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IMPACT OF THE ESTABLISHMENT OF A TREATMENT UNIT OF NATURAL RUBBER (*HEVEA BRASILIENSIS*) ON THE FLORA OF ATTINGUÉ, IN THE SOUTH OF CÔTE D'IVOIRE

KOUASSI Kouadio Henri

Unit of formation and research (UFR), in Agroforestry of Jean Lorougnon Guédé University, Côte d'Ivoire

KOUASSI Roland Hervé

Department of Sciences and Technologies, Section of life sciences and earth, National high school of Abidjan, Côte d'Ivoire

SORO Dodiomon

Unit of formation and research (UFR), in Biosciences of Félix Houphouet Boigny University, Côte d'Ivoire

N'GUESSAN Koffi

Unit of formation and research (UFR), in Biosiences, Felix Houphouet Boigny University, Côte d'Ivoire

ABSTRACT

This report highlights and evaluates the negative impacts of the construction and the exploitation of a treatment unit of Hevea brasiliensis on the flora of Attingué, a locality in the south of Côte d'Ivoire. The objective of this study was to identify and evaluate the impacts of the project on the flora in order to put forward measures of attenuations or corrective. The itinerant inventory and the method of quadrat were associated during floristic inventories. The results showed that the flora is fairly diversified and fairly homogeneous. The destruction of the floristic potential of regeneration (DPE) and the ecological disturbances (EP) were the major impacts during the prospection and construction. The proliferation of herbaceous (PRO) and the impoverishment (APA) of woody species were the major impacts during the production phase. At the end of the project, the evolution of floristic diversity (EVD), was the most perceptible impact. These impacts caused during all the phases of the project contributed to weaken the flora of the site and exposed it to the risks of biological, ecological and climatic imbalances.

Keywords: Impact, Flora, Treatment unit, Natural rubber, Hevea, Attingué, Côte d'Ivoire.

Contribution/ Originality

This study, one of rare is conducted in Côte d'Ivoire in order to identify negative and positive impacts of all activities on the environment. It is a recent innovation, which is a security measure

against the various ecological disturbances related on the various human activities and the climate changes.

1. INTRODUCTION

The West African flora is generally rich and diversified. Many species of this flora organize themselves to provide luxuriant and diversified vegetation. But following the example of many agricultural countries, the flora of Côte d'Ivoire undergoes over the years, of many aggressions whose leading causes are, inherent agriculture, forest holding, the bush fires etc. [1]. During these last years, of the additional causes in particular, the fast urbanization and the development with its corollaries: the real estate transactions, constructions of great production units and transformation, creations of mechanized plantations of industrial plantations [2] became sources activities of impacts. In addition, in many African countries, the pressure exerted on the natural resources believes inordinately [3]. Also, the land pressure is felt it in a gradual way in certain localities of Côte d'Ivoire. Also, the problem of rural land which is moreover a cause of frequents conflicts and sometimes of fatal war is one of the direct causes of the land pressure. The reduction of natural spaces and exhaustion of phylogenetic resources, faunal and water appear among the causes major which requires the permanent follow-up and the evaluation of the available resources. Thus over the years, the durable measurements of integrated management of natural resources are recommended more and more to prevent possible eco-climatic imbalances. One of security measurements and protective of the environment is the identification and the evaluation of the environmental impacts related to any project. The study of environmental and social impact of the of a transformation unit of *Hevea brasiliensis* construction in the locality of Attingué intervenes at the end of the project in order to determine the positive and negative impacts of the project on the flora, the environment, fauna and on the population of the site. The main objective of this study was to identify and evaluate the subsequent impacts of the project in order to put forward measures of attenuations and/or corrective.

The present study highlights and evaluates the negative impacts of the project on the flora of the site. It comprises in addition, of the proposals of corrective measures or attenuation of possible eco-climatic imbalances related to the exploitation on the flora of the locality and the inventoried sites. In this study, two aspects of the vegetation were approached: specific diversity and the diversity of the ecosystems

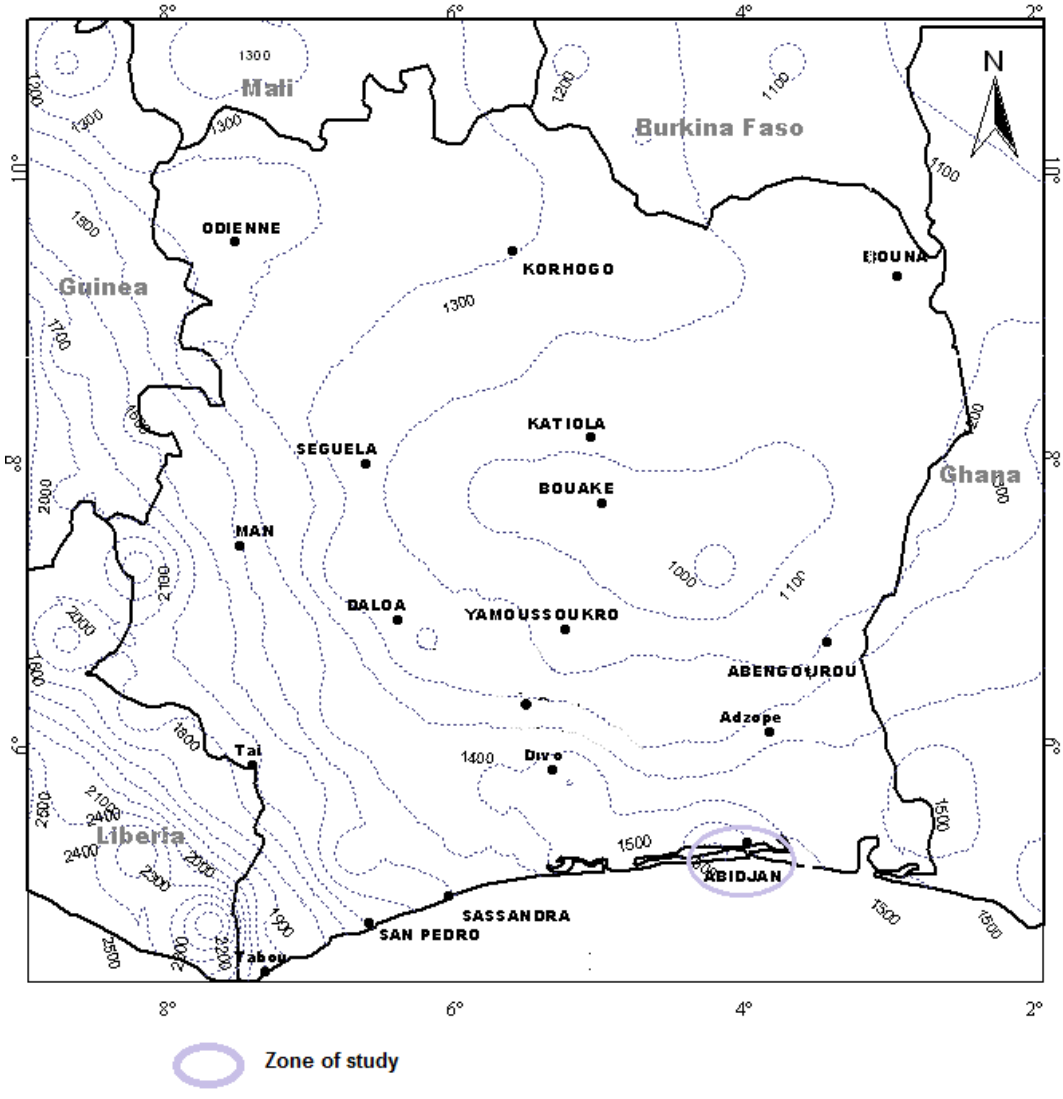
2. MATERIALS AND METHODS

2.1. Flora of the Site

The study was conducted at Attingué in the south of Côte d'Ivoire (Fig.1). From the floristic point of view, the site of the project belongs to the Guinean field. The vegetation of the site was formerly dominated by rainforest, with the presence of hydromorphic formations per place. This forest was made of three principal layers [4, 5]. One meets there the wet dense forest, the marshy forests, the enclaves, the raphiales, etc. The layer of the large trees was dominated by specimens of 50 with 60 m high and was characterized by woody species such as *Khaya ivoirensis*, *Lophira alata* and *Terrieta utilis*. The hydromorphic formations were made up of marshy forests and

mangrove swamps. This wide forest is very threatened nowadays Côte d'Ivoire, since it comprises several exploited species [6].

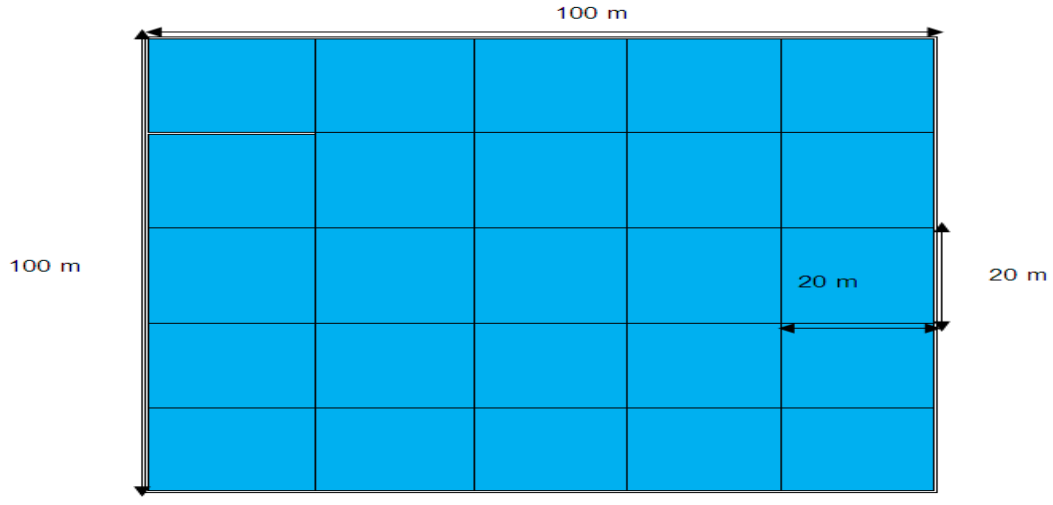
Figure-1. Localization of the zone of study



2.2. Floristic Inventory

The flora of the site and that of the contiguous ecosystems (zone cultivated, marshy zone, plantations of cacao-trees) were inventoried. Two methods were associated to conduct this study: the itinerant flora inventory by the enumeration of the species on layouts and the method of the small squares [7], which consists in describing the vegetation (enumeration and classification of the species) on surfaces of approximately 20 m on side (Fig. 2) according to the four cardinal points, with a precise spacing.

Figure-2. Configuration of the plots of the flora inventories



2.3. Flora Analyzes

Several indices were used for floristic analyses, however, the index of Shannon and Weaver [8], which has been used has a formula: $H = -\sum Pi(Log(2)Pi)$, With, pi: floristic contribution or relative frequency. This index varies from 0 (1 only species), to Log (N), when all the species have same abundance. The index of Equitability is associated (E). It is a relationship between floristic diversity observed and maximum theoretical diversity. The equitability of Pielou is written: E = H/log (N), With, N: total staff complement of the studied station. The equitability varies from 0 to 1. It tends towards 0 when the near total of species population is concentrated on only one species and is equal to 1 when all the species have same abundance. The identified impacts were coded and analyzed. Then values were allotted to these impacts before being analyzed in a matric table.

3. RESULTS

3.1. Actual Status of the Vegetation

The vegetation of the site luxuriant in the past is now seriously degraded and given way today to fragments of fallow (Fig. 3), completely in waste lands which shelter many plots of cultures such as: the cacao-tree (*Theobroma cocoa*), the Coffee-tree (*Coffea caenophora*), the Hevea (*Hevea brasiliensis*; Fig. 4), of many plots of food crops, the riparian forests (Fig. 5) and of the marshy zones (Fig. 6). However, there exists by places of the well preserved vegetation.

Figure-3. Fallow near the site

Figure-4. Hevea plot

Figure-5. Bordering vegetation of the Agneby river

Figure-6. Raphiale near the site

3.2. Wealth and Specific Diversity of the Site

The floristic wealth and diversity estimated starting from the absolute frequencies (Fa) and relative (Fr), of the inventoried species has given the characteristics below (Tableau1). Thus, the flora of the site is rich from approximately 111 species. The values of H and E estimated are respectively, to H = 3.52; E = 0.52 (Table 1).

Table-1. Index of diversity of Shannon-Weaver of the site

Espèce	Fa	Fr	pi	H
Abrus precatorus	3	0,6	0,00540541	-0,04071017
Acacia mangium	1	0,2	0,0018018	-0,01642584
Acacia pennata	3	0,6	0,00540541	-0,04071017
Adenia rumicifolia	2	0,4	0,0036036	-0,02924809
Aframomum sceptrum	1	0,2	0,0018018	-0,01642584
Ageratum conyzoïdes	2	0,4	0,0036036	-0,02924809
Albizia adianthifolia	4	0,8	0,00720721	-0,05128897
Albizia zygia	4	0,8	0,00720721	-0,05128897
Alchornea cordifolia	4	0,8	0,00720721	-0,05128897
Allophyllus africanus	4	0,8	0,00720721	-0,05128897
Alstonia boonei	1	0,2	0,0018018	-0,01642584
Anchomanens diformis	4	0,8	0,00720721	-0,05128897
Anthocleista djalonensis	1	0,2	0,0018018	-0,01642584
Anthocleista nobilis	3	0,6	0,00540541	-0,04071017
Antiaris toxicaria	4	0,8	0,00720721	-0,05128897
Aspilia africana	4	0,8	0,00720721	-0,05128897

Continue

Bambusca vulgaris	4	0,8	0,00720721	-0,05128897
Baphia nitida	4	0,8	0,00720721	-0,05128897
Blighia sapida	3	0,6	0,00540541	-0,04071017
Blighia welwitschii	2	0,4	0,0036036	-0,02924809
Cassia siamea	1	0,2	0,0018018	-0,01642584
Ceiba pentandra	3	0,6	0,00540541	-0,04071017
Cecropia peltata	5	1	0,00900901	-0,06121095
Centrosema pubescens	4	0,8	0,00720721	-0,05128897
Chromolaena odorata	4	0,8	0,00720721	-0,05128897
Citrus reticulata	2	0,4	0,0036036	-0,02924809
Cleome ciliata	1	0,2	0,0018018	-0,01642584
Cnestis corniculata	1	0,2	0,0018018	-0,01642584
Cnestis ferruginea	4	0,8	0,00720721	-0,05128897
Coffea canephora	3	0,6	0,00540541	-0,04071017
Cola nitida	3	0,6	0,00540541	-0,04071017
Colocasia esculenta	3	0,6	0,00540541	-0,04071017
Commelina benghalensis	4	0,8	0,00720721	-0,05128897
Commelina sp	3	0,6	0,00540541	-0,04071017
Costus afer	2	0,4	0,0036036	-0,02924809
Croton hirtus	1	0,2	0,0018018	-0,01642584
Cyathula prostrata	2	0,4	0,0036036	-0,02924809
Desmodium adscendens	4	0,8	0,00720721	-0,05128897
Dioscorea similacifolia	1	0,2	0,0018018	-0,01642584
Dissotus rotundifolia	2	0,4	0,0036036	-0,02924809
Elaeis guinensis	2	0,4	0,0036036	-0,02924809
Eragrostis aspera	2	0,4	0,0036036	-0,02924809
Erigeron floribundus	3	0,6	0,00540541	-0,04071017
Ficus exasperata	2	0,4	0,0036036	-0,02924809
Ficus sur	3	0,6	0,00540541	-0,04071017
Ficus sp	1	0,2	0,0018018	-0,01642584
Funtumia africana	1	0,2	0,0018018	-0,01642584
Hevea brasiliensis	4	0,8	0,00720721	-0,05128897
Hoslundia opposita	2	0,4	0,0036036	-0,02924809
Ipomoea sp.	2	0,4	0,0036036	-0,02924809
Lantana camara	3	0,6	0,00540541	-0,04071017
Mangifera indica	1	0,2	0,0018018	-0,01642584
Manihot exculenta	4	0,8	0,00720721	-0,05128897
Maranthocloa sp	3	0,6	0,00540541	-0,04071017
Mariscus cylindristachus	2	0,4	0,0036036	-0,02924809
Margaritaria discoidea	1	0,2	0,0018018	-0,01642584
Mesoneuron pentamianuum	1	0,2	0,0018018	-0,01642584
Mitracarpus scaber	1	0,2	0,0018018	-0,01642584
Mitracarpus villosus	1	0,2	0,0018018	-0,01642584
Milicia excelsa	3	0,6	0,00540541	-0,04071017
Millettia zechiana	1	0,2	0,0018018	-0,01642584
Mimosa invisa	1	0,2	0,0018018	-0,01642584
Momordica charantia	1	0,2	0,0018018	-0,01642584
Morinda lucida	2	0,4	0,0036036	-0,02924809
Motandra guineensis	3	0,6	0,00540541	-0,04071017
Musa paradisiaca	2	0,4	0,0036036	-0,02924809
Musanga cecropioïdes	3	0,6	0,00540541	-0,04071017
Myrianthus arboreus	3	0,6	0,00540541	-0,04071017

Continue

Nauclea latifolia	2	0,4	0,0036036	-0,02924809
Nelsonia canescens	2	0,4	0,0036036	-0,02924809
Nephrolepis biserrata	2	0,4	0,0036036	-0,02924809
Newbouldia laevis	2	0,4	0,0036036	-0,02924809
Oplismenus burmanii	3	0,6	0,00540541	-0,04071017
Oximum gratissimun	1	0,2	0,0018018	-0,01642584
Palisota hirsuta	2	0,4	0,0036036	-0,02924809
Passiflora edulis	2	0,4	0,0036036	-0,02924809
Passiflora foetida	4	0,8	0,00720721	-0,05128897
Panicum maximum	2	0,4	0,0036036	-0,02924809
Paullinia pinatta	4	0,8	0,00720721	-0,05128897
Persea americana	3	0,6	0,00540541	-0,04071017
Psydium guajava	3	0,6	0,00540541	-0,04071017
Phisalis micranta	3	0,6	0,00540541	-0,04071017
Phyllanthus amarus	1	0,2	0,0018018	-0,01642584
Phyllanthus sp	1	0,2	0,0018018	-0,01642584
Phymatodes scolopandria	1	0,2	0,0018018	-0,01642584
Piptadeniastrum africanum	1	0,2	0,0018018	-0,01642584
Psydium guajava	1	0,2	0,0018018	-0,01642584
Pteridium aquilinum	1	0,2	0,0018018	-0,01642584
Pueraria phaseoloïdes	1	0,2	0,0018018	-0,01642584
Pychnanthus angolensis	2	0,4	0,0036036	-0,02924809
Raphia houkeri	4	0,8	0,00720721	-0,05128897
Rauvolfia vomitoria	3	0,6	0,00540541	-0,04071017
Ricinodendron heudelotii	1	0,2	0,0018018	-0,01642584
Secamone afzelii	4	0,8	0,00720721	-0,05128897
Setaria barbata	1	0,2	0,0018018	-0,01642584
Sida acuta	1	0,2	0,0018018	-0,01642584
Smilax kraussiana	4	0,8	0,00720721	-0,05128897
Solanum turvum	2	0,4	0,0036036	-0,02924809
Spondias monbin	1	0,2	0,0018018	-0,01642584
Sterculia tragacantha	2	0,4	0,0036036	-0,02924809
Tabernaemontana crassa	4	0,8	0,00720721	-0,05128897
Talinum triangulare	1	0,2	0,0018018	-0,01642584
Terminalia menthali	1	0,2	0,0018018	-0,01642584
Thaumatococcus daniellii	2	0,4	0,0036036	-0,02924809
Theobroma cacao	1	0,2	0,0018018	-0,01642584
Traja benthamii	2	0,4	0,0036036	-0,02924809
Trema guineensis	2	0,4	0,0036036	-0,02924809
Triumpheta ronboidea	2	0,4	0,0036036	-0,02924809
Voacanga africana	2	0,4	0,0036036	-0,02924809
Xantosoma maffafa	1	0,2	0,0018018	-0,01642584
Zea mays	2	0,4	0,0036036	-0,02924809
				Ht = 3,56678719
				E = 0,52

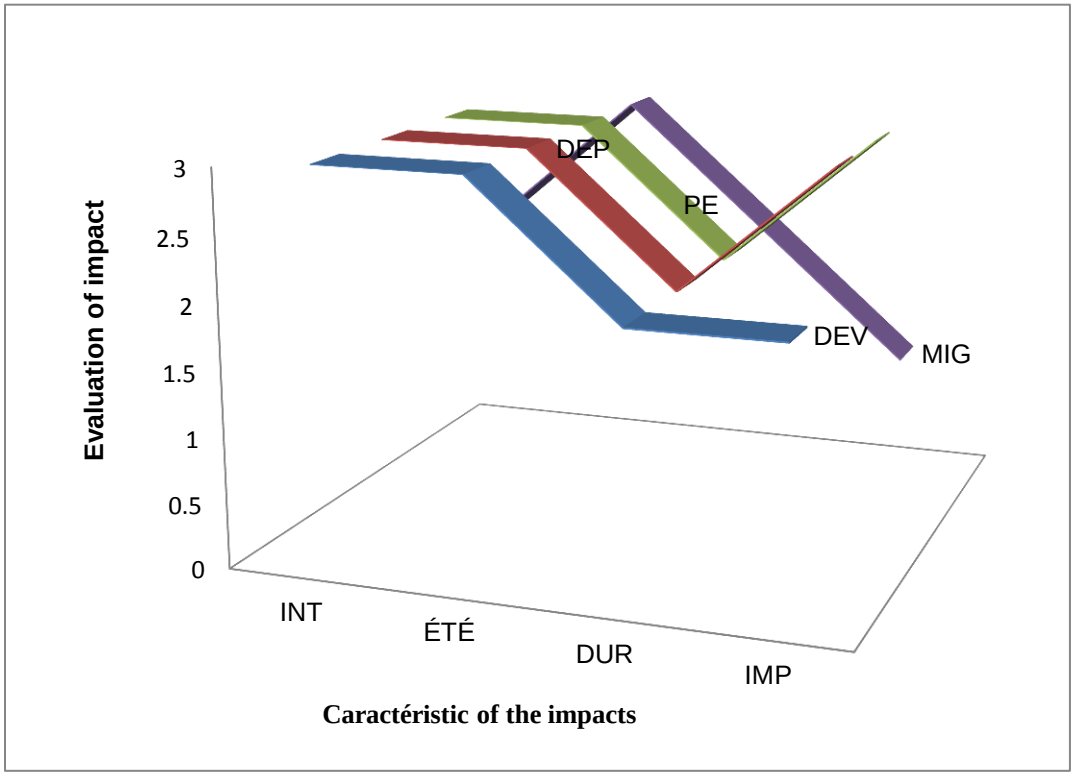
3.3. Identification, Analyzes and Evaluation of the Impacts Related to the Project

3.3.1. Phase of Prospection and Construction

The evolution of the curves (Fig. 7) shows the variation of the impacts related to the phase of prospection and construction on the vegetation, the flora of the site and on that of the contiguous vegetable formations. Thus, the destruction of woody species (DEV) was intense (3) and extended

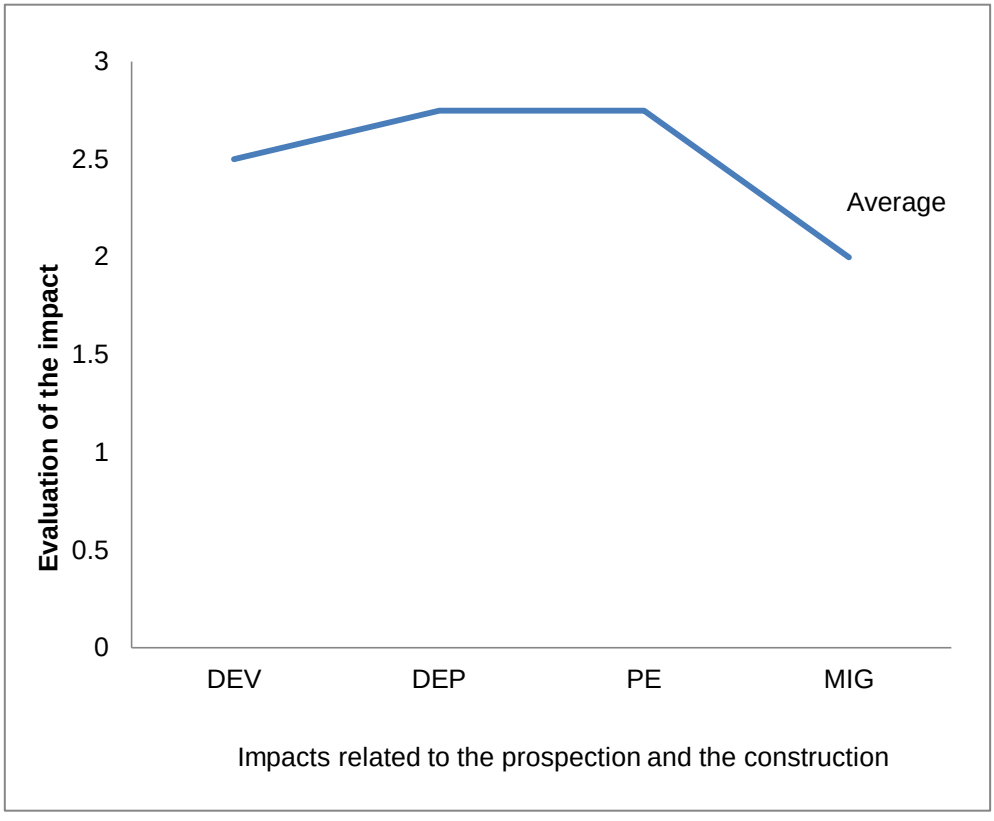
(3). On the other hand it was of lasted average (2) and average importance (2). The destruction of the potential of regeneration of flora (DPE) was intense (3), extended (3) and important (3). But it was of average duration (2). The ecological disturbances (EP) caused by the activities was intense (3), extended (3), important (2) and of average duration (2). In addition, the migrations of the small average and large fauna was fairly intense (2), extended (3), average duration (2) and low importance (1).

Figure-7. Evolution of the impacts related to the phase of prospection and construction of the factory, with, INT= intensity, ETE = extent; DUR = duration; IMP = importance; DEV = destruction of woody species; DEP = destruction of the potential of regeneration; PE = ecological disturbances; MIG = Migration of the fauna



The evolution of the average impacts on the flora during this phase (Fig. 8), watch that the destruction of the potential of regeneration of woody species (EPD) and the ecological disturbance (EP) were higher (2.75). The destruction of woody species (2.5) and the migration of the animals (2) were more low.

Figure-8. Evolution of the average impacts related to the production phase of the project, with, DEV = destruction of woody species; DEP = destruction of the potential of regeneration; PE = ecological disturbances; MIG = Migration of the fauna



3.3.2. Production Phase

The evolution of the curves (Fig. 9) shows the variation of the impacts related to the production phase on the vegetation, the flora of the site and on that of the contiguous vegetable formations. During this phase, the impoverishment of flora (APA) as well as the proliferation of herbaceous were intense (3), extended (3), long (3) and important (3). The destruction of the plant species (DEV) was fairly intense (2), extended (3), too long (3) and important (3).

The evolution of the average impacts on the flora during this phase (Fig. 10), watch that the proliferation of the weeds (PRO) and impoverishment of the flora in woody species were higher (3). The plant species destruction (DEV.) was less low (2.75).

Figure-9. Evolution of the impacts related to the production and the exploitation phase; with; INT= intensity, ETE = extended; DUR = duration; IMP = importance; APA = impoverishment of the contiguous flora; PRO = herbaceous proliferation; DEV = destruction of the plant species

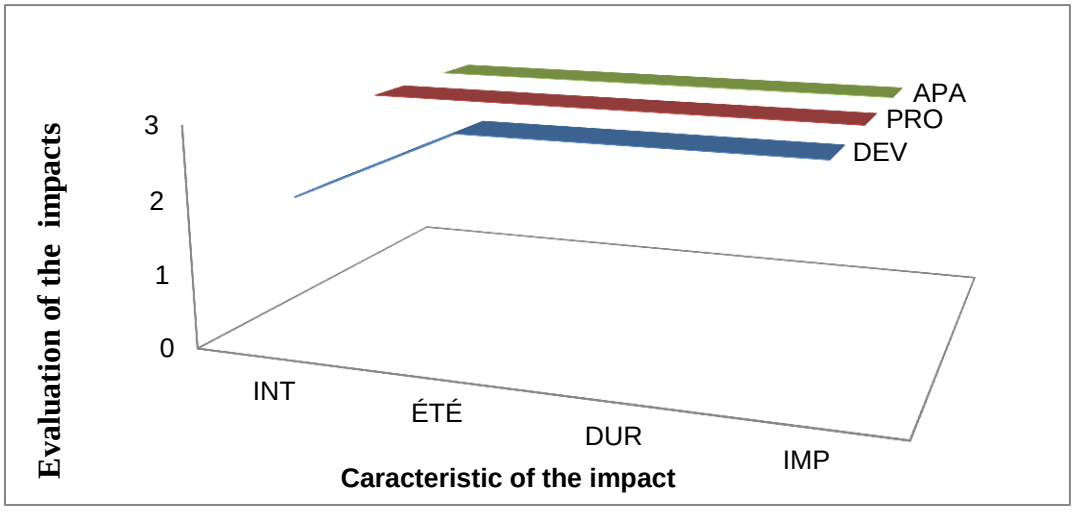
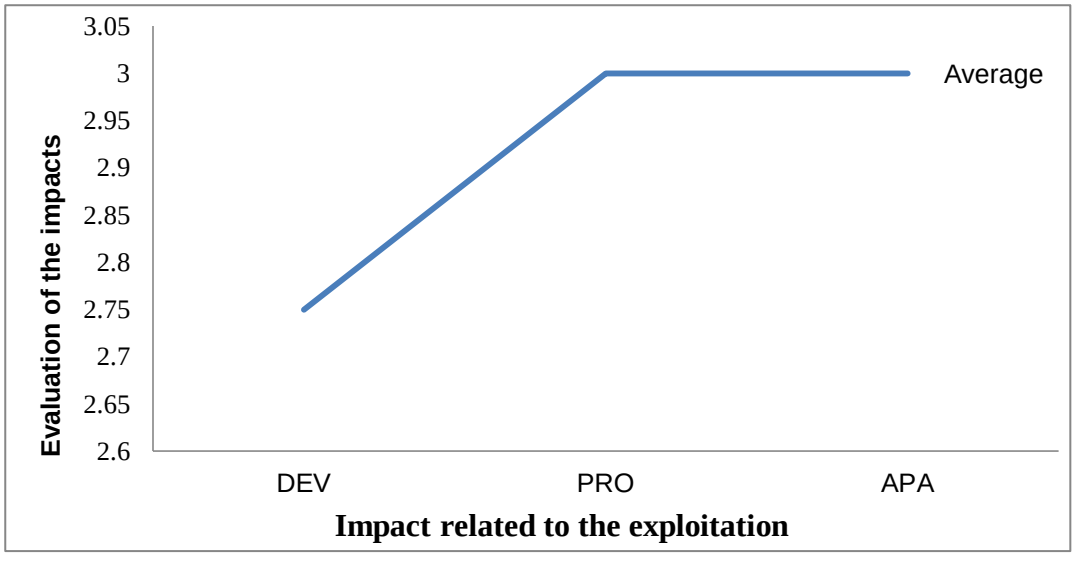


Figure-10. Evolution of the average impacts related to the production phase, with APA = impoverishment of the contiguous flora; PRO = herbaceous proliferation; DEV = destruction of the plant species



3.3.3. End of the Project

The evolution of the curves (Fig. 11) shows the variation of the impacts related to the closing of the project on the vegetation, the flora of the site and on that of the contiguous vegetable formations. During this phase, the evolution of the diversity of flora (EVD), was intense (3), too long (3), important (3), average extended (2). The evolution of the aspect of the vegetation during

this phase was long (3) and important (3). However, this evolution was fairly intense (2) and fairly extended (2).

The evolution of the average impacts on the flora during this phase (Fig. 12), watch that the evolution of floristic diversity (EVD) was higher (275) with this phase. The aspect of vegetation (PH) has less evolved (2.5).

Figure-11. Evolution of the impacts related to the closing of the project; avec INT= intensity, ETE = extended; DUR = duration; IMP = importance; EVD = evolution of the flora diversity; PH = evolution of the physiognomy of the vegetation

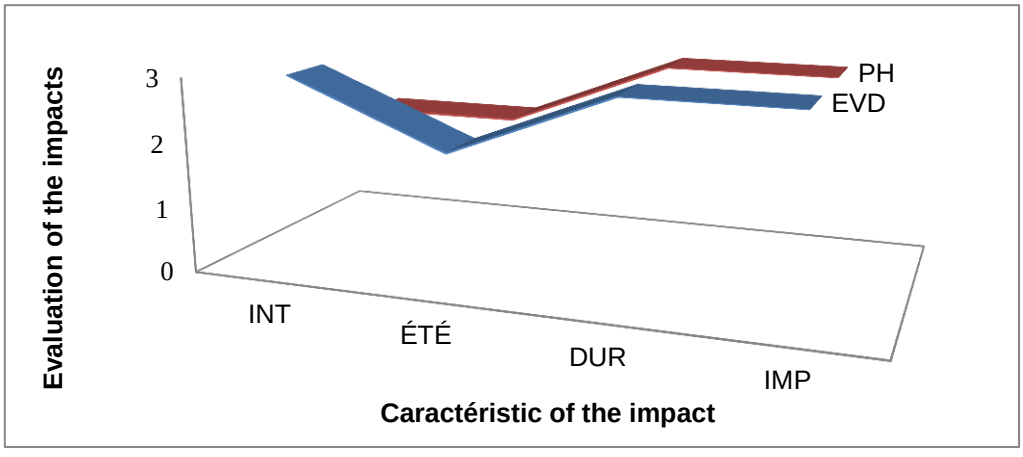
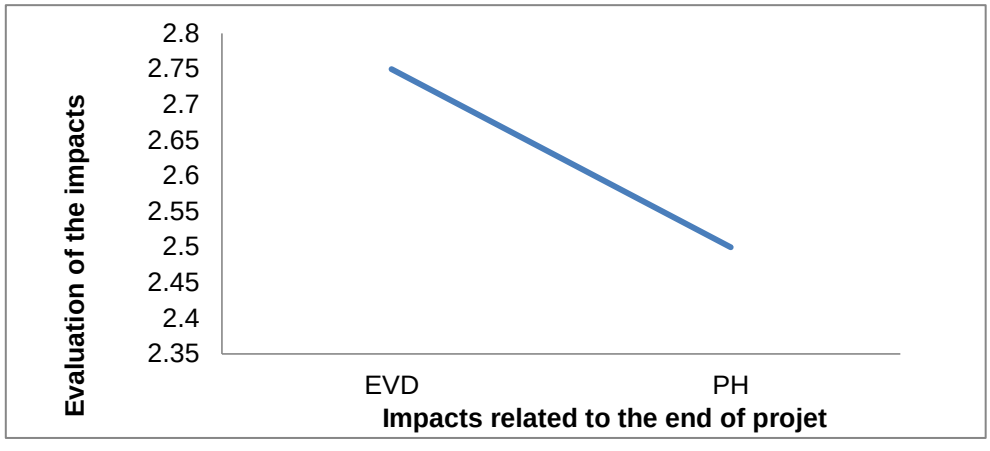


Figure-12. Evolution of the average impacts related to the closing of the project, with EVD = evolution of the flora diversity; PH = evolution of the physiognomy of the vegetation



4. DISCUSSION

4.1. Evolution of the Indices of Diversity

The analysis of the flora of the site shows that it is less diversified (H= 3.57) and fairly homogeneous (E = 0.52). The various activities undertaken in this zone were ecological sources of disturbances, and can be regarded as major disturbances of the ecosystems. Indeed, the site

inherited a very intense agricultural past. Also, with the husbandries based on the traditional systems of cultures, much deforestation of the vegetation related to the anarchistic and abusive exploitations were associated. The impacts related to the installation of the infrastructures of the factory, were caused by the machines motorized through scouring and compaction of the ground of the site, woody species cutting and the hiding of the seeds of certain woody species of the original flora. These causes also involved ecological and biological disturbances (destruction of the ecosystems). Moreover, these actions caused a dynamics in the contiguous vegetable formations of the site.

4.2. Evolution of the Environmental Impacts

The environmental impacts are observed during the phases of exploration and construction, of exploitation and at the end of the project. During the phase of construction, the opening of the access roads and the earthworks involved the destruction of the flora of the site and that of certain bordering vegetation of the site of the project. Some specimens of trees, shrubs, lianas and herbaceous were destroyed. The openings carried out in the flora contributed to increase to a significant degree the luminosity on the ground in these usually closed formations, exposing thus the species of the underwood very sensitive to excesses of light. The epiphytes are found on the ground following the demolition of the large trees. All these movements involved an ecological imbalance within the vegetable formations concerned. During the production phase, the extent of the disturbances was accentuated. The destruction became more important in the flora of the contiguous vegetation. The proliferation of herbaceous species is due to the exposure of the underwood to the too strong luminosities and the capacity of these herbaceous to the fast colonization of the mediums degraded as it mentioned by Claude, et al. [9]. In addition, the many frequentations of the workers in search of woody species for utility needs had an additional effect on the impacts; especially with regard to the destruction of vegetable numerous species. Also, the regular passages of the heavy machines contributed to imprison a lot of seeds, thus disturbing the natural regeneration of the plant species.

At the end of the project, the original vegetation almost disappeared following the many destruction perpetrated in the zone. The aspect of the vegetation was modified. Numerous species endemic, rare, with particular status, etc. which were numerous in the flora of the site during a long moments do not exist today in the zone. The rich and diversified flora disappeared and left on the spot new vegetation mainly made up the herbaceous ones. The surrounding formations have so suffered to the human pressure which they are more degraded. On the whole, the zone lost its rich and diversified forest and biological diversity regressed considerably under the pressures of anthropic origins. The characterization and the evaluation of the impacts on the flora of the site are supposed to bring a thorough lighting on the nature (intensity, extended and lasted) of the impacts. Thus, the intense impacts (DEV., EP and EPD) recorded with the phase of construction were caused by mechanical undergrowth cutting, scouring of the ground to the Bulldozer, the regular talks of site etc. the regular maintenance of the site which comprises the woody species demolitions have intensely affected all the components of the sometimes, compromising its total regeneration as it has been mentioned by Mitja and Puig [10] in forest zone and YOSSI [11] in zone of savanna.

During the phase of production, the intense impacts (APA, PRO) were only the consequences of the sources activities of impacts started since the phase of construction; they are amongst other things the regular talks of the site, the cutting in flora etc. At the end of the project, the intensity of the evolution of the diversity of the flora is related to the stoppage of the works. This suspension of the activities is the cause of this renewal of diversity. The significant impacts during the phase of prospection and construction (DPE and EP) were caused by the total destruction of the flora and the compaction of the ground at certain places by the mechanical machines during excavation work.

This destruction involved many consequences in particular the deforestation and the impoverishment of the flora in woody species (APA), the proliferation of herbaceous (PRO) and the destruction of numerous species thus setting them up in major impacts during the production phase. The importance of the evolutions of floristic diversity and the aspect of many vegetation of the site at the end of the project is related to the stop of any activity on the site like it has been above-mentioned. But this evolution is also related to the afforestation started during this phase with the woody species. These woody quality species have slow growth like it was mentioned by Ettien [12] and Kouadio, et al. [13].

4.3. Main Sources of Impact

The main sources of impact are the regular maintenance of the sites, mechanical undergrowth cutting, the compactions of the ground, the taking away regular in the flora and the afforestations at the end of the project. Indeed, these activities were sources of long, extended and important impacts at the same time. Also, many destruction in the flora have an additive effect on that of the regular maintenance of the flora

5. CONCLUSION

The flora of the site of the project fairly is rich and fairly diversified. This sector which inherited many crop years presents an average floristic homogeneity. Floristic diversity was strongly influenced by the installation, and the execution of the project. Many impacts whose destruction of the potential of regeneration of the flora, impoverishment of the flora in woody and proliferation the herbaceous ones were observed in the zone of the project. However, of measurements of attenuation such as: the afforestation containing woody leguminous and the protection of certain vegetable formations can strongly contribute to reduce the risks of eco-climatic imbalances which could occur in the long run. Moreover the integral protection of the humid mediums, the raphiales and the fallow, present on the site will be able to contribute to set up not only reservoirs of phylogenetic resources and sources of carbon dioxide purification (CO2) but also the only refuges of the animals in migration.

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