

Impact of the layout of a line of high voltage (HTA) on the flora of the locality of Agboville in the South-east of Côte d'Ivoire

Abstract

The aim of this was to identify and evaluate the impacts related to the realization of high voltage on the flora of Agboville in order to put forward measures of attenuation or corrective.

Study design: The vegetations were delimited into small squares plots or pieces. These small squares plots were distributed in all the flora of the study.

Place and duration of study: This work relates to the identification and the evaluation of the negative impacts of the layout of the line of high voltage on the flora of the study zone. It was conducted in Agboville, a locality in the south of Côte d'Ivoire during July to September 2013

Methodology: The itinerant inventory and the method of "quadrat" were associated during floristic inventories.

The results showed that the flora is approximately rich 89 species. It is however little, diversified and rather homogeneous. The destruction of the woody flora (DFL), the destruction of the floristic potential of regeneration (DPE), the evolutions of floristic diversity (EDF) and the aspect of vegetation (EPV) were the major average impacts during the prospection, the exploitation phases and at the end of the project. 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 the biological, ecological and climatic imbalances.

Keywords: Impact, flora, Agboville, High voltage, line, traced

I-Introduction

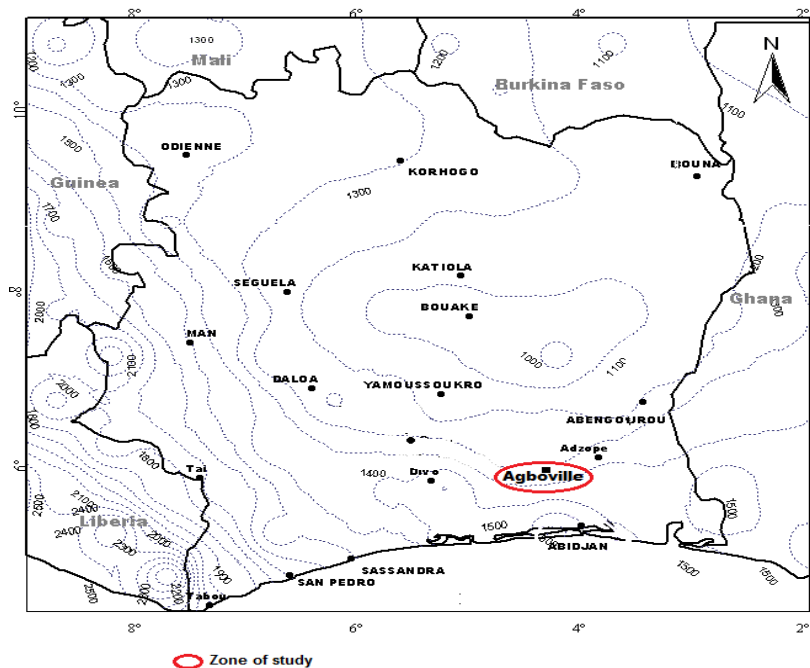
The natural resources available on planet become exhausted over the year. The recrudescence of the activities causes of impact is partly related to the growth of the demography of many countries throughout the world. In many African countries, in particular, those whose economy is based on the exploitation of natural resources, the preservation of these resources and biodiversity is from now a priority. In addition, the problem of rural land, sometimes source of fatal conflicts, is one of the emergent causes of biodiversity destruction.

The leading causes of this evolutionary destruction are inter alia, inherent agriculture, forestry holding, bush fires, etc. During these last years, of the additional causes in particular, the fast urbanization, with its corollaries: the real estate transactions, great production units and transformation constructions and creations of industrial plantations (Kouassi *et al.* [1]) became activities, sources of impacts. In addition, in many African countries, the pressure exerted on the natural resources believes inordinately (Kouassi *et al.* [2]). Face to these problems more and more, measurements of durable or integrated management of the natural resources are recommended to prevent possible biological imbalances. One of these measurements, before any activity cause of great disturbance of the ecosystems is the identification, the evaluation and the correction of environmental impact. Indeed, the destruction of many components of nature requires the taking into account of corrective measures or compensation aiming at minimizing the damage caused (impact of the projects) on the environment. Actually, human beings and the animals are the component which pays the full price of the consequences of much destruction caused within nature. This is why, any activity, source of impacts must be done in a reasoned way, in order to be in adequacy with the dynamics of the natural resources. The management of the environment must thus from now on integrate realities of the medium of kind to support the life in all its forms. For this

46 purpose, this report highlights and evaluates primarily the impacts of the opening of the
47 layout of the line of high voltage (HTA) on the flora of the ecosystems crossed by the layout.

48 2-Materials and Methods

49 From the floristic point of view, the site (Fig.1) of the project belongs to the Guinean field. In
50 this locality, one notes the presence of many hydromorphic **vegetation** closed by place. This
51 forest was made of three principal layers (Reizer, [3]; Guillaumet and Adjanohoun, [4]). In
52 addition to the hydromorphic formations, one meets **there the** wet dense **forest**, the marshy
53 forests of the enclaves, the raphiales, etc. The layer of the large trees was dominated by
54 specimens of 50 with 60 m high and was characterized by woody species such as **Khaya**
55 **ivoirensis**, **Lophira alata** and **Tarrieta utilis**. The hydromorphic formations were made up of
56 marshy forests and mangrove swamps. This wide forest is today very threatened in **Côte**
57 **d'Ivoire** since it comprises several exploited species (Aubréville, [5]).



58
59 Fig. 1: Localization of the zone of study

60 2-1- Floristic inventory

61 The flora of the site and that of the contiguous ecosystems (zone cultivated, marshy zone,
62 plantations of cacao-trees) were inventoried. Two methods were associated to conduct this
63 study. They were: the itinerant inventory of the flora by the enumeration of the species on
64 layouts and the method of the small squares (Gautier *et al.*, [6]) which consists in describing
65 the vegetation (enumeration and classification of the species) on surfaces of approximately
66 20 m on side (Fig. 2) according to the four cardinal points, with a precise spacing. With this
67 intention, 10 small squares of approximately 400 m² of surface were inventoried in each type
68 of vegetation crossed by the line of high voltage. They are approximately 5 types of
69 vegetations which were crossed by the layout of the line.

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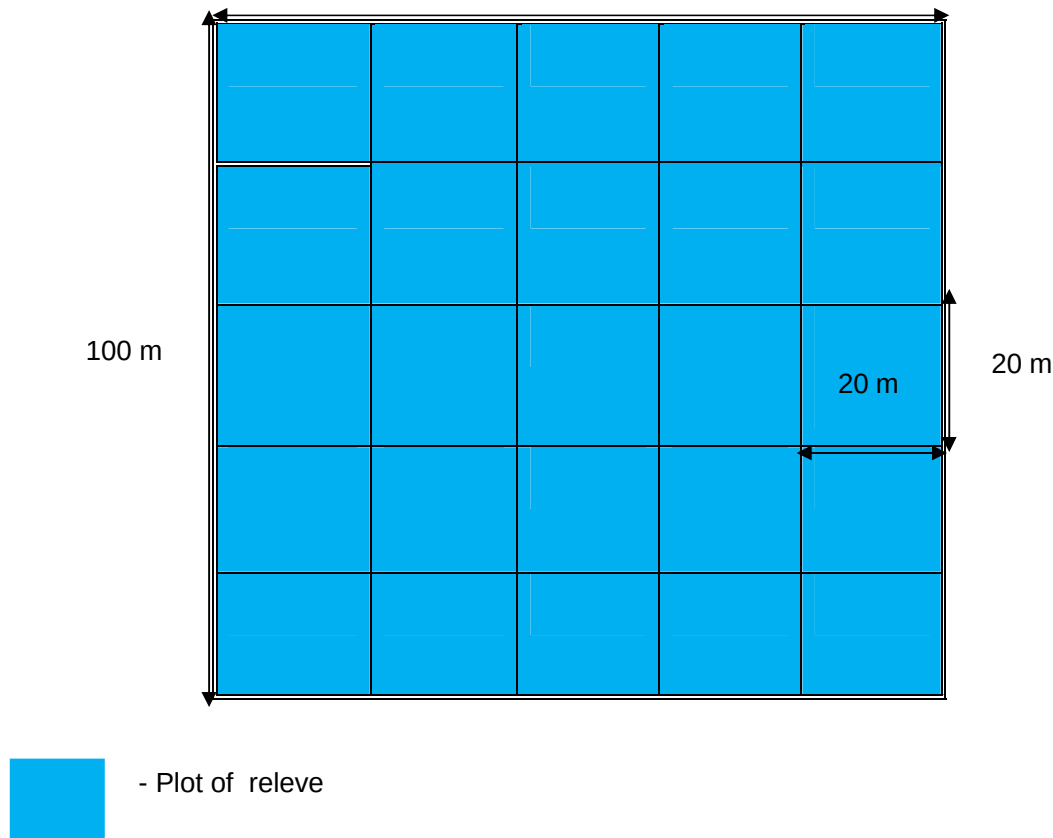
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88 Fig. 2: Configuration of the plot of inventory

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90 **2-2- Analysis of the flora**

91 The methods of analysis of diversity of the flora are available today. In the present analysis,
 92 the index of diversity of Shannon and weaver [7] was used to estimate the diversity of flora.
 93 Its formula is $H = -\sum p_i \log p_i$, with p_i = floristic contribution or relative frequency. This index
 94 varies from 0 (only 1 species) to $\log N$, (when all the species have same abundance). To
 95 this index the Equitability of Pielou (E) is associated. This equitability is a relationship
 96 between floristic diversity observed and maximum theoretical diversity. The equitability of
 97 Pielou is written: $E = H / \log N$, With, N = total staff complement of the studied station. The
 98 equitability varies from 0 to 1. It tends towards 0 when all species is concentrated on only
 99 one (1) species and is equal to 1 when all the species have same abundance.

100 **3-Results**101 **3-1- Actual statute of the vegetation**

102 The vegetations of the site at one time luxuriant, are seriously started and almost
 103 disappeared to the profit of the fragments of fallow (Fig. 3 A and B). The plots of culture, the
 104 marshy zones (Fig. 4 and 5) and the well preserved vegetations.



A

B

Fig. 3: Fallow in Agboville (near petit Yapo)



Fig. 4: Plot of Cassava (*Manihot esculenta*) Fig. 5: Marshy zone with, *Bambousa vulgaris*

3-2- Wealth and specific diversity of the sector of Agboville

The flora of the site is rich approximately 81 species. The values of Shannon index (H) and Equitability (E) estimated are respectively, $H = 3.6$; $E = 0.57$ (table 1).

Table I: Estimate of the values of the indices of diversity (H) and homogeneity (E), with F_a = absolute frequency, F_r = relative frequency, P_i = floristic contribution, H = Shannon index

N°	Species	Family	F_a	F_r	P_i	H
1	<i>Abrus precatorius</i>	Fabaceae	1	0,33333333	0,00411523	0,0326124
2	<i>Adenia cissampeloides</i>	Passifloraceae	3	1	0,01234568	0,07826975
3	<i>Ageratum conyzoides</i>	Asteraceae	2	0,66666667	0,00823045	0,05699434
4	<i>Albizia adianthifolia</i>	Mimosaceae	3	1	0,01234568	0,07826975
5	<i>Albizia zygia</i>	Mimosaceae	3	1	0,01234568	0,07826975
6	<i>Alchornea cordifolia</i>	Euphorbiaceae	3	1	0,01234568	0,07826975
7	<i>Alstonia boonei</i>	Apocynaceae	1	0,33333333	0,00411523	0,0326124
8	<i>Ananas comosus</i>	Bromeliaceae	1	0,33333333	0,00411523	0,0326124
9	<i>Anthocleista djalonensis</i>	Loganiaceae	1	0,33333333	0,00411523	0,0326124
10	<i>Antiaris toxicaria subsp africana</i>	Moraceae	1	0,33333333	0,00411523	0,0326124
11	<i>Antrocaryon micraster</i>	Anacardiaceae	2	0,66666667	0,00823045	0,05699434
12	<i>Aspilia africana</i>	Asteraceae	1	0,33333333	0,00411523	0,0326124
13	<i>Baphia nitida</i>	Fabaceae	1	0,33333333	0,00411523	0,0326124

14	<i>Blighia sapida</i>	Sapindaceae	1	0,33333333	0,00411523	0,0326124
15	<i>Carica papaya</i>	Caricaceae	1	0,33333333	0,00411523	0,0326124
16	<i>Cassia hirsuta</i>	Caesalpiniaceae	1	0,33333333	0,00411523	0,0326124
17	<i>Cassia siamea</i>	Caesalpiniaceae	3	1	0,01234568	0,07826975
18	<i>Cecropia peltata</i>	Cecropiaceae	2	0,66666667	0,00823045	0,05699434
19	<i>Ceiba pentandra</i>	Bombacaceae	2	0,66666667	0,00823045	0,05699434
20	<i>Centrosema pubescens</i>	Fabaceae	2	0,66666667	0,00823045	0,05699434
21	<i>Chromolaena odorata</i>	Asteraceae	3	1	0,01234568	0,07826975
22	<i>Cissus aralioides</i>	Vitaceae	2	0,66666667	0,00823045	0,05699434
23	<i>Cnestis ferruginea</i>	Connaraceae	2	0,66666667	0,00823045	0,05699434
24	<i>Combretum zenkeri</i>	Combretaceae	2	0,66666667	0,00823045	0,05699434
25	<i>Cordia platythyrsa</i>	Boraginaceae	1	0,33333333	0,00411523	0,0326124
26	<i>Croton hirtus</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
27	<i>Cyperus sp.</i>	Cyperaceae	1	0,33333333	0,00411523	0,0326124
28	<i>Desmodium adscendens</i>	Fabaceae	1	0,33333333	0,00411523	0,0326124
29	<i>Delonix regia</i>	Caesalpiniaceae	2	0,66666667	0,00823045	0,05699434
30	<i>Dioscorea smilacifolia</i>	Dioscoreaceae	2	0,66666667	0,00823045	0,05699434
31	<i>Dissotis rotundifolia</i>	Melastomataceae	1	0,33333333	0,00411523	0,0326124
32	<i>Elaeis guineensis</i>	Arecaceae	2	0,66666667	0,00823045	0,05699434
33	<i>Entandrophragma angolense</i>	Meliaceae	1	0,33333333	0,00411523	0,0326124
34	<i>Erigeron floribundus</i>	Asteraceae	2	0,66666667	0,00823045	0,05699434
35	<i>Ficus exasperata</i>	Moraceae	1	0,33333333	0,00411523	0,0326124
36	<i>Ficus sur</i>	Moraceae	1	0,33333333	0,00411523	0,0326124
37	<i>Hevea brasiliensis</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
38	<i>Hoslundia opposita</i>	Labiatae	1	0,33333333	0,00411523	0,0326124
39	<i>Ipomoea sp</i>	Convolvulaceae	1	0,33333333	0,00411523	0,0326124
40	<i>Lantana camara</i>	Verbenaceae	1	0,33333333	0,00411523	0,0326124
41	<i>Leucaena sp</i>	Mimosaceae	1	0,33333333	0,00411523	0,0326124
42	<i>Mallotus opositifolius</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
43	<i>Manihot esculenta</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
44	<i>Manniophyton fulvum</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
45	<i>Mareya micrantha</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
46	<i>Margaritaria discoidea</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
47	<i>Mezoneuron benthamianum</i>	Caesalpiniaceae	2	0,66666667	0,00823045	0,05699434
48	<i>Milicia excelsa</i>	Moraceae	1	0,33333333	0,00411523	0,0326124
49	<i>Millettia zechiana</i>	Fabaceae	2	0,66666667	0,00823045	0,05699434
50	<i>Momordica charantia</i>	Cucurbitaceae	1	0,33333333	0,00411523	0,0326124
51	<i>Morinda lucida</i>	Rubiaceae	1	0,33333333	0,00411523	0,0326124
52	<i>Motandra guineensis</i>	Apocynaceae	1	0,33333333	0,00411523	0,0326124
53	<i>Musa paradisiaca</i>	Musaceae	1	0,33333333	0,00411523	0,0326124
54	<i>Musanga cecropioides</i>	Moraceae	2	0,66666667	0,00823045	0,05699434
55	<i>Myrianthus libericus</i>	Moraceae	1	0,33333333	0,00411523	0,0326124
56	<i>Nauclea latifolia</i>	Rubiaceae	1	0,33333333	0,00411523	0,0326124
57	<i>Nelsonia canescens</i>	Acanthaceae	1	0,33333333	0,00411523	0,0326124

58	<i>Panicum maximum</i>	Poaceae	1	0,33333333	0,00411523	0,0326124
59	<i>Passiflora foetida</i>	Passifloraceae	1	0,33333333	0,00411523	0,0326124
60	<i>Paullinia pinnata</i>	Sapindaceae	2	0,66666667	0,00823045	0,05699434
61	<i>Phyllanthus amarus</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
62	<i>Phyllanthus muellerianus</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
63	<i>Phyllanthus sp.</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
64	<i>Piptadeniastrum africanum</i>	Mimosaceae	1	0,33333333	0,00411523	0,0326124
65	<i>Pouzolzia guineensis</i>	Urticaceae	1	0,33333333	0,00411523	0,0326124
66	<i>Psidium guajava</i>	Rutaceae	1	0,33333333	0,00411523	0,0326124
67	<i>Pueraria phaseloides</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
68	<i>Pycnanthus angolensis</i>	Myristicaceae	3	1	0,01234568	0,07826975
69	<i>Raphia hookeri</i>	Arecaeae	1	0,33333333	0,00411523	0,0326124
70	<i>Rauvolfia vomitoria</i>	Apocynaceae	2	0,66666667	0,00823045	0,05699434
71	<i>Ricinodendron heudelotii</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
72	<i>Sida acuta</i>	Malvaceae	1	0,33333333	0,00411523	0,0326124
73	<i>Secamona afzelii</i>	Asclepiadaceae	1	0,33333333	0,00411523	0,0326124
74	<i>Solanum erianthum</i>	Solanaceae	1	0,33333333	0,00411523	0,0326124
75	<i>Solanum turvum</i>	Solanaceae	1	0,33333333	0,00411523	0,0326124
76	<i>Sterculia tragacantha</i>	Sterculiaceae	2	0,66666667	0,00823045	0,05699434
77	<i>Tabernaemontana crassa</i>	Apocynaceae	2	0,66666667	0,00823045	0,05699434
78	<i>Tragia benthamii</i>	Euphorbiaceae	1	0,33333333	0,00411523	0,0326124
79	<i>Trema orientalis</i>	Ulmaceae	1	0,33333333	0,00411523	0,0326124
80	<i>Triplochiton scleroxylon</i>	Euphorbiaceae	2	0,66666667	0,00823045	0,05699434
81	<i>Xanthosoma maffama</i>	Araceae	1	0,33333333	0,00411523	0,0326124
					I =	3,59513622
					E =	0,5670696

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117 3-3- Species with particular status inventoried in the zone

118 Five (5) species with particular status were inventoried in this flora (table 2). Among these
 119 species, some are vulnerable; some present risks of extinction, others still in danger because
 120 of their intense uses.

121 Table II: list of the species with particular status met in the sector of Agboville

N°	Species	Family	Statut
1	<i>Antrocaryon micraster</i>	Anacardiaceae	vulnerable (UICN, 2009)
2	<i>Cordia platythyrsa</i>	Boraginaceae	vulnerable (UICN, 2009)
3	<i>Entandrophragma angolense</i>	Meliaceae	vulnerable (UICN, 2009)
4	<i>Milicia excelsa</i>	Moraceae	vulnerable (UICN, 2009)
5	<i>Triplochiton scleroxylon</i>	Sterculiaceae	at the risk (UICN, 2009)

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3-4- Identification, analyzes and evaluation of the impacts of the project

3-4-1 phase of prospection

The curves (Fig. 6) show the variation of the impacts related to the phase of prospection on the flora and the vegetation of the line. The destruction of the woody flora (DFL) was intense (3), extended (3) and very long (3). The impact of this activity was medium important (2). The duration and the extent of the destruction of the potential of regeneration of flora (DPR) were medium (2). But it was low intense (1) and low important (1). The ecological disturbances (EP) caused by the activities were medium intense (2), medium important (2), and medium wide (2). They were very short (1).

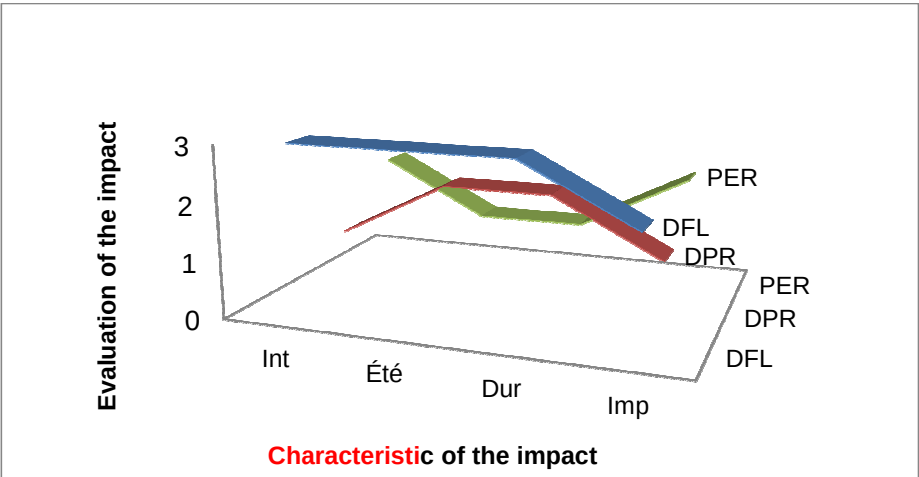


Fig. 6: Evolution of the impacts related to the phase of prospection with, Int = intensity, Ete = wide; Dur = duration; Imp = importance; DEV. = destruction of the plant species; DPR = destruction of the potential of regeneration; EP= ecological disturbance

The evolution of the average impacts on the flora during this phase (Fig. 7), shows that the destruction of the woody flora (DFL) was more accentuated (2.75). The ecological disturbance (EP) and the destruction of the potential of regeneration (EPD) were fairly high (1.5).

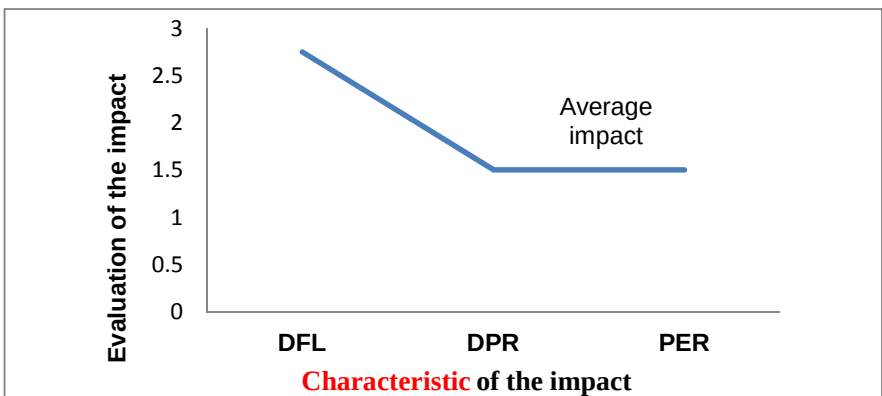


Fig. 7: Evolution of the average impacts related to the prospection and construction phase, with; DFL = Destruction of the species of the woody flora; DPR = destruction of the potential of regeneration; PER = ecological disturbance

2-3-2- Phase of exploitation

The evolution of the curves (Fig. 8) shows the variation of the impacts related to the phase of exploitation on the vegetation, the flora of the site and on that of the contiguous vegetation. During this phase, the woody flora destruction (DFL) and the potential of regeneration (DPR) destruction were highly significant (3), very long (3) and highly important (3). But they were low lying (1). The herbaceous proliferation were highly significant (3) and long (3). It was medium wide (2) and medium importance (2).

The Characterization of the average impact impacts on the flora (Fig.9), shows that the destruction of the woody flora (DFL) and the destruction of the potential of regeneration (DPR) were high (2.75) during this phase. The herbaceous proliferation was low intense (2.50).

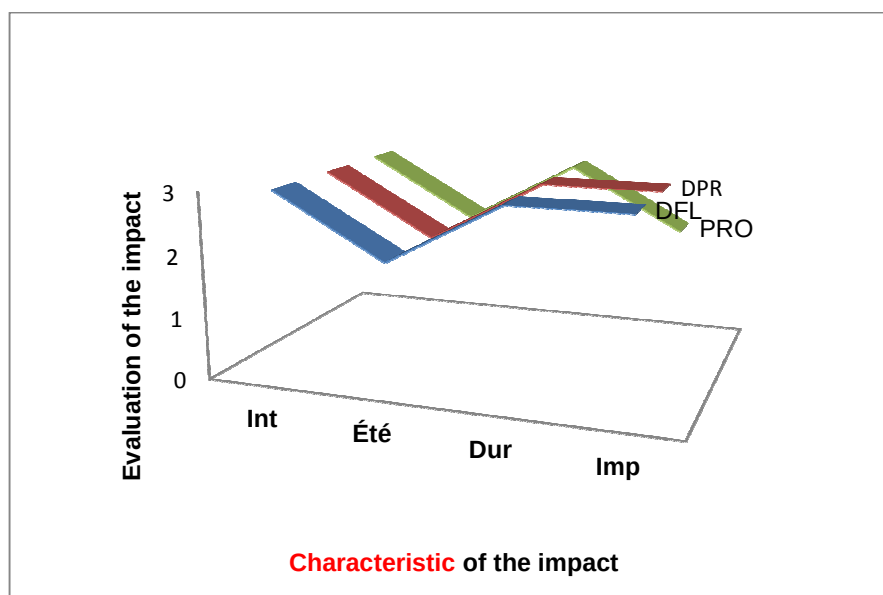


Fig. 8: Evolution of the impacts related to the exploitation phase, with; Int = intensity, Ete = wide; Dur = duration; Imp = importance; PRO = the herbaceous proliferation; DFL = destruction of the woody flora, DPR = destruction of the potential of regeneration

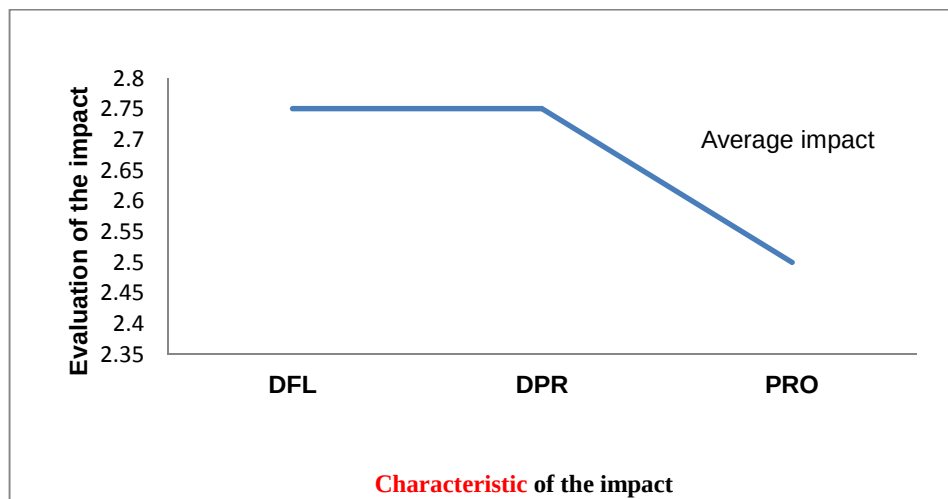


Fig. 9: Evolution of the average impacts related to the Exploitation phase, with; DFL = destruction of the woody flora; EPD = destruction of the potential of regeneration; PRO = the herbaceous proliferation

2-3-3- End of the Project

At the end of the project (Fig. 10), the fragmentation of the vegetation (FRV) were highly significant (3), very important (3), medium wide (2) and short (1). (EDF) The flora of the site has been mediumly diversified (2) and medium wide (2). This impact was very long (3) and very important (3). The appearance of the vegetation (EPV) has changed significantly (3) and very important (3). But it was medium wide (2) and have had medium duration (2). The average impacts evolution (Fig. 11) showed that the evolution of floristic diversity (EDF) and the appearance of the vegetation (EPV) were high (2.5). The fragmentation of the vegetation (FRV) was medium (2.25).

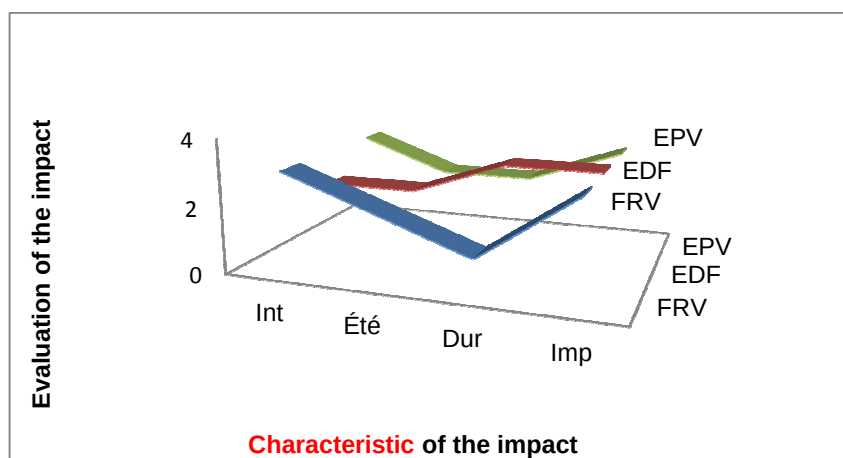


Fig. 10: Evolution of the impacts related to the end of the project; with Int= intensity, Ete = wide; Dur = duration; Imp = importance; EDF = evolution of the diversity of the flora; EPV = Evolution of the aspect of the vegetation; FRV= fragmentation of the vegetation

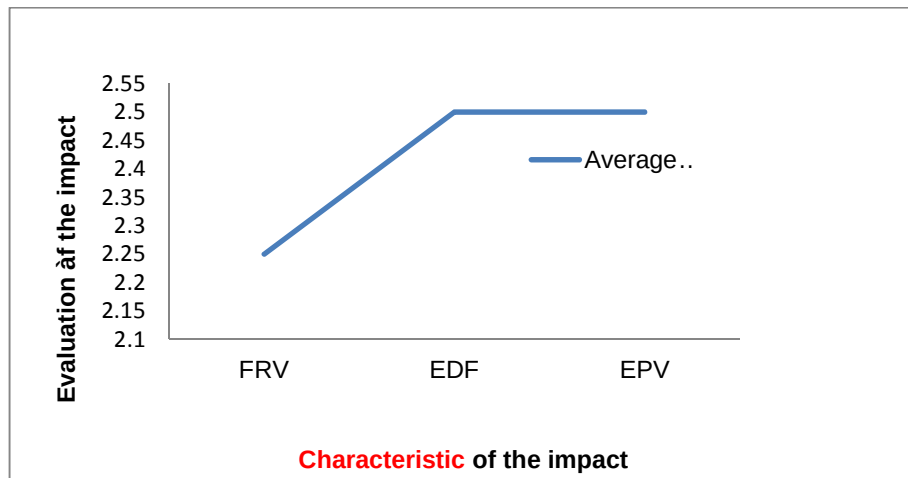


Fig. 11: Evolution of the average impacts dependent of the end of the project, with; EDF = evolution of the diversity of the flora; EPV = Evolution of the aspect of vegetation; FRV = Fragmentation of the vegetation

4-Discussion

4-1- Evolution of floristic diversity

The evaluation of the impacts on the flora of the vegetations showed that these vegetation were low diversified ($H = 3.60$) and rather homogeneous ($E = 0.57$). The various activities undertaken in this zone can be regarded as major causes of the disturbances and vegetations fragmentation. Indeed, the vegetations crossed by the path of the line are mainly the plots of culture or fallow which are intensely put in culture. This setting in permanent crop influenced the floristic diversity of the site. Also, with the agricultural practices based on the traditional systems of cultures, cause of many deforestation was associated. These destructions were related to the anarchistic and abusive exploitations of the trees species. The impacts related to the path of the line were caused by the machines through scourings and ground compaction, woody species cutting and the hiding of the seeds of certain woody species of the original flora. These destructions have also involved ecological and biological disturbances (destruction of the ecosystems). Moreover, these actions caused the dynamics of the contiguous vegetation of the site.

3-2- Evolution of the impacts on the flora of the site

The major impacts were observed at all project phases. During the phase of prospection, the openings of the access roads and the demarcations have caused the destruction on the path of the line and that of certain bordering vegetations of the line. 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 the species of the underwoods very sensitive, to excesses light. The epiphytes are found on the soil following the demolition of the large trees. All these major impacts caused an ecological imbalance in many vegetation.

3-2-1-Evolution of the impact during the exploitation phase

The activities carried out during the exploitation phase contributed to increase the impacts generated during the previous phases. The destruction of the original flora is a factor which facilitated the installation of herbaceous which has a great capacity to develop themselves. Their proliferation is due to the opening of the canopy of the vegetation which was closed before the realization of the project. The exposure of the ground to strong luminosity of the sun and rain erosion are additional factors which involved the regression of the original flora

to the profit of the adventitious, like it was mentioned by Claude *et al.* [8]. Also, the regular cutting of vegetation of the line of the high voltage (H T A) weakened the protection of the soil against erosion.

3-2-1-Evolution of the impact at the end of the project

At the end of the project, The vegetations of the site were deeply impoverishes by the project. Indeed, numerous species listed in the zone before the realization of the project disappeared from the site. The aspect of the vegetation was modified on the lines. The evaluation and the characterization of the impacts on the flora of the site are supposed to bring a thorough lighting on the nature of the impacts. Thus, the average impact most important during the phase of prospection was the woody flora destruction (DFL). The destruction of the potential of regeneration (DPR) and the herbaceous proliferation (PRO) were less important. These impacts were caused by undergrowth clearances, the regular cleaning of the path of the line, the regular maintenance of the site which comprises destruction of certain woody species have intensely affected all the components of the flora, sometimes compromising its total regeneration as it was mentioned by Mitja and Puig [9] in forest zone and Yossi [10] in savanna. During the exploitation phase, the average impacts most important (DFL, DPR) were only the consequences of the activities which started since the phase of construction; they are amongst other things the regular cleaning of the site, the woody species cutting, etc. The proliferation of herbaceous (PRO), less important during this phase was also related to the activities of maintenance.

The importance of the evolution of the diversity of the flora (EDF) and the aspect of the vegetation (EPV) were related to the end of the works. This suspension of the activities is what supported this renewal of diversity and the vegetation transformation. But this transformation is slow because of the slow growth of the woody species like it was mentioned by Ettien [11] and Kouadio *et al.* [12].

Conclusion

The flora of the path of the line is less diversified. This sector which inherited many years crop presents a floristic homogeneity. The floristic diversity was strongly influenced by the installation, and the execution of the project. Many impacts (destruction of the potential of regeneration of the flora, the impoverishment of the flora in woody species and the proliferation of the herbaceous ones in the flora) were observed at certain places of the path of the line. However, mitigation measures such as: the afforestations with the legume trees and the protection of certain vegetation will strongly contribute to reduce the risks of ecological imbalances which could occur in the zone on the future. Moreover the integral protection of the fallow still present on the site will encourage setting up reservoirs of phytogenetic resources, wells of carbon (CO₂) and also the refuges of the animals during their migration.

References

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