Land use and land cover dynamics in the Melap Forest Reserve, West Cameroon: implications for sustainable management

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ABSTRACT

The present study aims to analyse the dynamics of land use and land cover in the Melap Forest Reserve in West Cameroon on the basis of a diachronic analysis of Landsat 4 TM, Landsat 7 ETM + and Landsat 8 OLI_TIRS images for the years 1988, 2000 and 2018 respectively. Satellite images were processed using ENVI and ArcGIS software. The results showed that the Melap Forest Reserve consists of five main classes of land use/land cover; namely, forest, savannah, bare soil, cropland and built-up area. The analysis showed an ongoing deforestation and degradation of the forest. The forest class has been steadily decreasing from 1345 ha in 1988 to 664 ha in 2018, corresponding to a total loss of 680.9 ha (around 49%) over the 30-year period. The decrease in forest has led to an increase in savannah (+315 ha from 1988 to 2018); cropland (+351 ha); as well as built-up (+9 ha) and bare soil (+6 ha). The main actors of these changes, principally through agriculture, wood extraction and breeding. Then, the present study suggests participatory management, which includes local communities, for the restoration and the management of the study area.

INTRODUCTION AND BACKGROUND OF THE STUDY

The world’s forests cover an area of 4.06 billion hectares (ha), of which tropical forests account for 45% (FAO, 2020). Forest ecosystems provide several services such as climate regulation, provisioning of plant and animal resources, recreation and socio-cultural services (Carnol & Verheyen, 2010; Chevassus-au-louis & Pirad, 2011). Forests and their products play a critical role in the improvement of lives of the local communities. However, global demand for forest and food resources increase with population growth, leading to overexploitation and conversion of forest land to other uses (Temgoua, 2011). According to FAO (2020), 10 million hectares per year of global forest cover have been lost since 2015 and Africa had the largest annual rate of net forest loss in 2010–2020, at 3.9 million ha. Anthropogenic activities are the main causes of forest loss (Harris et al., 2012; Malhi et al., 2014; Le Quéré et al., 2016).

In tropical regions, extensive conversion of forests and agricultural intensification are typically identified among the most proximate causes of deforestation (Geist & Lambin, 2002). Agricultural expansion with the degradation of natural vegetation cover, is the most dominant trajectory of land use and land cover change tropical regions. FAO (2016) reports an increase in agricultural land of 6 million hectares per year in tropical countries. But other direct and indirect factors of this change are wood extraction, infrastructure extension, the development of the mining sector and other activities that change the physical attributes of the land cover (Gillett et al., 2016; Lambin et al., 2003; Momo Solefack et al., 2018; Temgoua et al., 2018a). In Congo basin, deforestation and forest degradation are concentrated around densely populated areas (Megevand, 2013). Changes in forest cover negatively affect the supplying of ecosystem services, such as climate regulation, biodiversity conservation, and carbon storage (Foley et al., 2005; Giam, 2017; Lucas et al., 2015; Pan et al., 2011). This land use change is one of the major causes of global climate change (IPCC, 2014).

The forests of the Congo basin constitute the second largest continuous forest massif after the Amazon. Despite their importance, these forests are also threatened by deforestation (Megevand, 2013). Between 2000 and 2005, annual net deforestation in the Congo Basin was estimated at 0.17% and annual net degradation at 0.09% over the same period (Ernst et al., 2013; De Wasseige et al., 2012). Recent studies show that even classified forests are facing many anthropogenic pressures that lead to their degradation and deforestation (Djongo et al., 2020; Fokeng et al., 2020; Kyale et al., 2019; Temgoua et al., 2018a; Zekeng et al., 2019).
The Cameroonian forest, represents the second largest tropical forest of Congo basin (after those of the Democratic Republic of Congo), covers an area of 22.5 million hectares, which represents about 48% of the national territory (De Wasseige et al., 2009). In Cameroon, De Wasseige et al. (2012) estimated the average annual rate of gross deforestation at 0.10% for the period 1990-2000 and 0.17% for the period 2000-2005. This shows that during these two periods, the rate of deforestation has increased. Between 1990 and 2010, FAO (2011) estimated that Cameroon lost 4400 ha of forests. For the planning and sustainable management of the natural forest resources, detailed knowledge of land use and land cover, as well as the detection of changes, is considered as key parameter for the assessment of the environment and its evolution over time (Verburg et al., 2011; Usman et al., 2015). Thus, remote sensing emerges as a fundamental technology to assist in this spatial and temporal planning of land use types and vegetation cover evolution (Hansen et al., 2013; Loveland & Dwyer, 2012; Temgoua et al., 2018a; Tsayem, 2010).

In Cameroon, since colonial epoch, in response to forest degradation, several forest reserves and protected areas have been created in the interest of biodiversity conservation (Temgoua, 2011). With a view to land-use planning, a zoning plan for the southern part of Cameroon has been drawn up (Côte, 1993). This zoning plan divides the forest area and makes a fundamental distinction between permanent and non-permanent forests. Forest reserves are part of the permanent forest estate that is designated to remain forested over the long term. Thus, within this permanent forest estate, agriculture is prohibited and the use of forest resources is subject to restrictions. Today, however, in Cameroon, these forest reserves are undergoing significant degradation due to strong pressure on natural resources by human activities (agriculture, timber extraction, grazing, road and housing construction), causing land use change (Fokeng et al., 2020; Fokeng & Meli, 2015; Temgoua et al., 2010; Wafo et al., 2005).

Like most reserves, the Melap Forest Reserve (MFR) in West Cameroon is encroached by local populations for agriculture and wood extraction. This reserve is also the main source of firewood supply of the surrounding cities and gradually the activities carried out there have led to its degradation (Chako, 2016). Due to the failure of the management of forest reserves by the government in Cameroun, the state decided to entrust decentralized entities such as non governmental Organizations (NGOs). Thus, the MFR, which was created in 1947, was retroceded in 2015 to the National Forest Development Support Agency (ANAFOR). However, this transfer of management requires the elaboration of a management plan. On the same line, evaluating forest cover loss in forest reserves can provide a baseline for sustainable forest management and conservation. The MFR has a lack of studies on land cover change and factors of deforestation and forest degradation. In fact, no monitoring of vegetation dynamics has been carried out in the reserve since his creation. Therefore, this study which aims at assessing the evolution of land use and land cover in the reserve through a diachronic analysis of satellite images over three different periods (1988; 2000 and 2018). In addition, the activities and the perceptions of the surrounding populations on the changes that this reserve has undergone over the years have been assessed. This constitutes a basic element for the new orientations of strategies and policies for the management of forest reserves in general and the MFR reserve in particular.

**Material and methods**

**Study site**

The Melap Forest Reserve is located in the Foumban Sub-division, Noun Division and West Cameroon region. It is located between latitudes 5° 44’ 30”-5° 48’ 30”N and longitudes 10° 52’ 0”- 10° 54’ 30”E (Figure 1). The climate is tropical sudano-guinean type characterized by two seasons; one rainy season from mid-March to mid-November and one dry season from mid-November to mid-March. The average rainfall is 1907 mm/year and the average annual temperature is 21.4°C (Njoukam et al., 1996). The soils fall into two main categories: poorly evolved soils (low proportion of lithsols and alluvial soils), which are mainly found along the Nchi River; and ferraltic soils, which occupy most of the reserve (Faure, 1986). The natural vegetation is dominated by shrub savannah characterised by the presence of Terminalia glaucescens, Annona senegalensis and Daniellia olivieri. However, the MFR has been reforested with exotic species, *Pinus* (about 15 species) and *Eucalyptus* (about 30 species) by the forest services (Njoukam et al., 1996). The population living around the reserve is mainly composed of Bamoun tribe. This population mainly practices agriculture, handicraft and petty trade.

**Data collection and analysis**

**Land use/land cover change**

The study was based on the Landsat 4 TM, Landsat 7 ETM+ and Landsat 8 OLI_TIRS satellite images of the study site for the years 1988, 2000 and 2018, respectively. These images were downloaded via [http://glovis.usgs.gov](http://glovis.usgs.gov) website of the United States Geological Survey-Global Visualization Viewer’s. In order to reduce cloud cover, images from the dry season period
were selected. ENVI 5.2 and ArcGIS 10.5 software were used to perform image processing. These images have been pre-processed to facilitate classification. This consisted in combining the spectral bands to obtain a multispectral image, resampling of the pixels to overlay and combine the images (Mama et al., 2013), enhancing of images to improve its appearance and facilitate the visual interpretation and analysis of the scenes by playing on the dynamics of the radiometric values in the frequency histogram (Donnay, 2000), colour composition, geometric correction and extraction of the study area.

The Super Vector Machine (SVM) algorithm was used for the supervised classification of Landsat scenes. SVM works by considering each pixel as a two-dimensional system vector, where each class has a pixel as a support vector to establish the class boundary (Boser et al., 1992; Cortes & Vapnik, 1995). In fact, several authors have demonstrated that the SVM algorithm is more accurate than the Maximum Livelihood Classification (MLC) and Neural Network (NN) algorithms (Arun et al., 2012; Naguib et al., 2009).

Subsequently, the classification results were compared with GPS points collected in the field. Thus, in order to evaluate the accuracy of the classification, two classification validation indices were determined: the overall accuracy (proportion of well-classified pixels, calculated as a percentage) and the Kappa index (ratio of well-classified pixels to the total number of surveyed pixels). The finalization, perfection and cartographic layout of the land cover maps resulting from the processing of satellite images were carried out using ArcGIS 10.5 software. The different steps of satellite images and production of maps are shown in Figure 2.

Change detection consisted in highlighting the change in land cover, quantifying the land cover change and developing the transition matrix. The simultaneous image analyses of the three studied years (1988, 2000 and 2018), using the spatial analysis functions of the GIS (Spatial analyst extension of the ArcGIS software), made it possible to develop the Land use/Land cover change matrix.

The quantification of the annual change was based on the calculation of the annual rate of change (R) given by Peng et al. (2008) formula below:

$$ R = \frac{A2 - A1}{A1} \times \frac{1}{T} \times 100 $$

where R is the annual rate of land cover dynamic, measuring the change rate of the target land cover type; A1 and A2 are the area of the target land cover type at the beginning and end of the study period, respectively and T is the study period, which is usually measured in year.

Figure 1. Localization of study site in the Western Region of Cameroon.
Activities and perception of the degradation of the forest reserve by local populations

In order to assess the perception of the local populations on the state and the management modalities of the reserve, semi-structured interviews were conducted and mainly involved 42 household heads including village Chiefs. The interviews were conducted in five villages: Mfentame, Njiketnkiet, Njiloum, Njinka and Njintout. They were selected because of their proximity to the forest reserve. The household heads were interviewed on their activities carried out in the reserve and the current state of the reserve, in order to get their perception of the changes that have taken place over time. These changes refer to the evolution of land use patterns. The interviews were supplemented by participatory observations. The difference in perceptions between respondents was tested using the Kruskal-Wallis ANOVA test with the STATISTICA 12 software. In case of significant differences between the tested variables, the Mann-Whitney U Test was used to separate the means.

Results

Image classification accuracies

The computed error matrices for the classified images revealed an overall accuracy of more than 80% for the three classification dates (Table 1). The classification of LULC using the Landsat 8 OLI for the year 2018 showed the highest classification accuracy (90%) and kappa index (0.83) compared to the Landsat 4 TM images used for the years 1988 which gave the lowest values (85% for accuracy and 0.80 for kappa index).

Land use/land cover dynamics from 1988 to 2018

In 1988, the land cover mapping identified four classes: bare soil, built up area, savannah and forest. These different land cover classes have evolved in size over the years, either by gaining or by losing surface area to give way to other land cover such as croplands that appeared only in 2000 and 2018 (Figure 3). Out of the four classes of land cover of 1988 (Figure 3A), the forest occupied 1345.2 ha, corresponding to 77.31% of

Figure 2. Flowchart showing the different stages of satellite images processing to obtain the land cover map.
Table 1. Values of overall accuracies and Kappa index.

| Landsat Imagery | Overall errors (%) | Overall accuracies (%) | Kappa index |
|-----------------|--------------------|------------------------|-------------|
| 4ETM (1988)     | 15                 | 85                     | 0.80        |
| 7 ETM (2000)    | 12                 | 88                     | 0.82        |
| 8 OLI_TIRS (2018)| 10                 | 90                     | 0.83        |

the total surface area of the reserve, followed by savannah with 246.21 ha (14.15%), bare soils with 145.39 ha (8.36%), and traces of human activities (mainly built up areas) with 3.2 ha (0.18%) (Figure 3A). Cropland areas were absent (Figure 3A and Table 2).

Changes in land cover became noticeable from the year 2000 (Figure 3B). The forest gradually decreased from 1345.20 ha in 1988 to 1103.77 ha in 2000 to reach 664.29 ha in 2018. Between 1988 and 2000, the forest cover decreased from 77.31% to 63.44% (corresponding to an annual change of −1.50%). Similarly, and during the same period, the bare soil decreased from 8.36% to 1.10% (annual change of −7.23%) while the built up area showed an exponential increase with an annual change of 20.81%. Cropland which did not exist in 1988, gained 372.23 ha corresponding to 21.39% of the total surface area of the reserve in 2000; then, a slight regression was observed in 2018 with an annual change of −0.32%. Between 2000 and 2018, the forest lost 11% of its surface, corresponding to an annual change of −2.21%. This forest lost occurred simultaneously with an increase of bare soils and savannah which presented the annual changes of 38.12% and 7.79% respectively.

The annual rate of change was negative in all periods for forest cover (Figure 4). Built up showed a continuous positive dynamic which was much more marked between 1988 and 2018 (Figure 4). Considering the whole period 1988–2018, the forest was the only land use class whose surface area regressed: 22.7 ha/year corresponding to a total loss of 680.9 ha over the 30-year period.

The transition matrices (Table 3) highlight the different forms of conversion that land use classes have undergone between 1988 and 2018. The transition matrix for the period 1988–2000 shows that 3.82 ha (0.22%) of estimated 8.36% (145.39 ha) bare soil remained intact and 8.13% underwent conversion to other forms of land use. Similarly, 1.76 ha (0.10%) of built up area remained unchanged and 0.8% (1.44 ha) underwent conversion to other forms of land use. Cropland is the new form of land use (21.38%) and was created during this period as a result of the conversion of the other categories. The forest was subject to degradation of 17.53%, since out of the 77.31% of the area occupied by this category in 1988, only 59.78% remained unchanged in 2000. 8.26% was converted into cropland, 8.29% into savannah, 0.13% into built up area and 0.85% into bare soil. As for the savannah zone, 4.22% remained intact and 9.48% were converted into cropland, 0.3% into forest, 0.13% into built up area and 0.03% into bare soil.

Between 2000 and 2018, 0.21% of bare soil remained in this category and 0.89% was converted to other forms of land use. 0.33% of built up area remained unchanged and 0.31% was converted to other categories. Cropland area underwent a change of 12.68% to other forms of land use. With regard to the forest, of the 63.44% in 2000, 26.5% was converted to other forms of land use and mainly to savannah (14.48%). 10.21% of the savannah zone remained unchanged against 3.22% that were converted into other forms of land use.

Local perception of degradation of Melap Forest Reserve

An analysis of respondents’ perceptions about changes in the MFR reveals that for only 7.14% of respondents, the reserve has changed over the years compared to 78.58% who did not perceive any change. Besides, 14.29% of respondents have no opinion on changes in the reserve. Statistical analysis shows that there is a significant difference in the mean of respondents’ perceptions about changes in the MFR (p = 0.0069). The proportion of respondents who say that the MFR has remained intact is higher than those who say they have no idea (p = 0.012) on one hand; and also higher than those who say there have been changes (p = 0.010) on the other hand.

The explanation of those who don’t perceive the change is that, the MFR continues to provide goods and services as before. The changes observed and evoked by a low proportion of respondents is the reduction of the forest cover due to the earthworks carried out for the asphalting of the national road number 6 (Foumban-Manki section), which crosses the MRF for 5 km. In addition, other reasons were raised to justify change cover, there were the cut down of trees for firewood and the increase in agricultural areas inside the reserve.

Activities practiced within the Melap Forest Reserve

Respondents reported the main activities practiced in the forest reserve. As shown in Figure 5, agriculture is the most common activity, cited by 48% of respondents, followed by wood extraction (24%), livestock raising (7%), and hunting (5%). 17% of respondents stated that they do not carry out activities in the reserve.

Forest cover in the reserve has been degraded largely due to agricultural activities. In 2018, 351.11 ha or 20.18% of the area was under cultivation. The main
Figure 3. Land use/land cover dynamics of Melap Forest Reserve from 1988 to 2018.
Table 2. Change in land use /land cover from 1988 to 2018 in Melap Forest Reserve.

| Land cover     | 1988  | 2000  | 2018  | Annual change from 1988 to 2018 (%) |
|----------------|-------|-------|-------|-------------------------------------|
|                | ha    | %     | ha    | %       | ha     | %       | 1988–2000 | 2000–2018 | 1988–2018 |
| Bare soil      | 145.39| 8.36  | 19.21 | 1.10    | 151.03 | 8.68    | −7.23     | 38.12     | 0.13     |
| Cropland       | 3.2   | 0.18  | 11.19 | 0.64    | 12.25 | 0.70    | −20.81    | 0.53      | 9.43     |
| Forest         | 0.0   | 0.0   | 372.23| 21.39   | 351.11| 20.18   | −37.57    | −0.32     | −1.69    |
| Savannah       | 1345.2| 77.31 | 1103.77| 63.44  | 664.29| 38.18   | −1.50     | −2.21     | −1.69    |
| Total          | 1740 | 100   | 1740 | 100     | 1740 | 100     | -         | -         | -        |

Figure 4. Annual rate of land use/land cover change in Melap Forest Reserve between 1988 and 2018.

Table 3. Land use/Land cover change matrix in Melap Forest Reserve from 1988 to 2018.

| LULC classes | Bare soil | Built up | Cropland | Forest | Savannah |
|--------------|-----------|----------|----------|--------|----------|
| 1988–2000    | **0.22**  | **0.30** | **3.58** | **3.34**| **0.91** |
| Bare soil    | 0.01      | **0.10** | 0.06     | 0.01   | 0.00     |
| Forest       | 0.85      | 0.13     | 8.26     | **59.78**| 8.29     |
| Savannah     | 0.03      | 0.13     | 9.48     | **0.30**| **4.22** |
| 2000–2018    | **0.21**  | 0.00     | **0.53** | 0.28   | 0.08     |
| Bare soil    | 0.04      | **0.33** | 0.24     | 0.00   | 0.04     |
| Cropland     | 4.27      | 0.31     | **8.71** | 0.67   | 7.44     |
| Forest       | 3.64      | 0.03     | 8.34     | **36.94**| 14.48 |
| Savannah     | 0.54      | 0.04     | 2.35     | 0.29   | **10.21**|

Note: The unchanged area proportion of each land use class was marked in bold.

process within the Melap Forest Reserve. From 1988 to 2018, the forest class lost 680.9 ha corresponding to 50.62% of its original surface area. Analysis of deforestation rates for the considered time periods 1988–2000 and 2000–2018 reveals deforestation rates of 1.5% per year and 2.21% per year respectively. This high rate of deforestation, mostly observed for the second period, shows that the forest reserve is under increasing pressure over time. The rate of deforestation observed in our study area is higher than those reported on one hand, by De Wasseige et al. in 2012 (0.10%) for the period of 1990–2000 in Cameroon, and on the other hand, by Ernst et al. in 2013 (0.26%) for the Congo basin during the 2000–2005 period.

While forests decreased, other land use classes increased in the study area. Cropland and savannah are the classes with the highest increases: 11.7 ha/year and 10.5 ha/year, respectively. This trend of decreasing forest cover in favour of other land use types was observed by many authors in other protected areas in Cameroon; some of these authors are Wafio et al. (2005) in Lafa-Madjam forest reserve; Fokeng and Meli (2015) in Santchou wildlife reserve; Temgoua et al. (2018b) in the teaching and research forest of Dschang's University; Djiongo et al. (2020) in Boubardjida national park and Fokeng et al. (2020) in Metchie-Ngoum forest reserve. However, this is not specific to Cameroon, as similar observations have also been made in the classified forest of Tiogo in Burkina Faso by Tankano et al. (2016); in the Manda national park in Chad by Benoudjita and Djiné Iggassou (2017); in the Djoli-Kera classified

crops were maize (Zea mays), groundnuts (Arachis hypogaea), potato (Ipomoea batatas) and cassava (Manihot esculenta). The extraction of wood is the second most important activity practiced within the forest reserve (Plate 1). Concerning livestock raising, the nomadic herders in search of pasture, graze their animals in the reserve. They are also responsible for bush fires which they use to renew the pasture.

Discussion

Error matrices calculated for the classified images showed a general confusion of less than 15% with the accuracy and degree of representation of ground truths (Kappa index) varying from 0.80% to 0.83%. The classifications performed are reliable if we refer to the scale of Landis and Koch (1977). Results on land cover change analysis show an ongoing deforestation
Increasing anthropisation is the cause of the changes in land cover and land use that have occurred in the Melap Forest Reserve over the last 30 years. We can note that in 1988, there were no croplands in the reserve. However, this class is present in the 2000 and 2018 images. The practice of agriculture in the reserve can be explained by the relaxation of controls in the early 1990s, which facilitated its encroachment by local people. This situation was also exacerbated by the economic crisis and the decline in civil servants’ salaries in the 1990s. In Cameroon, with population growth and in the absence of a real strategy to control and secure reserves and wooded areas, the phenomenon of illegal occupation has developed throughout the decades. Despite the fact that access to the forest reserve is prohibited, local people carry out several activities there, including agriculture but also wood extraction. This situation was also reported by Fokeng and Meli (2015) in the Saptchou forest reserve, Temgoua et al. (2010) in the Mbalmayo forest reserve and Fokeng et al. (2020) in Metchie-Ngoum forest reserve. Indeed most forest reserves of Cameroon are being transformed by rising population growth from within and without alongside settlement related activities like firewood harvesting, logging, farming and grazing (Fokeng et al., 2020). In fact in the Congo basin in general, deforestation is linked to increasing slash-and-burn agricultural activities, artisanal timber logging, firewood collection and charcoal production (Declée et al., 2014; Megevand, 2013). Kissinger et al. (2012) showed that agriculture is the main cause of deforestation in tropical areas, contributing to 35% of forest destruction in Africa.

In MFR, the extraction of wood is the second most important activity practiced within the forest reserve. The wood is intended for personal household use but also for sale. This sale is facilitated by the national road number 6 which crosses the reserve in its western part, but also by the proximity of Foumban city. Villages surrounding the classified forest largely depend on firewood as their main source of energy. Eucalyptus and Pine trees are the most exploited species. These species are used for firewood, but also for the construction of houses (poles and slats). Pine is also used to make indoor furniture and panelling. In recent years, logging of pine tree for cambium extraction has intensified in the reserve, creating a little more damage to the forest vegetation. The rehabilitation of the national road number 6 which passes inside the reserve would have also had an impact on the degradation of the vegetation cover. According to Gillet et al. (2016), the development of road networks is most often accompanied by negative impacts on forest cover.
An analysis of respondents’ perceptions of changes in the MFR reveals that 78.58% don’t perceive the degradation. This can be explained by the fact that, local populations don’t yet feel any concrete impact in their activities of agriculture and wood extraction that they carry out in the reserve. This may also reflect an implicit refusal by local people to acknowledge that their illegal activities have a negative impact on the forest reserve.

Since 2015, the management of the reserve has been transferred to ANAFOR with the objective of restoring degraded forest cover. However, surveys show that only 59.52% of people are aware of this management entity. This reflects the lack of awareness, but also the fact that these restoration actions are not yet perceptible on the field and does not yet have an impact on forest cover, as the project only started in 2017. In the next few years, this project, if well carried out, could help restore the forest cover. As an example, Gbedahi et al. (2019) reports on the reconstitution of vegetation cover in the commune of Bassila in northern Benin through the implementation of a forest resource restoration project.

Since its creation, the management methods of the Melap Forest Reserve were based on repression characterized by strict control and exclusion of local communities that were not involved in the management (Njoukam et al., 1996). This management approach focussed on the central administration has shown its limits and local communities continue to invade the reserve as the State no longer has the means to ensure control. It would be unrealistic today to envisage sustainable management of the MFR without taking into account the presence and interests of the various stakeholders involved in the forest, including local communities. It is essential to involve them in the planning and the management processes of the reserve as they can play an important role in land use/land cover change. Then, we strongly recommend that local communities of the MFR should be associated in the restoration project, and encouraged to set up individual or community afforestation of the reserve.

Conclusion

Land cover and land use dynamics between 1988 and 2018 in the Melap Forest Reserve is characterized by a significant and continuous regression of the forest area in favour of other types of land use, particularly cropland and savannah. The change is mainly due to the weakening of state control of the reserve, which has led to its anarchic invasion by local communities. Agriculture and wood extraction are the main activities at the base of this change. Livestock raising, leading to bush fires, is also carried out in the reserve. Since local communities are the main actors in the degradation of the reserve, it is important that they should be involved in the management and restoration through participatory management.

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