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EFFECTS OF ARMED CONFLICT ON LOWER CASAMANCE NATIONAL PARK ENVIRONMENT IN THE SOUTHWESTERN SENEGAL

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ABSTRACT

In a national and international context where protected areas play an increasingly important role both in the environment preservation and in the local populations economy, this article aims to determine the impacts of the armed conflict between the Senegalese government and the MFDC on the environmental dynamics of the Lower Casamance National Park. The methodological approach is based on remote sensing for understanding the evolution of vegetation. It is based on the analysis of multi-date satellite images using PCI Geomatica software. This approach allowed to assess spatio-temporal evolution of the Park land occupation and its immediate surroundings since its creation in the early 1970's. The results indicate, against all expectations, a conservation and progress of the forest and a significant degradation of the mangrove mainly due to natural and non-anthropogenic conditions. The other classes (water, savanna, mudflat and salt flats) increase slightly.

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INTRODUCTION

This research, entitled "Effects of armed conflict on Lower Casamance National Park (PNBC) environment in southern Senegal" is part of the research themes on protected areas in Africa. These areas hold many interests and constitute an increasingly important development issue. In economic terms, they make a significant contribution to eco-tourism activities, environmental resource trade, and play an important role for feeding local communities (Calandra, 2000; Ibo and Léonard, 2000). They also have a geopolitical interest for States especially when they integrate in their governance the autochthonous population participation and sustainable development international norms. The linkage to these new "international prescriptions" allows African States to develop their partnership and their funding source (Blanc-Pamart and Boutrais, 2002; Mbembe, 1999). However, faced with these important issues, several protected areas in Africa are characterized by conflicts that are often linked to the choice of their territory and their zoning or development modality (Mengue-Medou, 2002; Giazzi and Morel, 2003).

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The PNBC is one of these specific types of protected areas evolving in a context of conflict between actors. Research on the theme has generally focused on the origin and nature of the conflict (Depraz, 2012; Cadoret, 2006; Petit, 2002), or on the adverse environmental effects of conflict in the protected area (Sène, 2014; Hanson *et al.,* 2009; Naaman, 2008; Vadrot, 2005). This research is part of the last case. The environmental consequences of armed conflict are often considered secondary to the urgency of peace and the safeguarding of human lives. However, they remain harmful and sometimes irreversible (Naaman, 2008). Thus, according to UNDP, "*environmental degradation is even more deadly than armed conflict and each of them is both the cause and the effect of violent conflict*" (UNDP, 2005, p. 164). In times of conflict, the environment is often affected. The direct impacts are the result of several factors: chemicals or physical destruction, but also the pressure of massive displacements of civilian populations. However, it seems important to us to understand the effects of conflicts on natural environments. What are the consequences for the environment of conflicts in areas reputed to be rich in natural resources? A review of the literature shows that several authors have worked on the issue. For instance, referring to the physical destruction of the environment by conflict, Naaman (2008) mentioned the Lebanon lands case ravaged and rendered infertile by repeated bombardments.

The Africa example is also reported by the author who refers to the use of "*a modern scorched earth policy*" used by certain ethnic groups to exert pressure on the enemy populations. Other authors, such as Vadrot (2005, p. 51), refer to the case of armed conflicts that provoke mass movements of populations or the formation of refugee camps. The immediate need for energy, water and food for tens of thousands of people forces them to deforest to cultivate and produce energy, and to dig wells for food. For example, WWF (2008) estimated that more than 300 km^2 of forest were destroyed for the needs of refugees during the genocide in Rwanda. In the absence of coordination within the camp for the collection of waste, they are abandoned on site. The Rwandan savanna has thus gradually become a desert strewn with rubbish (Vadrot, 2005, p. 51). During a conflict, a war economy develops, especially around arms trafficking financed by sales of drugs, skins, ivory, diamonds, gold, copper, wood and other raw materials (Tavares, 2015; Diallo, 2012; Vadrot, ib., p. 66). In addition, the irrational exploitation of resources causes serious damage to the environment (Bannon & Collier, 2003, p. 7). For instance, Hanson & al. (2009, p. 8) mention the case of the Democratic Republic of Congo. They indicate that rebel control over mining and logging is literally devastating Congolese natural Parks. Finally, to close this non-exhaustive list of the negative consequences of armed conflict on the environment, it is necessary to add the sale of bushmeat and the trafficking of animals from tropical and equatorial forests (WWF, 2008).

The main objective of the research is to assess the impact of the conflict on the spatio-temporal evolution of the Park environment. Thus, several questions are addressed. What is the impact of the conflict on the spatio-temporal change of the Park environment? The answer to this main question underlies other secondary questions: is there a degradation of the vegetation cover or a retreat of the forest since the advent of the conflict? If so, what are the direct conflict factors that could contribute to it? Does the presence of military bases of the Movement of the Democratic Forces of Casamance (MFDC) encourage the looting of the forest? Do population displacements to flee the fighting put pressure on natural resources? Is the increase in poverty of the local populations bordering the Park because of the conflict a factor of additional pressure on the natural resources?

MATERIALS AND METHODS

Research methods on the adverse environmental effects of conflicts on protected areas have mostly focused on recent sampling. Our approach integrates the temporality and questions the spatio-temporal change of the environmental effects of the conflict over a period of more than 40 years. It is based on the remote sensing which makes it possible to assess the change in the land use of the Park since its creation by the decree n° 70319 of April 10, 1970 on an area of 5000 ha.

Presentation of the study area: The PNBC is located in southwestern Senegal in the Ziguinchor region on the border with Guinea-Bissau. It is located in the heart of the conflict (Fig. 1) and thus constitutes an interesting object of study on the impact of an armed conflict on a protected area.

Unsupervised classification method: This method allows us to determine the dynamics of the Park's land cover through the use of satellite images over several distinct periods since its creation. The usefulness of this approach by remote sensing is essential because it allows the continuous monitoring of the dynamics of the natural environments through the detection of the different modifications of the vegetal cover due to the natural and anthropic factors (drought, bush fires, cuts, reforestation, and so on). In other words, the approach has the advantage of studying the dynamics and the evolution of the Park land cover by satellite images without running the risk of penetrating inside the site affected by the armed conflict. According to Jensen (2004), the detection of changes in remote sensing is the approach that leads to the identification of the different states of an object or phenomenon by a process of observations spread over time. The detection process is based on three approaches that are essentially algebraic methods, methods based on image transformations and methods for comparing image classification results. All these change detection techniques have proven their effectiveness. However, they must be adapted to the objects (environments) to which they apply in order to obtain optimal results. It is within this framework that we used the image classification approach in our article.

In a more practical way, the approach mobilized the following phases with the use of the Geomatica software:

- Mobilization of a series of Landsat images: January / February (middle of the dry season).
- Landsat 1 and 3 images at 60 m resolution were oversampled at 30 m.
- For each Landsat image: addition of NDVI (Normalized Difference Vegetation Index), NDWI (Normalized Difference Water Index) and NDSI (Normalized Difference Snow Index) indices if blue band is present.
- Perform unsupervised classification with the K-Means classifier (16 classes, 64 iterations) using Landsat bands and indices.
- Labeling classes created via visual validation, to obtain 5 classes: water, forest, mangrove, savanna and soil (including mudflat and salt flats).

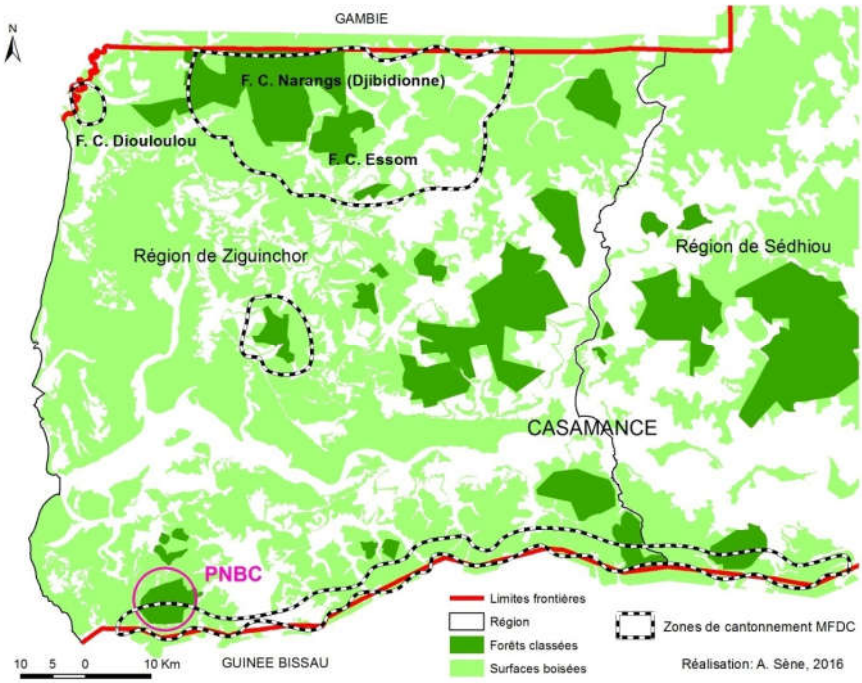
RESULTS

5 classes of Park land cover are distinguished with the analysis of satellite images: water, mangrove, forest, savanna and the class composed of mudflat and salt flats. 2 sets of maps chosen at 2 different periods of the year (January / February and November) are studied to determine the land use change. The series of January / February is composed of 4 maps of the years 1973, 1979, 1985 and 2015. Between 1973 and 2015, a degradation of the mangrove in the north and south part of the Park and an advance of the forest were noted. Indeed, the 1970s correspond to the beginning of the years of drought (Tab.1) which are at the salinity rise origin causing the mangrove mortality and the appearance of new species which adapt to the new ecological conditions. This process has led to the forest in growth. Precipitation in Lower Casamance has been decreasing since 1920. It goes from an average of 1681.8 mm in the 1921-1930 decade to an average of 1305 mm in the 1991-2000 decade. It reveals a great irregularity from one year to another and from one decade to another. This is the result of climate change. In the climatic classification, the region which is classified as a "humid" zone from 1921 to 1970 degenerates for two decades (1971-1990) in the "subhumid" zone

Table 1 Precipitation variation in Lower Casamance

Decades	Precipitations (mm)	Climatic classification
1921-1930	1681,8	Humid
1931-1940	1634,4	Humid
1941-1950	1447,0	Humid
1951-1960	1559,6	Humid
1961-1970	1487,7	Humid
1971-1980	1148,8	Subhumid
1981-1990	1116,1	Subhumid
1991-2000	1305,0	Humid

Source: Sagna et al., 2017



Source: Sène, 2016

Figure 1. PNBC location

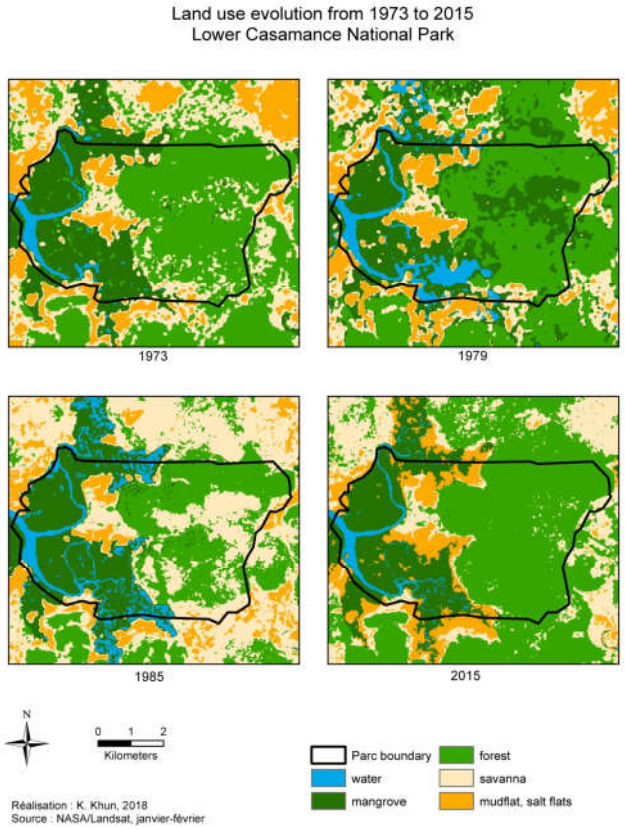
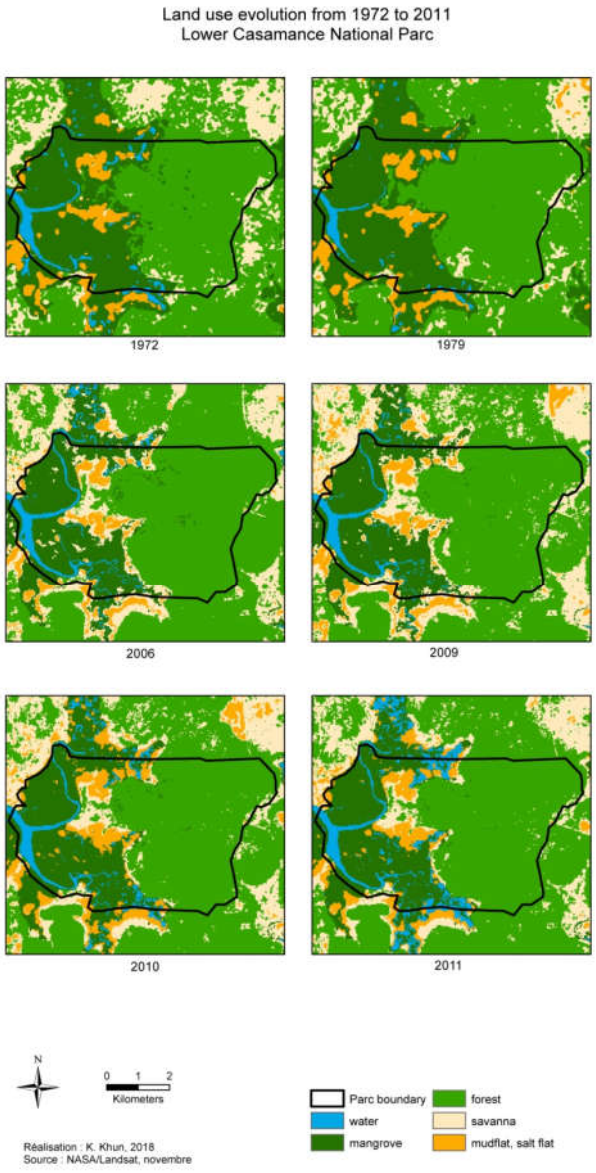


Figure 2. PNBC land use evolution from 1973 to 2015 for the January/February Series



Source: Khun, 2018

Figure 3. PNBC land use evolution from 1972 to 2011 for the November Series

Table 2. PNBC land use size evolution from 1972 to 2011 for the November Series

	Area 1972 (ha)	Area 1979 (ha)	Area 2006 (ha)	Area 2009 (ha)	Area 2010 (ha)	Area 2011 (ha)	Variation Area 1972-2011 (ha)
water	139,23	85,86	144,27	133,83	172,35	243,09	103,86
mangrove	1291,68	1234,71	959,94	961,92	990,36	949,23	-342,45
forest	1662,12	1760,49	1825,38	1758,42	1784,88	1798,83	136,71
savanna	72,18	74,61	280,71	341,19	169,65	151,74	79,56
mudflat, salt flats	193,95	203,49	148,86	163,8	241,92	216,27	22,32

Source: Khun, 2018

corresponding to years of drought. Then it falls back into the "humid" zone from the decade 1991-2000 (Table 1). However, there appears to have been clearing in the early 1980s (1985 map). During this period, Park officers lived within the protected area with increased resource monitoring. Thus, it can be understood that this is not a case of clearing caused by local communities, but rather facilities related to the opening of the paths, ponds, salt pans and the installation of watchtowers (Fig. 2). For security reasons, the Senegalese State has officially closed the Park on January 13, 1993. The November series is composed by the 6 maps of the years 1972, 1979, 2006, 2009, 2010 and 2011. Between 1972 and 2011, there is a degradation of the mangrove in the center of the Park and a slight increase of the surface occupied by the forest.

The reasons given in the first series are valid here since there is a degradation of the mangrove and a conservation of the forest throughout the years (Fig. 3). More specifically, Table 2 shows larger area variations for mangroves and forests. Between 1972 and 2011, surface area increases by 136.71 ha for the forest and decreases significantly by -342.45 ha for the mangrove. The other classes (water, savanna, mudflat and salt flats) increase slightly between the two dates. Table 2 also shows that the areas occupied by the forest and mangrove are much larger in the Park.

DISCUSSION

Figures 2 and 3 show that the Park is well preserved despite its location in the heart of the Casamance armed conflict.

However, the literature indicates that armed conflicts around the world, and in Africa in particular, lead to severe degradation of the protected area environment (Hanson *et al.,* 2009; Naaman, 2008; Vadrot, 2005). Then, what justifies the particularity of the PNBC?. A return to historical elements of the area provides a better understanding of the spatio-temporal dynamics of the Park's land use. The outbreak of the Casamance crisis in the early 1980s completely disrupted the living conditions of inhabitants near the protected area. Several clashes between the armed elements of MFDC and the Senegalese army have caused enormous loss of life and displacement of people (Ebere, 2015). This has created a disastrous socio-economic situation accentuated by poverty and the fear of the populations. It has also affected the governance of the Park by provoking its closure and the departure of the agents responsible for its management. All activities in and around the park stopped because of clashes between the two parties. Then, the protected area is used as a safe haven by MFDC armed elements even if it is not a resource-grabbing area to finance the protagonists of the crisis. This situation justifies the Park being abandoned by the local communities and no longer managed by State agents. Out of any exploitation, its forest resources developed.

On the other hand, the degradation of the mangrove is linked to climatic change factors. These are the pluviometric irregularity and deficit and the salinization recorded in the region in the two decades of 1970 and 1980 (Sène, 2018). This process is at the origin of the appearance of new invasive forest plant species. The PNBC, located in the southern part of Lower Casamance on the border with Guinea-Bissau (Fig.1), is sheltered from conflict-related degradation. The situation is completely opposite in the northern part of the region. Indeed, the governance of forest resources in this area has a particularity related to the conflict and the presence of the Gambian border. On the one hand, the presence of MFDC armed elements hinders State surveillance and protection efforts and creates conditions for the corruption of its agents. On the other hand, private sector actors in the Gambia, particularly the Chinese, are working in collusion with the Senegal raiders by providing them cutting equipment and vehicles and also marketing illegal forest products from Casamance in the Gambia (Sene, 2014). So, these conditions allow the illegal exploitation of protected and community forests of localities close to the border in this northern part of the region. For instance, according to Caramel (2016): "*The Gambia, whose natural forests have yet been decimated, sends as much timber as Côte d'Ivoire to China, where the furniture industry is the only reason for this organized looting. In 2015, Chinese industrialists bought 58,000 m^3 of wood from The Gambia for 36.7 million euros, according to Chinese customs statistics. That would be the equivalent of 140,000 trees.*" In the same vein, Gassama (2018) testifies on RFI that the North of Lower Casamance, along the border with The Gambia, is currently being desertified because of the excessive cutting of the forest. Thus, timber traffic is moving more and more towards the southern border of Casamance with Guinea-Bissau. In this context, the likely PNBC deterioration in the short or medium term proves to be a concern for the local populations but also a concern for the institutions in charge of environment and development. The absence of the Park vegetation degradation during the last forty years of conflict can be explained, in addition to the reasons advanced above, by the fact that the fighting does not take place directly inside the protected area, but in its surroundings.

The only constraint noted is that the bombardments, each time they took place, caused the animals to flee to other territories outside the Park. This has resulted in the disappearance of certain animal species such as the forest buffalo. All these upheavals impact the people lives fleeing the fighting and who are exposed to difficult living conditions. Moreover, the calm observed in recent years, marked by the gradual return of the populations to their original territory, sounds like a new era and a reason for hope in the perspective of a total reopening of the Park and the revitalization of activities for the population well-being.

Conclusion

The interest of this research resides in the fact that it has improved our knowledge on the Casamance conflict effects on the PNBC land cover evolution. Contrary to the results reported in the references, which insist to the significant degradation of the protected areas environment in a context of armed conflict, the PNBC is characterized by the conservation, or even the development of its vegetation cover in spite of the armed conflict. The mangrove degradation is rather related to climatic change, particularly rainfall irregularity and decrease in the 1970s and 1980s accompanied by land salinization. These new conditions have also caused the appearance and development of new forest species. Two main factors explain the conservation of the Park's forest resources.

The locale populations fear because of the armed clashes around the Park and its occupation by armed elements of the MFDC explains why they dare not go inside the protected area anymore. Then, for security reasons, the Senegalese State has officially closed the Park since 1993. Consequently, the planning activities that required clearing and deforestation for construction of tracks and infrastructures are no longer done. Under these conditions, the protected area has remained since the outbreak of conflict in the early 1980s sheltered from human activities. However, just in the northern part of Lower Casamance, the dynamics of protecting forest resources is completely opposite. As in most cases, protected forests in this area suffer significant degradation due to conflict. In this zone, an international traffic of the forest resources is organized with the help of the Chinese installed in Gambia and with the complicity of Senegalese and Gambian States representatives. The remote sensing of change method allowed us to trace the history of the Park's land use over the last 40 years. Thus, its ability to invest temporality through the study of the spatio-temporal evolution of the protected area environment is an important asset. Moreover, this approach has another advantage which is to study a mined conflict zone with the presence of armed elements without suffering the constraints of the site.

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