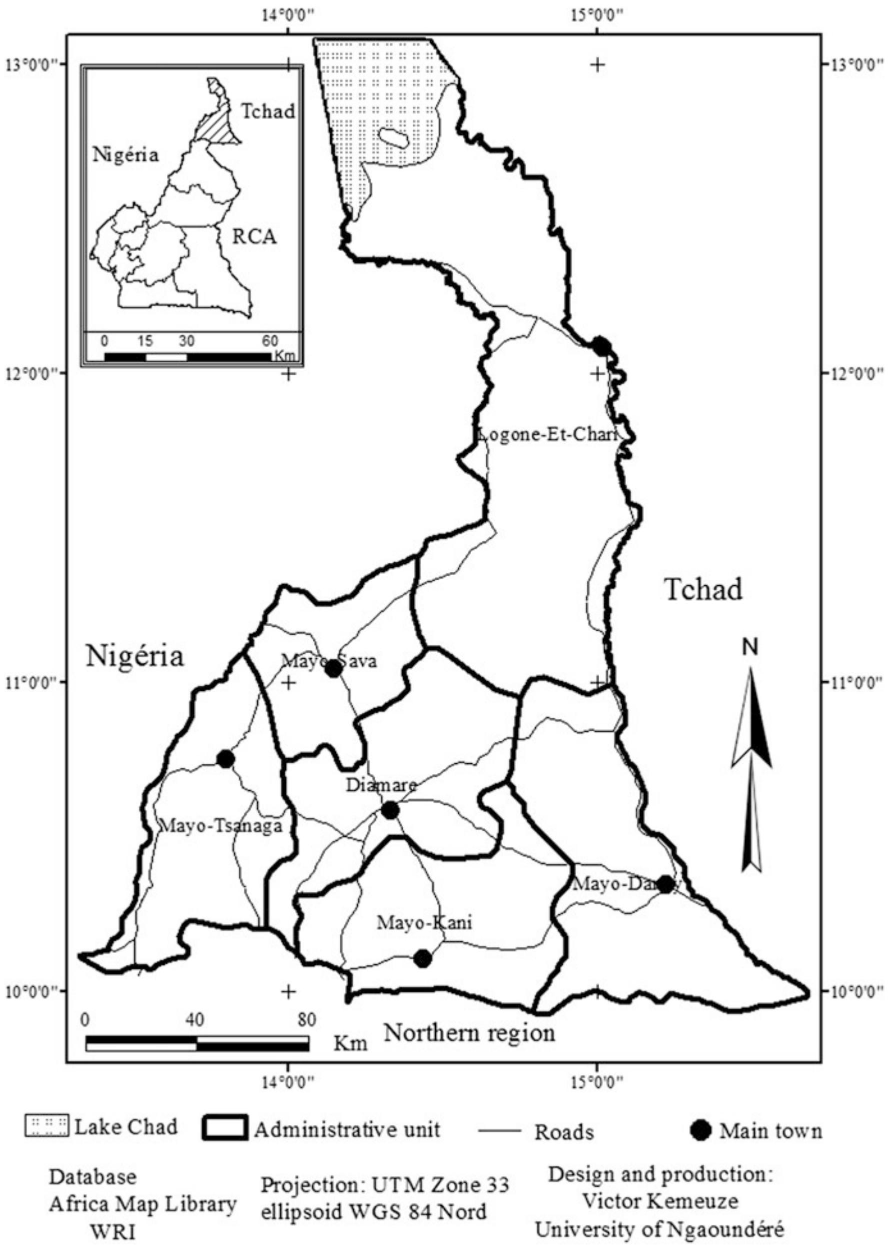

Fig. 6.1 Location of the study area

The semi-arid zone of Cameroon is the hottest and driest part of the country. The climate of the region is characterized by the dry and wet seasons. Annual total precipitation is between 400 and 1000 mm and depends on the landscape shape. Annual average mean temperature is between 25 °C and 27 °C in the cooler seasons

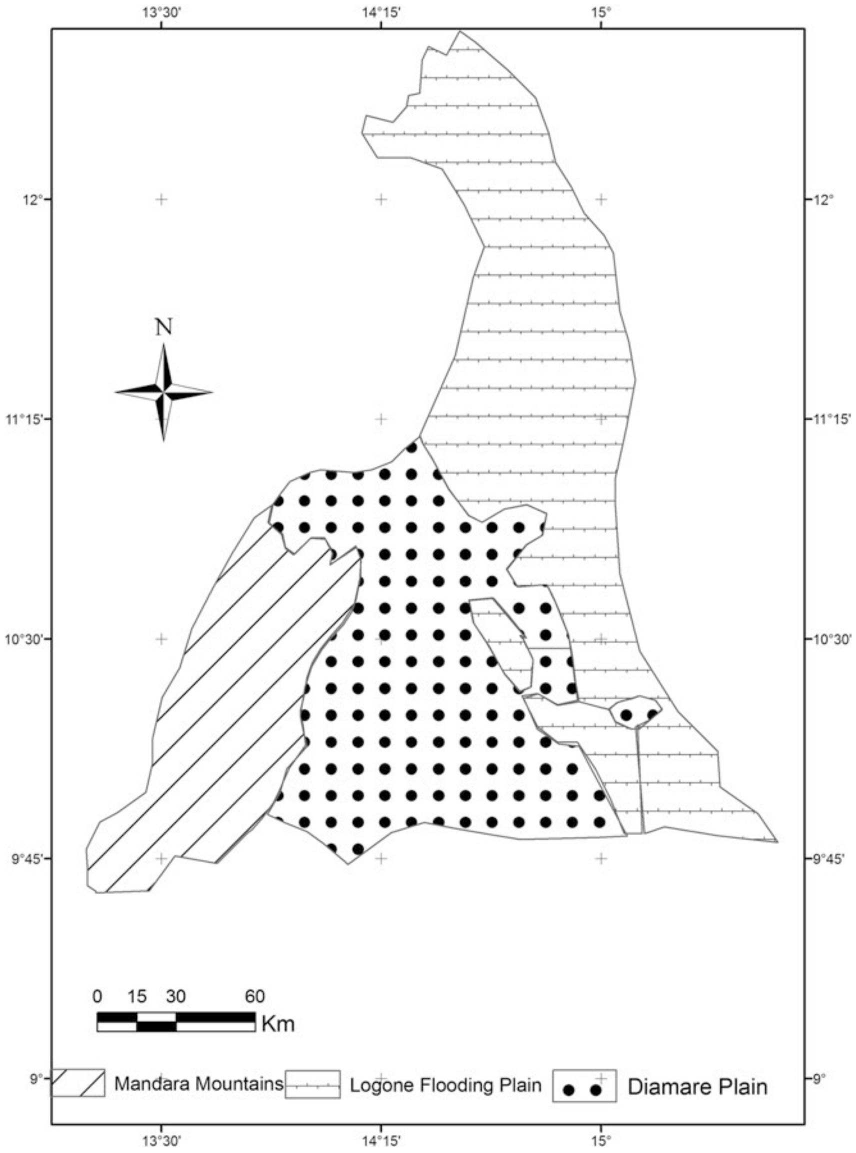

Fig. 6.2 Ecological zones of Far North Region

(September–February) and 27 °C and 30 °C in the warmer seasons (March–August) (McSweeney et al. 2012).

The Far North Region contains six divisions which include Diamare, Logone and Chari, Mayo Danay, Mayo Kani, Mayo Sava and Mayo Tsanaga. These divisions were grouped into three main ecological zones (Fig. 6.2) according to their climatic, floristic and topographic affinities and socio-economy characteristic: (a) regularly flooded Logone plain with low population density with shrub steppe and flooded grassland, (b) the Mandara Mountain zone with woody savanna and (c) the plain of Diamare with high population density (Tabopda Wafo 2008) and woody steppe and shrub savanna (Konga Mopoum 2013). We assume that management practices of land and floristic composition should be different according to the main above zones.

6.2.2 Data Collection

Data were collected in two main steps.

Step 1: Identification and Characterization of the Main Land Use
Semi-structured interviews and focus group discussions were used to identify the main land use of the study area. A total of ten focus group discussion was conducted with questionnaire in several king palaces including Lara, Kaele, Pette and Yagoua in Diamare plain; Goulfey, Guirvidig, Waza and Maga in Logone plain; and Mogode and Rhumsiki in Mandara Mountains. In each village at least six notables participated in group. The discussion was focused on land use description and management practices. Semi-structured interviews were conducted with four local administrative in each division. The data collected were completed by field observations.

Step 2: Land Use Management Assessment
Household semi-structured interviews were conducted using questionnaire in the three main ecological zones. The questionnaire was only based on the use and management of plant resources in the main land use types. The management criteria used were as follows: nature of plant species (natural or planted) in the land use, harvesting technics and availability of exploited resources. At the end of this step, a total of 598 households have participated to our interview with 150 in Logone plain (25% of households), 199 in Mandara Mountains (33%) and 249 in Diamare plain (42%). This activity has been carried out in Lara, Kaele, Guidiguis, Pette and Yagoua in Diamare plain; Goulfey, Guirvidig, Waza and Maga in Logone plain; and Gouria, Mokolo, Mogode and Rhumsiki in Mandara Mountains.

6.2.3 Data Analysis

The classification and characterization of land use was done using Intergovernmental Panel on Climate Change (IPCC) good practice guidance (GPG) for land use, land use change and forestry (LULUCF) (IPCC 2003) and FAO land cover classification system (Di Gregorio and Jansen 2000). The GPG for LULUCF describes six land-based structures for reporting emissions and removals of greenhouse gases. These land-based structures include forest land, cropland, grassland, wetlands, settlements and other lands (lands that do not fall within any of the other categories). The data collected were computed using XLSTAT-Pro 7.5 for statistical analysis. These data

Table 6.1 Distribution of land use into ecological zone (+ = present; − = absent)

Land use	Mandara Mountains	Diamare plain	Logone plain
Cropland	+	+	+
Grassland	−	−	+
Settlements	+	+	+
Wetlands	+	+	+
Forest land	+	+	+
Other lands	+	+	+

were presented per ecological zone. Significant different means were separated using one-way analysis of variance (ANOVA) with Student-Newman-Keuls (SNK) test at confidence interval of 95% (Golding et al. 2000).

6.3 Main Land Use of the Far North Region of Cameroon

A total of six main land uses was identified in the Far North Region of Cameroon according to the IPCC good practice guidance for land use, land use change and forestry. These include cropland, forest land, grassland, wetlands, settlements and other lands (rock, sandy area) (Table 6.1).

The croplands include farming systems (treeless farms and agrosystem parkland), fallow, orchards and gum arabic's plantation. The forest lands include forest plantation, steppe, shrub savanna and tree savanna. Grassland only included periodically flooded grassland, while the settlement comprises urban forest.

According to land cover classification system based on dominant life form and density of woody plants, Table 6.2 presents the characterization of the main land use and the main uses of these zones based on field observations. It was found that many of these land uses are areas of perennial and seasonal grazing, non-timber forest product (NTFP) and fuelwood collection, straw collection for house and fence building, recreation and windbreak.

6.4 Household Characterization

Table 6.3 presents the main characteristics of the households in each ecological zone. The average size of household is eight persons in the whole study area. At least 72% and 60% of head of household is unschooled respectively in Mandara Mountains and Logone plain. The sample population in the study area is mainly farmers and breeder.

Agriculture is the main source of household's income in the Diamare plains and Mandara Mountains. This activity is followed in those ecological zones by breeding, fuelwood and NTFP exploitation (Table 6.4).

Table 6.2 Characteristics of the main land uses of the semi-arid area of Cameroon

Land use	Dominant life form	Relative density of woody plants (%)	Mains uses
Forest land	Shrubs	≤40%	– Perennial grazing – NTFP collection – Fuelwood collection – Timber collection – Straw collection for house and fence building
	Trees	>40	– Seasonal grazing – NTFP collection – Fuelwood collection – Timber collection – Straw collection for house and fence building
Grassland	Grass	≤1%	– Seasonal grazing – NTFP collection – Straw collection for house and fence building
Wetlands	–	0%	– Livestock's watering – Other uses
Settlements	Trees	Between 10% and 20%	– Windbreak – Soil erosion protection – NTFPs collection – Fuelwood collection – Timber collection – Recreational area
Croplands	Treeless	0%	– Market garden – Cotton production – Subsistence crops – Paddy field
	Shrubs	≤1%	– Market garden – Cotton production – Subsistence crops – Seasonal grazing – NTFP collection – Fuelwood collection – Straw collection for house and fence building
		≥60%	– Orchards – Gum arabic plantations
	Trees	≤10%	– Market garden – Cotton production – Subsistence crops – Seasonal grazing – NTFP collection – Fuelwood collection
		≥60%	– Orchards

(continued)

Table 6.2 (continued)

Land use	Dominant life form	Relative density of woody plants (%)	Mains uses
Other lands	Bare laterite soil	0	–
	Bare sandy soil		–
	Rock	0	–
	House	0	–
	Burning area	0	–

Table 6.3 Household characterization in the main ecological zones of the semi-arid area of Cameroon

Variables	Mandara mountains	Diamare plain	Logone plain	Average	*p*-value
Sex (%)					
Female	6.2[b]	8.3[b]	22.7[a]	10.9	0.02
Male	93.8[a]	91.7[a]	77.3[b]	89.1	0.02
Age (year)	46.2[a]	39.3[b]	44.4[a]	42.3	0.00
Marital status (%)					
Single	0.9[b]	9.2[a]	7.7[a]	6.5	0.06
Married	98.1[a]	88.6[b]	81.9[b]	89.8	0.01
Widower	1.0	2.2	10.4	3.7	0.01
Number of person/household					
Number of people	9[a]	7[b]	8[ab]	8	0.03
Education (%)					
Not schooling	72.2[a]	25.9[b]	60.5[a]	46.5	0.00
Primary school	21.3	26.1	18.6	23.1	0.6
Secondary	6.5[b]	46.1[a]	20.9[a]	29.4	0.00
University	–	1.9	–	0.9	–
Principal occupations (%)					
Farmer	92.5	92.4	61.3	82.1	0.11
Craftsman	2.0	2.4	0.7	1.7	0.4
Trader	1.0[a]	0.4[a]	8[b]	3.1	0.00
Breeder	43.2	77.5	44.0	54.9	0.09
NTFP operator	20.6	17.3	20.7	19.5	0.7
Fisher	–	–	2.0	0.7	–
Others	3.0[b]	2.4[b]	9.3[a]	4.9	0.01

Means not sharing the common letter in a column are significantly different at $p = 0.05$ probability

Table 6.4 Main household source of income in the semi-arid area of Cameroon

	Diamare plain $N = 249$	Logone plain $N = 150$	Mandara Mountain $N = 199$	Average	p
Agriculture	58.5[a]	17.2[b]	57.0[a]	49.1	<0.0001
Orchards	3.9[a]	0.5[b]	1.5[ab]	2.5	0.06
NTFPs	5.4[a]	0.8[b]	2.1[a]	3.4	0.09
Fuelwood	3.8[b]	12.1[a]	1.81[b]	4.9	0.04
Breeding	28.4[a]	28.3[a]	12.5[b]	23.9	0.01
Other	0.9[b]	41.2[a]	25.1[a]	16.6	<0.0001

Means not sharing the common letter in a column are significantly different at $p = 0.05$ probability

Table 6.5 Main products exploited by farmers (% of household managing the land use) of the semi-arid area of Cameroon

Land use types	Product	Diamare plain $N = 249$	Logone plain $N = 150$	Mandara Mountain $N = 199$	Average	p	F
Croplands	NTFPs	67.3[a]	72.0[a]	80.2[a]	72.0	0.59	0.5
	Fuelwoods	69.8[a]	15.3[b]	76.9[a]	61.3	0.00	8.9
	Timber	6.6[a]	0.3[a]	2.7[a]	4.3	0.12	2.3
	Fodders	81.4[a]	37.9[b]	52.4[a]	64.6	0.00	10.9
Settlements	NTFPs	17.7[b]	60.2[a]	2.2[b]	21.4	<0.00	14.6
	Fuelwoods	18.5[a]	0.8[b]	2.8[b]	10.5	0.01	5.6
	Timber	3.7[a]	7.9[a]	0.8[a]	3.7	0.19	1.8
	Fodders	3.3	–	0.4	1.8	0.39	1.0
Grasslands	NTFPs	27.9[b]	54.0[a]	–	24.9	0.00	7.7
	Fuelwoods	1.7[b]	55.1[a]	–	11.6	0.00	41.9
	Timber	33.4[a]	4.1[b]	–	18.0	0.01	5.9
	Fodders	34.0[a]	1.6[b]	0.2[b]	17.9	0.00	7.3
Forest lands	NTFPs	70.8[a]	65.4[a]	54.4[a]	65.0	0.32	1.2
	Fuelwoods	69.1[a]	9.8[b]	27.1[b]	45.4	0.00	17.2
	Timber	43.2[a]	16.0[b]	41.2[ab]	37.4	0.12	2.3
	Fodders	37.7[a]	8.7[b]	9.7[b]	24.5	0.02	4.3

Means not sharing the common letter in a column are significantly different at $p = 0.05$ probability

6.5 Key Products and Services of Land Uses

The main services provided by these land uses include provisioning, supporting, regulating and cultural services. The key provisioning services are NTFPs, fuelwood, timber and fodders (Table 6.5).

Croplands and forest lands are the major land uses which provide most of the NTFPs and fuelwoods. A total of 75 citations of local names of plant species have been recorded as NTFPs exploited in cropping systems. Only 53 of them have been identified. Of these identified plants species, 43 are natives while ten are exotics. The top ten most cited NTFPs of cropland are *Adansonia digitata*, *Ziziphus mauritiana*, *Mangifera indica*, *Faidherbia albida*, *Psidium guajava*, *Citrus aurantifolia*, *Ximenia americana*, *Azadirachta indica*, *Acacia nilotica* and *Ziziphus spina-christi.* A total of 48 plant species have been cited as exploited as fuelwoods in cropping systems with six exotic species. The top ten species include *Faidherbia albida*, *Balanites aegyptiaca*, *Ziziphus mauritiana*, *Acacia* sp., *Azadirachta indica*, *Anogeissus leiocarpa*, *Tamarindus indica*, *Terminalia macroptera*, *Senna siamea* and *Mangifera indica* (Appendix).

The leafy stems of cereals, oilseed cakes, cottonseeds, straw and hay are the main products used as fodder by farmers in cropland followed by *Hyphaene thebaica* and *Borassus aethiopum*. Woody species include *Faidherbia albida*, *Anogeissus leiocarpa*, *Ziziphus* spp., *Balanites aegyptiaca* and *Tamarindus indica* (Appendix).

As for the other services, many plant species cited in cropping systems contribute to soil fertilization. These species include *Acacia* spp. (*Acacia hockii*, *A. gerrardii*, *A. nilotica*, *A. senegal*, *A. seyal*), *Faidherbia albida*, *Leucaena* sp., *Piliostigma reticulatum*, *P. thonningii*, *Prosopis africana*, *Sesbania sesban* and *Tamarindus indica* (Appendix). Among the forest lands, some sacred grooves have been recorded in the Diamare plain and Mandara Mountains. These areas are mostly used for cultural purposes by communities of these zones.

6.6 Management of Natural Resources in Land Uses

Only 5% of households in Mandara Mountain are treeless farm owners followed by 20% in Diamare plain and 70% in Logone plain (Fig. 6.3).

Of the total plants cited in the croplands, most of them have been preserved by local farmers (74%) during establishment of the farm. Systematic cutting is the main

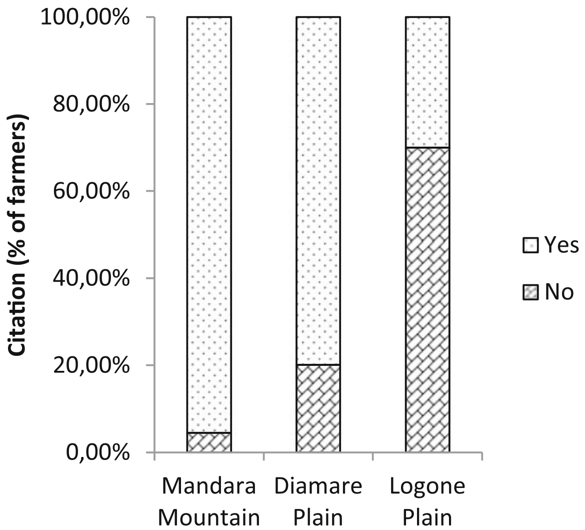

Fig. 6.3 Percentage of households with treeless farms

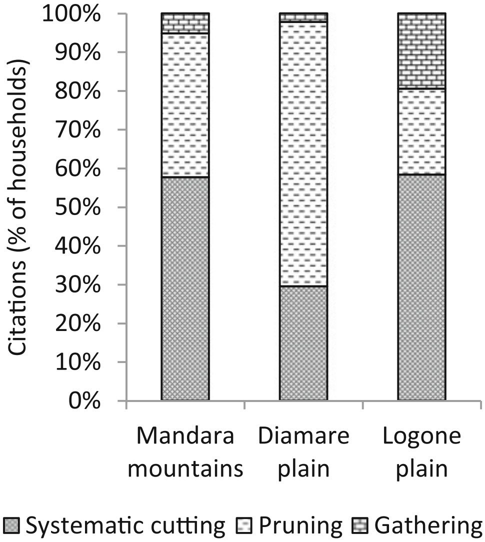

Fig. 6.4 Harvesting methods of plant resources

harvesting method in Mandara Mountains and Logone plain (done by 58% of households). In the Diamare plain, pruning is the most frequent harvesting technic followed by systematic cutting and gathering (Fig. 6.4). According to the smallholder's farmers these different techniques are necessary to maintain the quantity of trees in the farming systems.

In the whole Far North Region, a total of 12% of farmers argue that the quantity of trees in their farms is constant since their creation while 42% and 42% argue for the increasing and decreasing tree quantities, respectively, and then 4% no idea.

As far as the prospects to increase the number of trees in farming systems are concern, 40% of farmers in the Logone plain disagreed while only 7% agreed and 52% had no opinion (Fig. 6.5).

6.7 Land Use and Biodiversity Conservation

Land use in semi-arid areas of Cameroon has good implications for plant species conservation according to the assertion of local famers. A total of 141 citations of local plant names have been recorded during interviews. These include 93 different citations in croplands, 83 in forest lands, 47 in settlements and 38 in grasslands. Only 97 plant species including 69 in croplands (agroforests, orchards, fallows and gum arabic's plantation), 59 in forest lands, 37 in settlements and 32 in grasslands (Fig. 6.6) were identified during field survey in the whole study area. If these citations are confirmed by field assessment, land use types of semi-arid areas of Cameroon will be considered among the richest habitat for plants in the Sahel.

Agroforestry parkland is recognized as a good way to conserve biodiversity. This statement has been established by several studies in many countries over the world

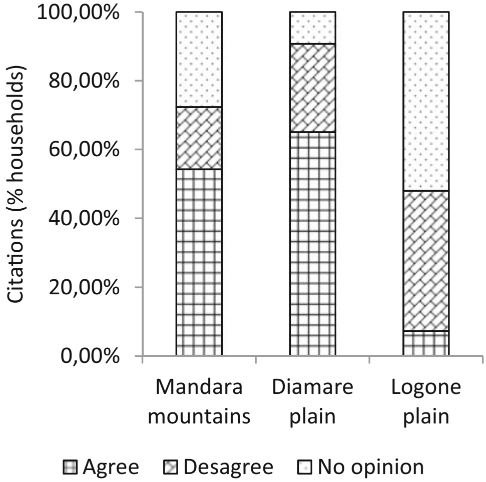

Fig. 6.5 Prospect to increase the potential of trees in farming systems

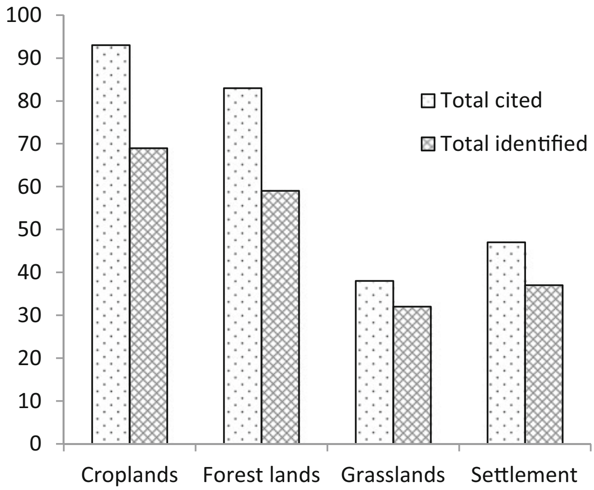

Fig. 6.6 Plant species citations in the main land uses

(Foley et al. 2005; Moreno-Calles et al. 2010). Agroforestry plays five key roles in conserving biodiversity. These include provision of habitat for species with high tolerance of disturbance; safeguarding the germplasm of sensitive species; reduction of the rates of conversion of natural habitat by providing a more productive, sustainable alternative to traditional agricultural systems; providing connectivity by creating corridors between habitat remnants which may support the integrity of these remnants and the conservation of area-sensitive floral and faunal species; and providing other ecosystem services such as erosion control and water recharge, thus preventing the degradation and loss of surrounding habitat (Jose 2009; Buck et al. 2004).

At least 95% of smallholder's households affirmed having agroforestry parklands in the Mandara, 80% in Diamare plain and only 30% in Logone plain. Concerning the species richness of these agroforestry parklands, a total of 69 plant species of croplands have been cited by smallholders' farmers in the whole study area and highlight the role of these land uses in biodiversity conservation. Field assessment is needed to confirm this species richness not only at the level of the whole study area but also at the level of each agroforest. However, comparing with other African countries situated within the same ecological area, this species richness is far above 56 plant species identified by Kindt et al. (2008) and Nikiema (2005) respectively in parklands in Mali and Burkina Faso. Of the 69 plant species of these agroforestry parklands, 59 of them are native species, which confirms the fact that multi-strata agroforestry systems cover an intermediate level of plant biodiversity that lies between forests and monocrop perennials or field crops (Swallow and Boffa 2006; Oke and Jamala 2013).

6.8 Land Use and Climate Change

Agroforestry, urban and peri-urban forestry and forest planting offer the opportunity for development of synergies between efforts of climate change mitigation and effort to support vulnerable populations to adapt to the undesirable consequences of climate change (Verchot et al. 2007; Lwasa et al. 2014).

Agroforestry parkland in smallholder agroecosystems of sub-Saharan Africa has a great potential in carbon sequestration through physical and biological processes. Thus, it plays an important role in climate change mitigation (Smith et al. 2008; Luedeling and Neufeldt 2012) through carbon sequestration. Takimoto (2007) shows that agroforestry parkland of West African Sahel has the potential for sequestering more carbon than in treeless land use systems. Furthermore, Smith et al. (2008) estimated at -0.73 to 1.39 Mg C $ha^{-1}year^{-1}$ the potential of carbon sequestration of agroforestry parkland in dryland areas, while Luedeling and Neufeldt (2012) estimated 1.47 Mg CO_2 $ha^{-1}year^{-1}$ in Sahelian parkland. The 69 plant species cited in cropland have a potentiality to mitigate climate change through carbon sequestration. However, the carbon stock potential of agroforestry parklands remains unknown in the semi-arid area of Cameroon. This information could be useful for the REDD+ (reduction of emission of deforestation and forest degradation with sustainable management of forests, conservation of forest carbon stocks and enhancement of forest carbon stocks) project initiators and for the implementation of the National Appropriate Mitigation Action (NAMA) plan.

Carbon sequestration by urban forest and other community-based afforested (A)/reforested (R) areas of semi-arid area of Cameroon also offers a great opportunity for Clean Development Mechanism (CDM) of the Kyoto Protocol of the United Nations Framework Convention on Climate Change. Agroforestry could also be one of the potential CDM sink projects (Roshetko et al. 2007) if criteria are adequately respected. Some authors indicate that land use systems and agricultural practices which contribute to increase the soil carbon stock could generate carbon offsets

(Hurteau and Brooks 2011; FAO 2000). However, the appropriate agroforestry systems for CDM in semi-arid areas need to be identified.

Urban and peri-urban forestry has also been identified as one of the good approaches to mitigate climate change globally and in African dryland in particular by reducing atmospheric carbon and other urban emissions (Fuwape and Onyekwelu 2010; Lwasa et al. 2014). Urban and peri-urban forestry is well developed in many cities in the Far North of Cameroon. An assessment of small-scale forestry estimated at 75.5 hectares the total area of forest planted by local farmers between 1983 and 2011 with the aim of climate change mitigation and adaptation. A total of 41 plant species were cited as exploited in urban forests. The main cited include *Azadirachta indica*, *Acacia senegal*, *Eucalyptus camaldulensis*, *Khaya senegalensis* and *Senna siamea.* Some of these plant species have been reported as relevant for urban systems in Togo (Raoufou et al. 2011).

According to McPherson et al. (1994), carbon sequestration of urban trees can range from 16 to 360 kg $yr.^{-1}$ respectively for small slow-growing trees with 8–15 cm diameter at breast height and for larger trees growing at their maximum rate. In Cameroon, the capacity of carbon sequestration by urban forest is not well known. However, it has been reported that average carbon sequestration of *Azadirachta indica* is 6372.0 kg C ha^{-1} $year^{-1}$ and *Dalbergia sissoo* 1415.11 kg C ha^{-1} $year^{-1}$ (Shankar et al. 2014).

The sustainable management of these land use can help to avoid deforestation in semi-arid areas of Cameroon and increase their potentials as main carbon sinks.

6.9 Adaptation Options

According to the fifth assessment report of the Intergovernmental Panel on Climate Change, semi-arid areas are among the most vulnerable ecosystems to climate change (IPCC 2013). Many adaptation options including improved tree management and planting through agroforestry, urban and peri-urban forestry, afforestation/ reforestation, etc., can both reduce the negative impacts and take advantage of the positive aspects of changes (Woodfine 2009; UNDP et al. 2009). These land uses are present in study area and constitute an opportunity.

6.10 Conclusion

Many land use systems in semi-arid areas of Cameroon provide some services which are relevant for the livelihoods of the local population. Among these land uses, agroforestry, orchard development, afforestation/reforestation through urban and peri-urban forestry and other forest plantations have been identified as opportunities to combat desertification and enhance climate change mitigation and adaptation and biodiversity conservation. However, the result of this study relies mainly on the perception of local smallholder's farmers. The field assessment of plant resources of these land uses is necessary in order to quantify the capacity of each of these land uses in biodiversity conservation and carbon stock.

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Appendix: Availability of Plant Species in the Land Use Type

		Settlement				Grasslands				Cropland				Forest lands			
N°	Species	T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs
1	*Acacia nilotica*	1	1	1	1	1	0	0	1	0	1	0	1	1	0	0	1
2	*Acacia polyacantha*	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0
3	*Acacia senegal*	1	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0
4	*Acacia seyal*	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
5	*Acacia* sp.	0	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1
6	*Adansonia digitata*	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1
7	*Anarcadium occidentale*	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
8	*Annona senegalensis*	0	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1
9	*Anogeissus leiocarpus*	0	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1
10	*Asparagopsis* sp.	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
11	*Azadirachta indica*	1	1	1	1	1	0	0	1	1	1	0	1	1	1	0	1
12	*Balanites aegyptiaca*	1	1	1	1	1	1	0	1	0	1	0	1	1	1	1	1
13	*Bombax costatum*	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
14	*Borassus aetiopium*	1	1	0	1	0	0	0	1	1	1	0	1	1	0	0	1
15	*Boswellia dalzielii*	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
16	*Brachiara* sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
17	*Carica papaya*	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
18	*Cassia occidentalis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
19	*Cassia* sp.	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	*Cissus quadrangularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
21	*Citrus aurantifolia*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
22	*Citrus lemon*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

(continued)

N°	Species	Settlement				Grasslands				Cropland				Forest lands			
		T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs
23	*Citrus* sp.	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
24	*Citus aurentifolia*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
25	*Cochlospermum planchonii*	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
26	*Combretum collinum*	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	1
27	*Combretum glutinosum*	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1
28	*Combretum molle*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
29	*Commiphora kerstingii*	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
30	*Costus spectabilis*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1
31	*Crinum* sp.	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
32	*Croton gratissimus*	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
33	*Daniellia olivieri*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
34	*Detarium microcarpum*	0	1	0	1	0	0	0	0	0	1	0	0	1	1	0	1
35	*Dioscorea* sp.	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
36	*Diospyros mespiliformis*	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1
37	*Entada africana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
38	*Eucalyptus camaldulensis*	1	1	0	0	0	0	0	0	0	1	0	1	1	1	0	1
39	*Faidherbia albida*	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1
40	*Ficus glumosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
41	*Ficus gnaphalocarpa*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
42	*Ficus platyphylla*	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
43	*Ficus* sp.	1	1	0	1	0	0	0	0	0	0	0	1	0	1	0	1
44	*Ficus sycomorus*	0	0	0	0	1	0	0	0	0	1	0	1	1	1	0	1
45	*Ficus thonningii*	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1
46	*Gardenia aquala*	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
47	*Gardenia erubescens*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

48	*Gardenia triacantha*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
49	*Gossypium* sp.	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
50	*Grewia* sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
51	*Guiera senegalensis*	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0
52	*Haematostaphis barteri*	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	1
53	*Hexalobus monopetalus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
54	*Hibiscus cannabinus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
55	*Hyparrhenia rufa*	1	0	0	0	1	0	1	1	1	0	0	0	1	1	0	1
56	*Hyptis spicifera*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
57	*Ipomoea* sp.	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
58	*Khaya senegalensis*	0	1	0	0	1	0	0	1	0	1	0	1	1	1	0	1
59	*Lannea fructicosa*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
60	*Lannea schimperi*	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
61	*Leptadenia hastata*	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
62	*Leucas martinicensis*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
63	*Leucena* sp.	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
64	*Mangifera indica*	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0
65	*Mitragyna inermis*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
66	*Moringa oleifera*	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0	1
67	*Nauclea latifolium*	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1
68	*Parkia biglobosa*	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0	1
69	*Phoenix dactylifera*	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1
70	*Piliostigma reticulatum*	0	0	0	0	1	0	0	1	0	1	0	1	1	1	0	1
71	*Piliostigma thonningii*	0	1	0	1	0	0	0	0	0	1	0	1	1	0	0	0
72	*Psidium guajava*	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
73	*Ricinus communis*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
74	*Sclerocarya birrea*	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	1

(continued)

N°	Species	Settlement				Grasslands				Cropland				Forest lands			
		T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs	T	FW	F	NTFPs
75	*Senna occidentalis*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
76	*Senna siamea*	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0
77	*Senna singuena*	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1
78	*Senna tora*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
79	*Sesbania pachycarpa*	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1
80	*Sida rhombifolia*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
81	*Sporobolus* sp.	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0
82	*Steganotaenia araliacea*	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
83	*Stereospermum kunthianum*	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1
84	*Strophantus tomentosus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
85	*Strychnos spinosa*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
86	*Swartzia madagascariensis*	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
87	*Tacca leonpetaloides*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
88	*Tamarindus indica*	0	1	1	1	1	1	0	1	0	1	0	1	1	1	0	1
89	*Terminalia macroptera*	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1
90	*Terminalia mentali*	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
91	*Terminalia* sp.	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
92	*Vetiveria nigritana*	1	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0
93	*Vitellaria paradoxa*	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0	1
94	*Vitex doniana*	0	1	0	1	0	0	0	0	0	1	0	1	0	1	1	1
95	*Ximenia americana*	0	1	1	1	0	0	0	0	0	1	0	1	1	1	0	1
96	*Ziziphus mauritiana*	0	1	0	1	0	1	0	0	0	1	0	1	1	1	0	1
97	*Ziziphus spina-christi*	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
	Total	**13**	**28**	**13**	**30**	**18**	**6**	**4**	**26**	**7**	**48**	**2**	**53**	**39**	**41**	**5**	**52**

T timber, *FW* fuel-wood, *F* fodder, *NTFPs* Non-timber forest products

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