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Potentials of Protected Areas as Carbon Sinks and Implication on Climate Change in Cameroon

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Abstract

Cameroon has 115 000 km2 land area designated as Protected Areas (PAs), providing society with many ecosystem services including climatechange mitigation. The study was aimed at examining the potentials of inland and coastal PAs as carbon sinks and implication on climate change mitigation in Cameroon between 1978 and 2014. Data for the study was obtained from both primary and secondary sources. Remote Sensing and Geographic Information System (GIS) techniques were used in the analysis of satellite imageries.The land cover change trajectory revealed a drop in the rate of conversion of dense forest within inland PAs compared to coastal PAs.Results reveaked carbon sequestration withininland PAs between 1978 and 2014 and the PAs were able to absorb166,590.73tonnes/ha CO2from the atmosphere and build up carbonresulting to the amelioration of the local and regional climate of the area with a positive impact on global climate change.Within the coastal PAs, there was 71,418.48 tonnes/haCO2 emission through 1978 – 2014 with resulting negative impacts on the climate.The constraints to effective PA management identified were human and capital resource problems, hostility of the local population, delayance in law enforcement and poverty.To ensure their roles in climate moderation there should be a better forest policy implementation withinPAs in Cameroon by making available more capital and human resources to PAs management to enable them cope in the face of growinganthropogenic threats.

Keywords: Cameroon; Climate change; CO_2 Emission; Land cover change; Protected areas

Introduction

Climate change is arguably the toughest environmental challenge of the 21st century. Forests play a major role in the global carbon cycle and contain a substantial proportion of the world's terrestrial biodiversity. Forests also provide a broad range of other 'ecosystem services' including; supporting services such as nutrient cycling, soil formation and primary productivity; provisioning services such as food, water, timber and medicine; regulating services such as erosion control, climate regulation, flood mitigation, purification of water and air, pollination and pest and disease control; and cultural services such as recreation, ecotourism, educational and spiritual values [1]. One of the key supporting services provided by forests is carbon removal from the atmosphere (sequestration and the long-term storage of this carbon in biomass, dead organic matter and soil carbon pools. Of the global forest carbon stocks, an estimated 55 percent (471 Pg C) is stored in (sub-)tropical forests, of which more than half is stored in biomass [2].However, Deforestation and forest degradation in the tropics and sub-tropics have a large negative impact on terrestrial biodiversity, and thus on the provision of those ecosystem services that are most closely linked to biodiversity. Today, more than ever, the future of the global forest carbon sink is highly uncertain. The loss of biodiversity, linked to deforestation and forest degradation, could further diminish the ability of forests to effectively provide multiple ecosystem services, including, carbon sequestration.When forests are burned or cleared for uses such as cropland, pasture, infrastructure or urbanization, the net flow of carbon from the atmosphere into the forest ends. Deforestation also causes the release of the stock of carbon that has accumulated both in the trees themselves and in the forest soil. In the last 300 years alone, more than half of the earth's land surface has been transformed by human activities[3], driving widespread habitat losses and ecosystem alteration [4]. This has resulted to the setting aside of forest sites designated as protected areas (PAs) to preserve areas of considerable ecological, spiritual, or aesthetic value and safeguard biodiversity. There are over 100,000 parks, nature reserves, other land and marine areas designated as protected areas covering over 12% of the earth´s land surface [5]. These areas have the potentials of contending future climate change, So far, studies have been carried out to evaluate the success of PAs using measures such as the representativeness of PA networks in terms of their species diversity, [6], assuming that PAs provide effective protection once established. Alternatively, by investigating management 'inputs' – e.g. whether PAs have management plans, boundaries,staffing, and other management systems and processes [7], assuming that increased levels of management equates to successful protection. In Africa, protected areas are the cornerstone of *in situ* biological conservation [8] and are a major means of reducing deforestation [9] and contributingto climate change mitigation and adaptation, both on global and local scales. The role of protected areas in pulling carbon dioxide (CO_2) out of the atmosphere through plant photosynthesis and storing it as organic matter in vegetation and soil has become a topic of intense interest to the climate-policy community [10]. However, their role in contributing to climate changebyestimating carbon dioxide emissions from Land cover change is currentlyinsufficiently recognized inthe development of national strategies and policies in Cameroon.Understanding the potentials of PAs in climate regulation becomes imperative in this era of intensive degradation of forest resources.The focus of this paper is to state whether PAs are capable of continuously providing the regulatory service of climatemoderation by estimating CO_2 emissions from PAs in Cameroon due to land cover change and also to identify constraints to PA management to enable putting on place appropriate policies for effective management.

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Materials and Methods

Study area

Cameroon is a country endowed with abundant forests located between latitudes 2º and 5º north of the equator, and occupying about 45.6% of the national territory [11].Itis ranked second in terms of forest cover in Africa after the Democratic Republic of Congo (DRC). It is bordered by Nigeria to the west, Chad to the north, the Central African Republic to the east, Congo, Gabon and Equatorial Guinea to the south and the Atlantic Ocean to the south west. Cameroon has an estimated 22 million hectares of forest resources with the forest sector contributing more than 3% of the gross domestic product (GDP) and accounting for 7% of total export [12]. Most of the forests form part of the Congo Basin forest which is the second largest area of dense tropical forest in the world, following the Amazon basin [13]. Cameroon's forest is a vital resource to the Central African region given that it fulfils critical environmental, economic, social and cultural functions in the region. Cameroon's tropical forest is fast disappearing and national and international environmental groups (nongovernmental organizations) fear at such a high rate of deforestation, the country's rainforest might cease to exist in a matter of a few years from now, if something is not done toremedy the situation. One of the biggest environmental challenges facing the country today is the destruction of the natural vegetation.A number of protected areas have consequently been created with the intentionto conserve this biological wealth (Figure 1). Cutting across different ecological regions and ecosystems types and are widely distributed within the national territory. There are a total of 42 protected areas and most are gazetted with a management plan put in place.The total surface area occupied by PAs in Cameroon is 115,000 km² (Table 1). Closed forests are concentrated in the South and along the coast while areas of mangroves are found in the Gulf of Guinea and areas of Acacia woodland occur in the North. Cameroonian forest contains a high biological diversity and endemism. The country is one of the most ecological diverse spots and is ranked fifth in biodiversity in Africa after the Democratic Republic of Congo, South Africa, Madagascar and Tanzania [14] andis a signatory to the UNFCCC and the Kyoto Protocol.More recently the country has participated in the Conferences of the Parties (COP).

The Korup National Park extend from latitude 4° 54´ to 5° 28´ North and longitude 8° 42´ to 9° 16´ East covering 126,900 ha of forest, most of which is evergreen forest. The area was originally set aside as a "Native Administrative Forest Reserve" in 1937. In 1962 it was modified and the forest was renamed Korup Forest Reserve [15]. Following the presidential Decree No. 86/1283 of 30th January 1986, the forest reserve was upgraded to the status of a National Park. Korup is located 60 km inland from the Atlantic Ocean, and 10 km from the border with Nigeria. Korup National Park is reputedly one of the richest lowland African forests in terms of floral and faunal richness and diversity. Bakossi National Park is located between latitude 4° 40′ to 5° 15′ north of the Equator and longitude 9° 36′ to 9° 70′ east of the Greenwich Meridian covering an area of 29,320 ha standing 2,411m above sea level. The Bakossi reserve was created in 1956. In 2000, the main section of the reserve was designated as a protected area. All logging was banned and Bakossi became a "strict nature reserve". It was upgraded to the

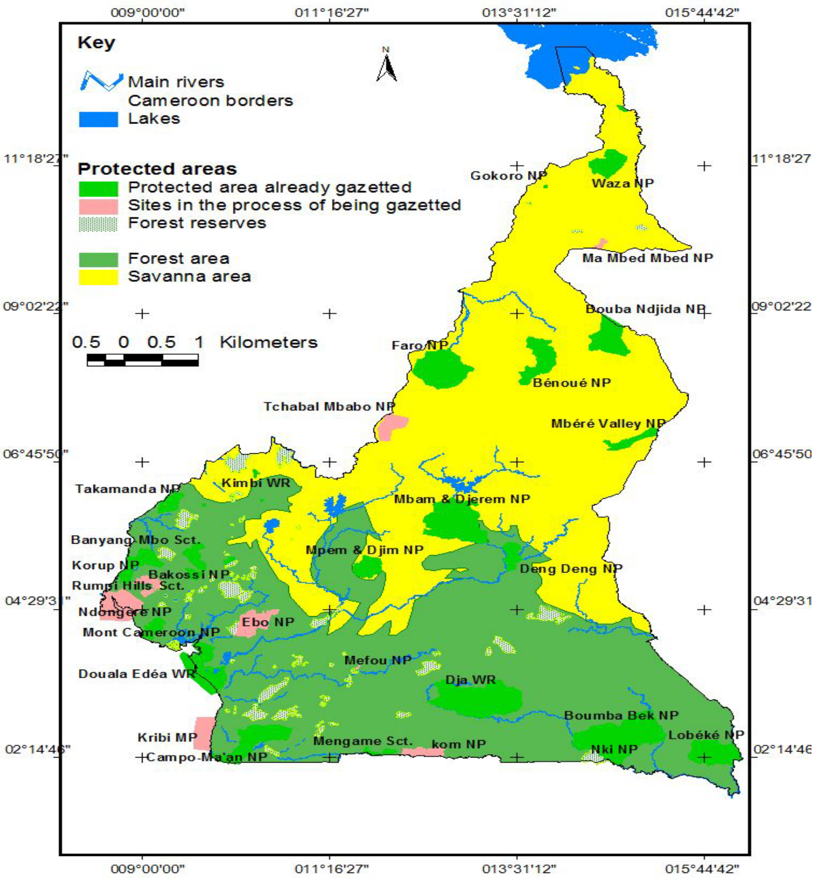

Figure 1: Map of Cameroon showing the Protected Areas.

Table 1: Land use in Cameroon.

Land reclassification	Area (km^2)	%
Area of territory	475 446	100.0
Total land area	465 412	97.9
Semi-arid	102 068	21.2
Wooded savanna	101 992	21.0
Coastal & maritime zone	9670	1.0
Tropical forest zone	394 700	82.5
Land under cultivation	19 668	3.0
Stretch of coastline	402	
Protected area coverage	115 000	24.2
Rate of deforestation (1996)	200 000	

Source: MINEP 2008

status of a National Park in 2007 and officially inaugurated early in 2008. The vegetation of Park ranges from the equatorial rain forest type, tropical savannah and Sahel and the eastern flank is dominated by a mature rain forest. The Douala-Edea reserve is located within $9^0 31' – 10^0$ 05E and $3^0 14' – 3^0 53'$ N [16]. The reserve was gazetted in 1932 and in 1997 it became a strict nature reserve. It is situated within the Kribi – Douala basin of the coastal Atlantic Ocean. It has an aerial coverage of 160,000ha. The Douala-Edea reserve is a wetland area with 2 distinct ecosystems: marine and humid tropical forests. This reserve also harbours one of the country's important mangrove forest areas. The mangrove forests mainly consist of *Rhizophora mangle*, *Rhizophoraracemosa* (red mangroves), *Rhizophoraharrisonii* and isolated patches of *Avicennia Spp* or *Lagunculariaracemosa* (white mangrove) together with Nypa palm (*Nypafruticans*). *Rhizophora* makes up more than 90% of the Douala-Edea mangroves. The mangrove area is occupied by over 20 villages and many fishing camps with a total population of more than 5600 (57% of the total reserve population) [17]. More than 70% of the mangrove resident population consist of foreign nationals; Nigerians, Ghanians, Beninois and Niger Republicans with Nigerians constituting more than 60% of the total population. The Bois des Singes reserve, created in 1974 by decree N° 261 of July 1947 is located within $9^0$41E and $3^0$59N and covers a surface area of about 40 hectares. It was originally created for recreation and protection. It is located in the Douala II municipality of the Wouri Division in the littoral region. Arguments that favored the creation and the maintenance of this small reserve was the fact that it was a zone improper for human habitation, an area that could protect the city of Douala against rising sea levels and for protection of the vegetation and forests in the area. It is surrounded by a flooded area bordering the river Wouri.

Selection of study areas and sample sites

Four PAs were chosen from both along the coast and inland. Factors guiding the choice of the areas are that the areas cover a significant portion of Cameroon's forest land. Secondly, they are host to both state institutions and non-state actors in charge with the implementation of the 1994 forest policies within protected areas in the country. Thirdly, the protected areas selected for the study are all classified under the permanent forest where no form of exploitation is permitted. Two inland PAs-the Korup and Bakossi National Parkswere selected in the South West Region and two coastal PAs-the Douala Edea and Bois de Singes reserves selected in the Littoral region (Figure 2).

Thetimeperiod (1978-2014)

The time period 1978 to 2014 was chosen for various reasons. Firstly, 1978 was used as a base map period because the first Landsat imageries for the area were available in this period. Secondly, to see the rate of land cover changes before and after the enactment of the 1994 forestry laws. It also covers at least two to fifteen years following the dates of enactment of two major forest and land use policy eras in Cameroon (that is the 1976 Land Use Ordinances and the 1994 Forest Policy). This is a reasonable time span to observe any meaningful changes in land cover. Thirdly, the year 1978 shows the state of ecological system 8years before the creation of the Korup National Park. The year 2000 is chosen as an intermediate point to distinguish the immediate effects of post- park creation and resettlement and 2014 to show the present state of the protected areas. Also, over shorter time periods changes will not be visible but over a longer time period (36 years), meaningful changes can be seen.

Data Collection

Primary data for land cover change was obtained from ground control points (GCPs) collected from all the land cover and land use types within the protected areas with the use of a hand held Global Positioning System (GPS). The Land Sat data (TM, ETM$^+$ 1973, 2001) and SPOT 2013 were acquired from the Global Land Cover Facility (GLCF) (http://glcf.umiacs.umd.edu), Earth Explorer website and Ministry of Forestry and Wildlife respectively. The image data were acquired in an Orthorectified format geocoded in the spheroid and datum WGS84, with map projections UTM32 for the four protected areas. Secondary data was obtained from documented sources such as journals, textbooks, reports, articles and the internet. Data was collected from government offices, non-governmental agencies, libraries, teaching and research institutions, International Organizations, and textbooks. Information was gathered through review of library books, maps, journal articles, census data, annual reports, conferences and seminar proceedings, progress reports, and evaluations of past and ongoing conservation-oriented projects in the area and websites. Some of the institutions visited included the Regional Delegations of MINFOF, the National Archive Buea, Cameroon Wildlife Conservation Society (CWCS), Korup National Park Authority, Bakossi Park Authority.

Determination of land use land cover change and carbon dioxide emissions from land cover change

To evaluate the changes in forest, cover relative to other land uses over the past 36years within protected areas, Geographic Information System (GIS) and Remote Sensing techniques were used in the analysis of satellite imageries between 1978 and 2014. The activities that were carried out include; satellite image processing and classification for LULCC detection. Erdas Imagine 9.2 software was used in processing and analysing the imageries.

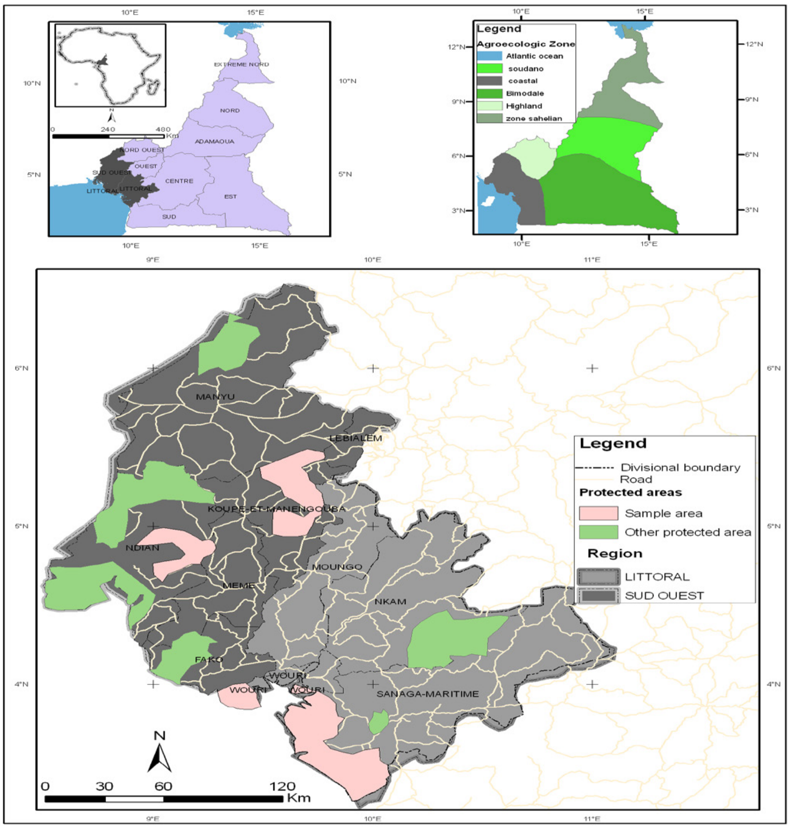

Figure 2: Map of Littoral and South West Region showing the sample sites.

Carbon dioxide emissions from Land cover change was estimated [13,18] formula as follows:

Carbon emission = ½ (biomass) * 3.67 * loss (1)

The mean biomass for forests in Sub Saharan Africa (134) [19] and revised [13] was used. The loss was calculated from the attribute table statistics of the classified images.

Results and Discussion

Land cover change detection qualification and quantification

Land cover change analysis over the period 1978 to 2014 in Korup and Bakossi the inland PAsrevealedthree important land cover changes as can be seen on Figure 3. The resultsrevealed that the dense forest coverage in Korup was lower in 1978 than was the situation in 2000 and 2014.The total surface area occupied by the dense forest was 96,882, 113,398 and 110,787 hectares respectively for the year 1978,2000and2014 (Figure 3). The resultsrevealed an increase in the dense forest coveragein 2000 and 2014 in relation to the 1978 figures. This increase can be attributed to the better enforcement ofthe 1994 forest laws in the area. Between 2000 and 2014 there was a reduction in the forest area from 113,398 to 110,787 hectaresreflectinga total loss of 2,611 hectares over 14 years representing an annual deforestation rate of 0.16ha. The decrease in the forest area can be attributed to the incresase in the built up area reflecting population increase, infrastructural development most especially the newly constrccted road through the Korup Park to Erat and the extension of the Permanent Users' Zones (PUZs) within the Park. The Park Authorities have extended the external boundaries of the PUZ with five management structures; communal forest where only hunting for subsistence can be carried out using traditional methods as spelt out in the law, a farm expansion zone, a farm reserve land because the population will grow over so as to prevent a situation where the population will start asking government to give another part of the park for settlement. They have reserved part of the PUZ that cannot be tampered with until after 25 years.The total surface area occupied by forest in Bakossi was 20,679, 18,497 and 28,629 hectares for 1978, 2000 and 2014 respectively. Before the creation of the reserve in 2000, there were no strict laws guiding access into the reserve. Hence, free access in and out of the area resulted to a reduction in the forest area from 20,679 in 1978 to 12,232 hectares in 2000 representinga total loss of 8,447 hectares and an annual loss of 384 hectares. The results show a decrease in the area under savanna/ secondary forest from 29,118, 12,569 and 8209 hectares in Bakossi for the year 1978, 2000 and 2014 respectively (Figure 3). This decrease can be attributed to the regeneration of secondary forestdue to a decrease in human interferance in the area. The period between 2000 and 2014 witnessed an increase in the area occupied by forest from 12,232 to 28,829 hectares representing an annual increase of 1,186ha in the area. This increase can be attributed to the enforcement of the 1994 forest policies thereby indicating a positive impact of forest policies towards maintaining the forest cover. The spatio temporal trend of savanna within Bakossi showedthat the area undersavanna was 7900, 9375 and 5 hectares for 1978, 2000 and 2014 respectively. The increase observed in2000 can be attributed to an increase in deforestation between 1978 and 2000 before the implementation of the current policies. The decrease observed in 2014 is due to savanna regeneration to forest following the exclsion of human activities inthe area following the implementation of the 1994 forest policies. The results revealed

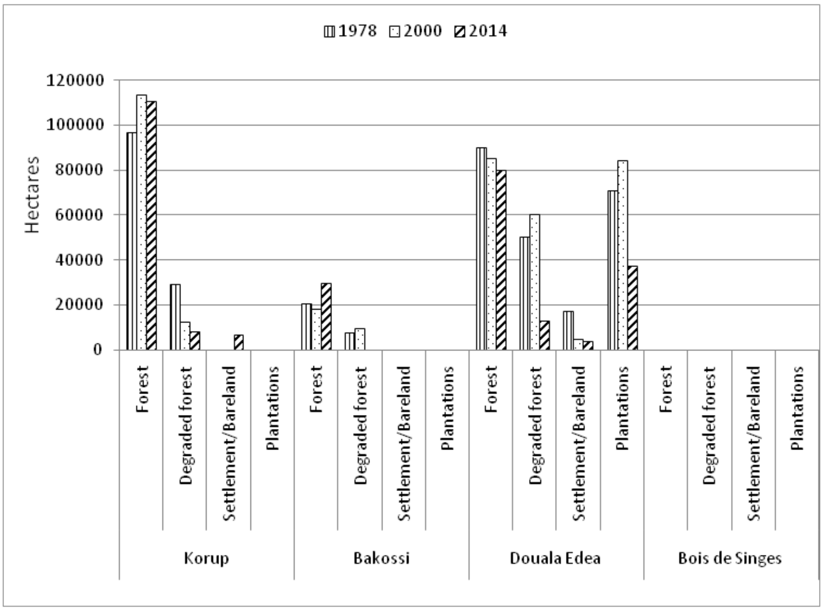

Figure 3: Land Cover / land use change between 1978 and 2014 within coastal and inland protected areas.

a steady increase in settlements throughout the study period (0, 33 and 7,004 hectares for the year 1978, 2000 and 2014 respectively) in Korup. This increase in settlement is linked to population growth due to improvement in medical facilities as stipulated by the Malthusian theory of population growth. In Bakossifollowing the creation of the reserve in 2000 built up areas and barelandexperienced a downward trend from 55, 402 to 0 hectares. Most of the settlements inside the reserve were hunting villages and the people relocated outside the reserve to be engaged in farming and other activities following anti poaching campaigns and sensitisation by WWF and other NGOs in the area.Within the coastal PAs, there was an increase in the rate of conversion of dense forest to, secondary forest, settlement and other land uses following the implementation of the 1994 forest policies. The reasons for this include; the absence of vibrant conservation bodies in the area, ignorance of forest laws and policies by the population and the negative attitudes of the local non indegenous communities towards conservation. Within the Douala – Edea reserve the forest cover reduced from 89874 in 1978 to 80101 hectares in 2014. In the Bois de Singes reserve there was a reduction from 38.08 ha in 1978 to 13h in 2014. The deforestation rate was 1.2% between 1978 and 2000 and 4.3% within 2000 and 2014 representing the highest so far recorded. The reasons for this are due to the lack of conservation organizations to implement conservation policies, nearness to the city of Douala and high pressure from the urban poor who are fast transforming the reserve into a residential area. This clearly demonstrates that the forest policies are ineffective towards the conservation of forest resources in the region.

Carbon dioxide emissions within protected areas

The biosphere is a strong determinant of the chemical composition of the atmosphere. This has been true since the existence of the biosphere, and hence well before the presence of humans. There is, however, a strong evidence that the expanding human use and alteration of the biosphere for food, fuel and fibre is contributing to increasing atmospheric concentrations of greenhouse gases (GHGs). The dominant gas of concern in this source category is CO_2. There is concern that GHG emissions from human activity (anthropogenic GHGs) are having an ef fect on the global climate. Carbon dioxide is the principal anthropogenic GHG. The amount of carbon from anthropogenic CO_2 entering in the atmosphere has grown from a few million tons per year in 1850 to over 9 billion tons per year today. Deforestation and other land-cover changes typically release carbon from the terrestrial biosphere to the atmosphere as CO_2[13]. Remotely sensed tropical deforestation data (from the Advanced Very High Resolution Radio-meter, AVHRR, and Landsat TM, respectively) to estimate carbon emissions releases. (Figure 4) show the carbon emission estimates for both the inland and coastal PAs. Carbon dioxide emission results inland revealed that there was carbon sequestration in Korup and Kupe between 1978 and 2014 (Figure 4) indicating that the trees were able to absorb CO_2 in the atmosphere and build up carbon. This resulted to the amelioration and moderation of the local and regional climate of the area with a positive impact on global climate change. An analysis of the 1978 – 2000 CO_2 emission trends in the area revealed that there was carbon sequestration in Korup and Kupe. The 2000 – 2014 periods revealed there was emission in Korup and sequestration in Kupe.On the other hand, in the coastal areas, there was CO_2 emission through 1978 – 2014 in Douala-Edea and Bois de Singes reserves with resulting negative impact on the local and global climate. This is an indication that the forest management policies on the ground are ineffective in maintaining the forest land cover in these PAs.

Drivers of biodiversity loss and natural resources degradation within protected areas

The smooth functioning of PAs has been hindered by a shortage of logistics and human resources. PA surveillance and enforcement units are ineffective and inefficient. The problems of PA management identified can be broadly classified into human and capital resource problems, hostility of the local population, delayance in law enforcement and poverty.

Human resource problem

The effective application of laws within a PA is dependent on the available manpower especially field workers to constantly monitor and watch against intruders. An analysis of the staffing situation of Eco

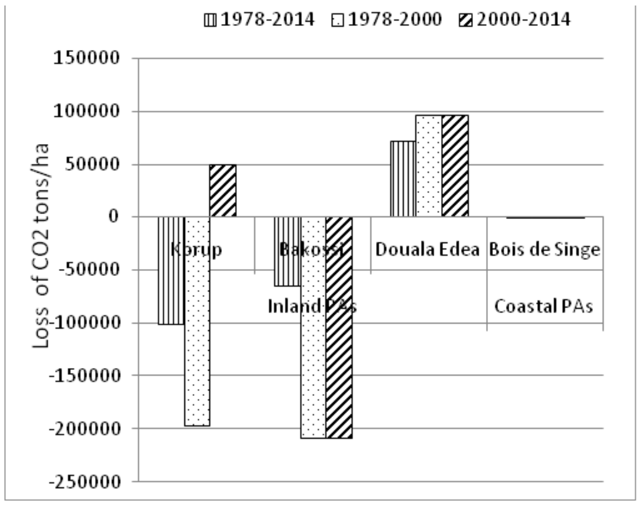

Figure 4: Average yearly CO_2 emissions for inland and coastal Pas.

guards reveals a situation of under staffing thereby exposing the PAs to human activities. The management authorities complained that the number of eco guards for patrol are few to cover the entire reserve. In Korup there are 12 guards to cover 126,000 hectares giving a ratio of 1 guard to 10,500 hectares while Bakossihas just 7 forest guards making it practically impossible for them to cover the entire reserve area. In Douala - Edea there are 15 guards in total while Bois des singes on the other hand has no forest guard. For an effective PA surveillance, IUCN recommend a ratio of 1 guard to 5.000 hectares in open forests and 1 guard to 3.000 hectares in closed forest like Korup, Kupe and Douala – Edea reserve. The implication of this is that illegal exploiters find their way in and out without being caught.

Capital resource problem

The capital resource is simply the means and logistics available to management to execute the programs and project stipulated by the law to guarantee the smooth functioning of activities within PAs. The finances available for the execution of activities are not regular and sufficient for the smooth functioning of activities within PAs. Key informants from the Delegation and the Conservator cited this as a problem of under-funding. PAs lack the means to acquire new equipment and to maintain old ones such as cars, bikes, boats and to purchase fuel. For example, the Delegation of Environment in Korup has only one four-wheel drive car and two motor bikes. This is a hinderance to major operations like patrols. They also complained that by the time they are called up for intervention, they do not always make it because of no bikes, boats or fuel. The situation was similar within the Bakossi Park and the Douala-Edea reserve. The conservator of the Douala-Edea reserve said presently the two boats they have for patrol within the reserve are not in good condition.

Hostility of the local population

The effective management of PAs depends on the active involvement of local communities. Local communities must be involved, and their needs and aspirations considered if biodiversity conservation is to succeed. Lack of involvement of the forest-adjacent community (FAC) through consultations in the policy formulation processes exacerbates threats since the community does not consider itself as part of the management team.The lack of adequate compensation or failure to take into account the needs, of local people who initially depended on resources in the area occupied by the PAs has compelled the local people to go against park rules and to harvest resources in the park. The local population receives insufficient compensation for having no access to resources in the park that they initially depended on. In this situation, local people see no benefit in their engagement with the park administration and continue to go against park rules to access resources in the park. This has to conflicts. The hostility of the population towards the authorities is a serious problem as sometimes, their lives are threatened. For instance, within the Bois de Singes reserve the management authorities of a CIG narrated an incidence where they were chased with cutlasses as they were planting mangroves in degraded areas. The Divisional delegate also cited a case where he was chased out of the area.

Delayance in law enforcement

The timely and rapid intervention of the law in handling cases within PAs will go a long in ensuring the effectiveness of PAs. Most at times, decisions that have to be taken concerning the reserve follows undue protocol which at times accounts for slow actions concerning issues of the reserves. Cases of arrests and projects concerning the PAs have often been delayed and some never executed. Forexample, within the Bois de Singe reserve as narrated by the Delegate for Environment and Forestry, in the year 2000, there was evidence of demographic pressure yet no action was taken to arrest the situation. In 2012 the governor created a surveillance group to manage the reserve but the situation grew worst as people were continuously encroaching and by 2013, it was discovered that degradation was 80%.

Poverty

The Convention on Biological Diversity (CBD), adopted at the Earth Summit and now ratified by 190 countries including Cameroon, clearly links conservation with development, recognizing in its preamble that “economic and social development and poverty eradication are the first and overriding priorities of developing countries”. Article 8 of the CBD, on in situ conservation, calls for systems of protected areas and various measures to conserve and sustainably use biological diversity, as well as requiring countries to promote efforts to support “environmentally sound and sustainable development in areas adjacent to protected areas, with a view to furthering protection of these areas.” This provides a legislative justification for linking poverty issues to in situ conservation [19,20], and an acknowledgement that poverty can pose a threat to the survival of protected areas. There is now widespread acceptance that conservation policy should, at the very least, do no harm, and where possible should contribute to poverty alleviation [21]. The rural poor people largely depend directly on natural resources to sustain their livelihoods, but are forced for survival to use them unsustainably. They may have little voice in decision-making. Poverty which is one of the most controversial problems in Cameroon is a primary challenge to the management of PAs as the livelihood of most forest communities depend on the forest. For instance, in the Douala – Edea reserve the exploitation of NTFPs such as *Gnetumafricanum, Raphiasp, Irvingiagabonensis, Garcinia kola, Curcumalongaas* is the main source of livelihood of the local communities. The communities of Erat, Akwasang and Ikondo Kondo within the Korup Park also complained bitterly about the authorities banning them from collecting bush mango their only source of livelihood from the forest without putting in place alternative income generating activities that can sustain them. The local communities complained that the presence of PAs in their communities has resulted to deteriorating standards of living and they cannot educate their children as was the practice before. Both human and natural factors were identified as the major drivers of PAs degradation. While natural forces such as severe prolonged drought and other climatic changes have been identified as major drivers of habitat change and environmental degradation [22,23] "their effect on biodiversity is not as alarming as that caused by human activities" [24]. Similarly, asserts that human induced causes of biodiversity loss are recognized to be more persistent as opposed to natural ones[25]. This argument is further illustrated, who contend that the population dynamics of the surrounding settlements of protected areas have adverse impacts on biodiversity[25]. PAs are likely to undergo increasing pressures, depending on the land use and socio-economic dynamics of the regions in which they are located. Some are located in densely populated areas where poverty and insufficient employment opportunities dictate that local human populations rely on local resources for food and energy needs. Such situations are common in Cameroon as also reported throughout the developing world [28].

Responses to biodiversity loss and natural resources degradation within protected areas

To address the problem of biodiversity loss and ecosystem degradation, Cameroon has put in place an institutional framework and ratified multilateral and regional environmental agreements, together with national policies and laws relevant for biodiversity conservation. The current framework for the protection of Cameroon's rich biodiversity is characterized by a plethora of biodiversity related policies, legislations, regulations and institutions with intervention measures through programs and projects to ensure their implementation. Responding within the dynamics of an increasing realization of the importance of biodiversity to the environment, livelihoods and the nation's economy, the last decade has been marked by a corresponding expansion in the framework of legal norms and modification of the institutional framework with defined roles and responsibilities for biodiversity protection within protected areas.

Conclusion

Protected areas in Cameroon are suffering from degradation with impacts on climate variability and change. However, Cameroon's responses sofar to the challenges and opportunities of climate change have been slow, inadequate and erratic. Climatechange mitigation and adaptation decisions should be given priority and national policies should be drawn to integrate climatechange.The country should also develop national and local climate change institutionalframeworks to strengthen the coordination, networking and information flows with differentlevels of governments and local civil societies to have better response to poverty eradication within PAs andclimate change. Having an economy with clear dependency on climate sensitive sectors such agriculture,forestry, fishery, pastoralism, etc. adaptive capacity should be given an insight, The way forward is to develop a sustainable forest management policy with focus on climate change having a potential not only to avoid negative impacts on forest resources and biodiversity conservation but providing opportunities for greatersustainable rural development andpoverty alleviation through suitable income generation and employment opportunities.

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