



Socio-economic and Environmental Transformations in a Context of Sectoral and Industrial Ecology: The Case of the Chad - Cameroon Pipeline

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/AJEBA/2022/v22i2330737

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/91815>

Original Research Article

Received 12 July 2022
Accepted 17 September 2022
Published 23 September 2022

ABSTRACT

This study examines the balance of power, generally convenient to operating companies that threaten life on our planet and hamper the concept of sustainable development. The Contingent Assessment Method (CAM) is used to determine the Willingness To Pay (WTP) by the neighbouring populations. Data collection in the field highlights the preferences expressed by residents in the ecological zones crossed by the PCC (Pipeline Chad Cameroon). The effects of this operation are mainly negative for locals and their area of residence. For instance residents are restrained to more on agropastoral activities rather than other farming activities thus reducing their income, destruction of yards with water storages thus resulting to certain diseases such as STIs and tuberculosis. On the other hand, the pipeline mainly benefits the operating company which realizes super-profit. It is important to emphasize that big projects, such as oil and mining projects are a guarantee to sustainable development in the economical, social and environmental sector.

Keywords: Chad-Cameroon pipeline; ecosystem; ecology; population; willingness to pay.

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1. INTRODUCTION

There are a lot of preoccupations still pending on what industrial projects bring to developing economies. The Chad-Cameroon Pipeline (CTP) project is one of the largest investment projects in sub-Saharan Africa. Implemented by the Exxon-Petronas-Chevron Consortium, this US\$3.7 billion project involves the development of 300 wells in three oil fields in Chad. We will present the CTP after its financing and complementary components.

Thanks to its geographical position with Chad, Cameroon is an asset in the evolution of this investment. With a surface area of 475,442 km², Cameroon is bordered to the north by Chad¹. To the west, it has a 364 km long opening on the Atlantic Ocean. The environmental stake lead us to present its four regional units. Oil transport via the Chad-Cameroon pipeline extends over 1070 km, 891 km of which pass through 242 villages spread over 5 regions in Cameroon. The oil is transported via the pipeline to Kribi (a seaside resort), where a floating terminal² is installed 11 km from the coast. The pipeline is 76 cm in diameter and is buried 100 cm deep in the ground, 150 cm under roads, rivers and railways [1]. The 300 identified wells produce 225,000 barrels per day and for 25 years, production will be 924 billion barrels (1 barrel = 160 litre) according to the operating company COTCO.

The CTP is financed by Chad and Cameroon government, the international consortium³, and the World Bank (WB). According to Point [2], it should promote the development of Cameroon and Chad. Its implementation has led to complementary projects⁴, such as Cameroon petroleum environment capacity enhancement project⁵, Chad management of the petroleum economy project, and Chad petroleum sector management capacity-building project. The WB supervises all the activities of the pipeline and the non-governmental organisations (NGOs) involved. The government⁶ thus plays the role of

"transmission belt" between the populations and the oil companies through the organisation of platforms on the different activities and the reciprocal exchange of information. The latter has provided an insight into environmental management and also given an impact to this exploitation. The theory leads us to see the point of view of the specialists in these fields.

In 1866, German biologist Ernst Haeckel came up with the study of ecology. It is the study of the relationship between living beings and their environment on an international scale. Industrial/sectoral ecology, on the other hand, is a practice of environmental management that relies on industrial production systems based on ecosystem models [3]. Industrial ecology is a mode that, instead of reasoning in terms of reducing the level of pollution at the end of the chain, aims to reduce material and energy flows by designing industrial ecosystems in which these flows circulate, constituting one of the modalities of sustainable development [4].

This analysis is based on the standards established by the Environmental Management Programme, Pemunta and Tabenyang, [5] respecting the socio-economic and environmental impact and the implementation of the MDGs⁷ to better expose the possible positive and negative effects of the Chad-Cameroon pipeline [6].

Examining the impacts of the Chad-Cameroon pipeline is vital because of the many painful experiences⁸ around the world. This study would serve as a compass for the governments concerned, the operating company and civil society in the area. The "Peoples' Tribunal of Cameroon"⁹ has condemned the consortium and its subcontractors for the disrespect of economic and social rights and pre-established standards

¹ Cameroon shares the largest border with Chad of 1,122km in Central Africa.

² Single-hull oil receiving and transfer vessel.

³ Exxon, Petronas and Chevron.

⁴ Capacity building project in environmental management of oil project in Cameroon.

⁵ Management of oil projects in Chad.

⁶ Capacity building in the management of the oil sector in Chad.

⁷ Through the intervention of the Ministry of Water and Environment (MEE), the Ministry of Environment and Nature Protection (MINEPN), the Ministry of Health (MINSANTE),

the Ministry of Posts and Telecommunications (MINPOST), inspectors, managers, the Pipeline Steering and Monitoring Committee (CPSP) and the National Hydrocarbons Company.

⁸ Poverty reduction and environmental protection.

⁹ For example, the tragedy of 24 March 1989 when the tanker T/U Exxon Valdez ran aground in Prince William, Alaska, releasing more than 27,000 barrels of oil into the environment and causing the release of a 7,000 km² oil slick, covering 800 km of coastline. Millions of migratory and water birds, marine mammals, otters and several species of whales were threatened by the oil spill

⁹ This is a body to which people come to present the impacts of the PPTC. It was established by FOCARFE in June 2005 (see Statute of the Peoples' Tribunal, 2005).

of environmental protection¹⁰ rights. The consortium is also indexed in its way of instituting abstract methods following the civil society moratorium during the year 2005 and in its insufficient actions to mitigate the damages generated by the route of the oil pipeline. Hence the following question: What are the socio-economic and environmental stakes of the Chad-Cameroon pipeline according to the local population?

The following section presents the assessment socio-economic and environmental impacts with the help of some literature review on the socio-economic and environmental impacts of industrial projects. We will further analyse the method on how the populations were compensated for the possible loss of their comfort and environmental values resulting from the Chad-Cameroon pipeline. Finally our results will allow us to make political recommendations.

2. LITERATURE REVIEW

This section outlines the explanatory theories and empirical evidence of the effects of socio-economic and environmental transformations in a context of sectoral and industrial ecology.

2.1 Theoretical Synthesis

The theoretical grounding goes back to the seminal contribution¹¹ of Frosch and Gallopoulos [7], around which the debates and the development of numerous tools are based. Following the mini-boom, we witnessed the evolution of these primary products [8], within the framework of their exploration and exploitation. These products are the source of many environmental problems. The pipeline makes the situation effective in the sense of Pareto impacts [9] (Dasgupta, 2001). The work of Arrow (1973), Rawls and Sen [10] shows the impossibility theorem of welfare and social welfare functions respectively, thus, makes it possible to achieve environmental regulation of industries.

Tools are listed in order to repair the negative impacts and perpetuate industrial projects in a

context where the relationship between these two countries on an international level platform is put in place. These include: negotiation: it is complicated with the presence of the stowaway [11]. The agents pay in proportion to the pollution produced, but only a small amount to reach the collective optimum [12].

Standards, taxes and the polluter-pays principle are also part of these tools. The tax is a public instrument. The operating company is responsible for taking social costs into account leading to PPPs (Hume, 2010). This principle is required for impact assessments and is an economic regulatory instrument. Other theories considered are, incentive theory and the theory of externalities. The latter has a central place in the consideration of environmental impacts and is the foundation of PPPs (Varian, 1987). They can be positive or negative. Baumol and Oates [13] suggest internalising these effects¹² through their characteristics. They speak of transferable¹³ externalities. Other studies take a different approach to this notion, such as those of Viner [14,15], who refers to pecuniary externalities. While Cornes and Sandler [16], speak rather of distributional externalities.

Davis and Kamien (1972), show that externalities are impediments to the efficient functioning of market mechanisms. The theory of property rights does not purely obey economic forces. The arrangements observed in several countries do not always constitute an optimal solution from an economic or social perspectives. In Cameroon, the exploitation of the vast majority of land was governed by customary law, which was not recognised by the state until very recently. Despite the imperfections of these socially sub-optimal land tenure systems, which often remain economically inefficient in the long run [17].

The precautionary principle is undeniably taken into account in the process of sustainable development [18]. Hence, the rise of environmental economics theories since 1960 to limit the misuse of natural resources in world economies. In recent decades, the international scientific community has focused its attention on environmental problems relating to the

¹⁰ Decision of the Peoples' Tribunal of Cameroon; First session of 30 September 2005.

¹¹ This article recalls the principle of industrial ecology, which goes beyond the theoretical framework that apprehends an industrial symbiosis according to which industrial ecology is part of a territorial development dynamic. All this is done by insisting more particularly on the decisive role of territorial projects and interactions that create specific resources

¹² Internalizing these effects means that the collective or social costs are borne by those who generate them. And from then on, the individual optimum becomes compatible with the social optimum.

¹³ These are externalities where the agent who suffers them is able to pass them on to a third party, for example in the case of waste transport.

irrationality and inadequacy of human use of natural resources (Bard, 1992). Pollution of the air, water, soil, fauna, and flora are all polluted by harmful human activity. And cause the environment to lose its economic and vital functions [19]. This explains the difficulty of regenerating the environment, hence the problem of the Club of Rome¹⁴.

2.2 Empirical Synthesis

On an empirical side, this study aims for an effective and transparent intervention to help the international consensus in the decision-making of government authorities based on the results obtained. It will also help to take into account the needs of the disaster-affected populations through the field survey and the RAC calculation carried out within the framework of this work. For Laffont and Tirole [20], the involvement of households in the direct management of environmental affairs favourably modifies existing environmental policies (economic growth, population explosion, etc.).

Since the 1970s, environmental economics has undergone significant development with the help of NGOs and international institutions such as the WB, WWF, WCED¹⁵ and WRI¹⁶, which has gained recognition in the wake of numerous environmental disasters. The discovery of sustainable development in 1987 under the leadership of Norwegian Prime Minister Gro Harlem Brundtland laid the foundations for environmentally friendly sustainable development with an emphasis on the protection and preservation of the ecosystem. It was reinforced in 1992 by the WB's World Development Report (WB, 1992). According to Pezzey [21], efficient resource management helps to preserve the stock of natural capital. The WB proposes a rough study of long-term qualitative and quantitative effects which is to be carried out by research firms. In the case of the CTP, the firm Dames & Moore is involved.

We also have the works of Boidin and Zuideau [22] which explains the actions and means proposed make it possible to promote the improvement of the framework for stakeholder consultation (civil society, government, COTCO)

¹⁴ A broad-based council of scientists and politicians that addresses the complex issues of the global environment. It pioneered the concepts of sustainable development and ecological footprint.

¹⁵ World Commission on Environment and Development.

¹⁶ World Resources Institutes.

in order to effectively ensure social closure¹⁷. In addition, there are difficulties in adapting the interventions to the dynamics of the analyses. The sectoral approach is confused with the optimisation of material and energy flows [23].

One of the most recent and convincing studies, from our point of view, on environmental regulation and localisation of activities is that of Becker and Henderson in 2000. These studies reveal the degree of ecosystem disturbance and climate change and the impact on activities related to the use of nature [24].

Today, under the leadership of the WB and in order to highlight our work, the long-term assessment is carried out by the Dames and Moore¹⁸ law firm, as announced above through a "costs and benefits" analysis. In the light of the results, an extension of the analysis will be carried out using the contingent valuation method.

Thus, the work of Nguéda [25] confirms the use of this impact assessment. This work highlights the three areas of impact. Thus, in the socio-economic domain we have the effects that the pipeline has had on agriculture, health, employment and business opportunities; in the environmental domain, as well as impacts on water, the management of cultural and sacred sites, and land restoration.

3. EMPIRICAL STRATEGY

The assessment of socio-economic and environmental impacts has made remarkable progress over the last two decades [26] (Knestsh, 2000) OECD manuals [27] and World Bank reports [28].

3.1 The Presentation of the Survey Units and the Data Collection Method

3.1.1 Sampling

Our survey will focus on the heads of households in the districts of the villages represented¹⁹ on

¹⁷ The platform that brings together the operating company, the Pipeline Steering and Monitoring Committee and NGOs, set up since 2005 to resolve the multiple claims of the populations. Over the years, many claims have been made. They have increased from 120 to 240 in 3 years.

¹⁸ Dames & Moore is an American audit firm specializing in environmental impact audits. It was recruited to carry out this study for the Chad-Cameroon Pipeline industrial project.

¹⁹ The results of this analysis are the reduction of indirect offset costs and the exclusion of consortium costs in the analysis.

the impacts crossed by the pipeline. The survey carried out is the quota route survey type with a sampling pitch of 2.

3.1.2 Questionnaire

Our survey was carried out by administering a 7-pages questionnaire to heads of household. This questionnaire was subdivided into four main parts, namely: Identification of the head of household, socio-economic and environmental assessment, the concept of vulnerability, and gender.

3.1.3 Fieldwork and processing

The questionnaires were entered using an input mask designed on the "CSPRO 2.6²⁰" software. The resulting database was transferred to SPSS11.0²¹ allowing us to perform the consolidation and analysis of this data. The estimates were made on STATA after a second export of the data.

As part of our field survey, the selected heads of households completed our questionnaire. The method used here is that of itineraries with one interviewer per village. The itinerary method, also known as the Politz method, is a non-probabilistic sampling method that forces the interviewer to follow a specific route for the survey [29].

3.1.4 To econometric estimation

We carried out this evaluation with the Cost Benefit Analysis which is based on the Quota Evaluation Method in order to determine the Consent to be received. The benefits generated by the pipeline make it possible to achieve a social optimum through a better harmonised compensation plan (Ballet, 2005). The choice of the Contingent Evaluation Method (MEC) results from the fact that there is no market for the assets. The statistico-descriptive analysis, which consists of presenting the different impacts and the level of their actions in the development process, is used for this determination.

²⁰ The Census and Survey Processing System permits to present the data bases of the investigation. This software has been elaborated thanks to the association of the programmers of U. S. Census Office, of International Macro and Serpros TO and serves to the seizure of the data and the apurement of the files.

²¹ Is a set of graphical, statistics and reporting tools and it is used for data verification with two types of a priori and posterior control. It is Data Mining Statistical and Predictive Analysis Software.

The Willingness to Receive (WTR) is an effective means of finding compensation for the harm suffered: environmental degradation and loss of well-being. Modelling is that of the dependent qualitative variable Y_i . In this the logistic model, Y_i is the level of satisfaction well-being or environmental quality. And the coefficients β_i that we determine from Odds Ratios (OR)²²

$$OR = \frac{(\pi(x+1)/(1-\pi(x+1)))/(\pi(x)/(1-\pi(x)))}{= e^{\beta_i}}$$

With P_i the probability that the project is satisfactory for the populations and for the environment. Therefore, $(1-P_i)$ denotes the probability of unsatisfactory (loss of well-being).

$$\text{Log}(P_i/(1-P_i))=Z_i=L_i$$

The Logit model makes it possible to measure the preferences of populations and the use of the environment in terms of discrete choices.

3.1.5 The payment card or determination of consent

It allows the WTR to specify exactly what the different groups expect in the areas and to propose specific corrections. The variables are designated based on the wording of the indicator questions of our analysis (some of which are found in the appendix).

We take into account the correlation matrix. It can be seen that each of the variables is strongly correlated with itself. The variable X_1 is strongly and positively correlated to the variable X_3 and a little less to X_2 and X_4 . Thus, for the first axis, we have the variables X_3 , X_2 and X_4 . For the second axis, we have X_1 and X_6 .

4. EMPIRICAL EVIDENCES AND DISCUSSION

PCA allows a large part of the variance to be explained with a minimum of factors. Its quality is adequate because with extraction it provides very good and relevant coefficients for almost all variables. These coefficients vary between 0.85 and 0.55. As factors 4 to 6 do not explain this variance sufficiently, they are not retained. The rigour of the choice of the extracted factors is

²² The ORs are interpreted according to whether they are less than or greater than unity (Taffé, 2004) in a logistic regression model (INS Lausanne in 2004).

done with the Cattell's elbow. This rigour can be observed at the level where there is a break in the latter. It is noted after the second factor, so that three factors are retained but rigorously two.

We rigorously retain only two components. The six factors have been grouped into two large generic groups which are also the two factor axes, we stop the analysis and interpret the factors.

4.1 Interpretation of the Factors

It is a matter of determining the combination of the factors significant for the degree of responsibility or are the factors significant for the degree of satisfaction as it reflects the degree of responsibility. To do this, we proceed in three steps. Following the examination of the matrix of non-rotating components, we observe that three variables saturate more strongly on factor 1 and therefore make it possible to define it. Only two variables saturate on factor 2. Factor 3 is not saturated by any of the variables. The simple factorial representation is based on Varimax rotation and preserves the independence (orthogonality) between the factors. The variables are much better distributed over the different factors, and at least one variable saturates each of the factors except X6, which saturates none of them.

4.2 Factor Labelling

So we have two components. The first axis, or component 1, with the variables X5 and X6, is the source of compensation income. On the second axis, or component 2, we have the variables X1, X2, X3 and X4, which is called environmental domain and property rights. Therefore, we can also think about eliminating this variable from the analysis. It is renamed "the attachment of land and cultural property rights".

We were able to analyse the perverse effects of the project, particularly for the indicators which are:

- agriculture, large areas crossed and 77.4% of cases of compensatory dissatisfaction;
- health: proliferation of diseases, particularly STIs/AIDS, noise and odour nuisance insufficient monitoring of 90% of the operating company against these diseases;
- employment and the creation of business opportunities: an almost satisfactory area despite job insecurity;

- water management: non-compliance with environmental ²³ regulations has led to disruption in the use of water points in one in three household. Land restoration and the management of cultural and sacred sites have also suffered negative effects, including desecrated places of worship, exhumed tombs, etc.

The results of the logistic regression obtained via Stata 14.0 allow us to assess the degree of satisfaction of heads of household following the compensation received (satisfied = 1 or not = 0). The Odds Ratios ²⁴ allow us to confirm these results since the majority of the variables are dichotomous variables. We have:

$$\text{CAR /domain} = \text{Average} * \text{number of analysis}$$

It is retained that these funds, efficiently oriented, will be fair, important and sufficient, in relation to the expectations of the local residents and the preservation of the environmental space. The RAC is the minimum amount that the heads of households are willing to not benefit directly from an improvement through the institutions set up. They prefer to defer it to dispose of it as they wish and according to their needs. The wishes of local residents to receive compensation for the destruction suffered and to accept the repairs; reflect reality. The high CAR depends on the magnitude of the effects within a region. The amounts committed will be used to improve the situation in lieu of the location of the industrial exploitation project. We note that in the South, the socio-economic and environmental effects are felt more strongly. This region has a very diversified fauna, flora, and human activities, from which the orchestrated effects impact several areas. Moreover it mobilises important means to urgently clean it up if we want to benefit from it in a sustainable way and if we want to ensure its emergence. The aggregated results of the average CAR are recorded in the Table 1.

Thus, an optimal distribution is made involving the degree of responsibility and participation from the different groups of actors, we have the following graph.

²³ The route was designed to avoid, as much as possible, water corners with high domestic use.

²⁴ ORs are interpreted as less than or greater than 1 (Taffé, 2004) in the INS Lausanne logistic regression model.

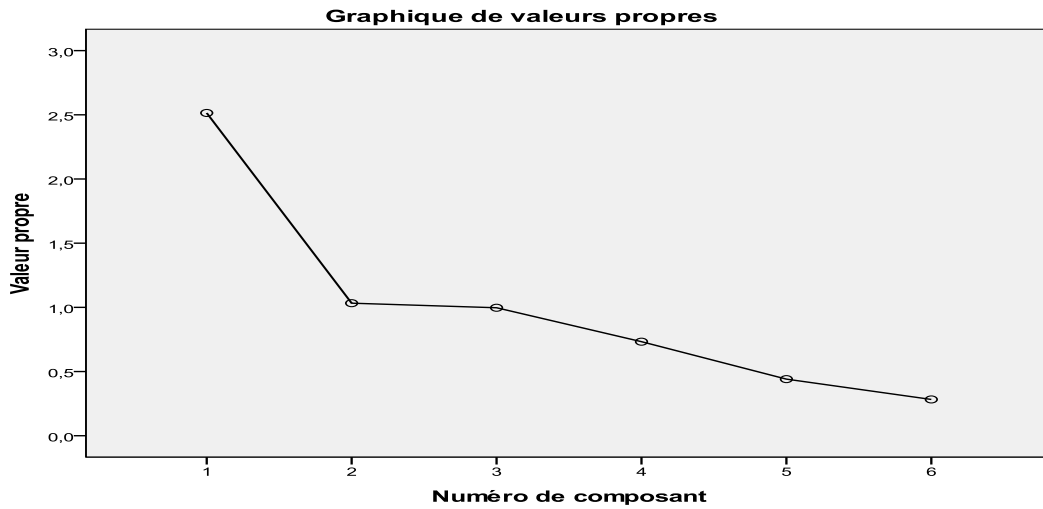


Fig. 1. Eigen value matrix
 Source: Author's Computation using XLSTAT

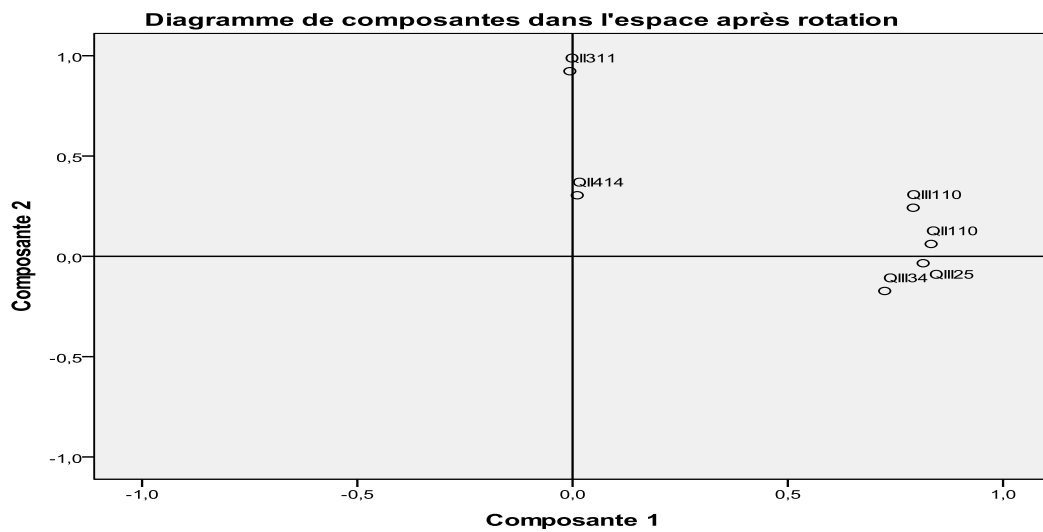


Fig. 2. Component in space after rotation
 Source: Author's Computation using XLSTAT

Table 1. Average WTR of characteristic variables

Characteristics	Average WTR
Region	62 960 993
Sex	58 850 513
Marital Status	59 433 477
Level of education	62 292 299
Religion	54 362 643
Sector of activity	58 536 916
Agriculture domain	59 781 622
Health domain	60 940 176
Individual community and regional compensation domain	59 434 982
Employment and business opportunities	59 986 960
Water management	58 819 495
Land Restoration	64 499 784
Management cultural and sacred sites	56 765 693
Gender Responsibility and vulnerability	59 240 344

Source: Author

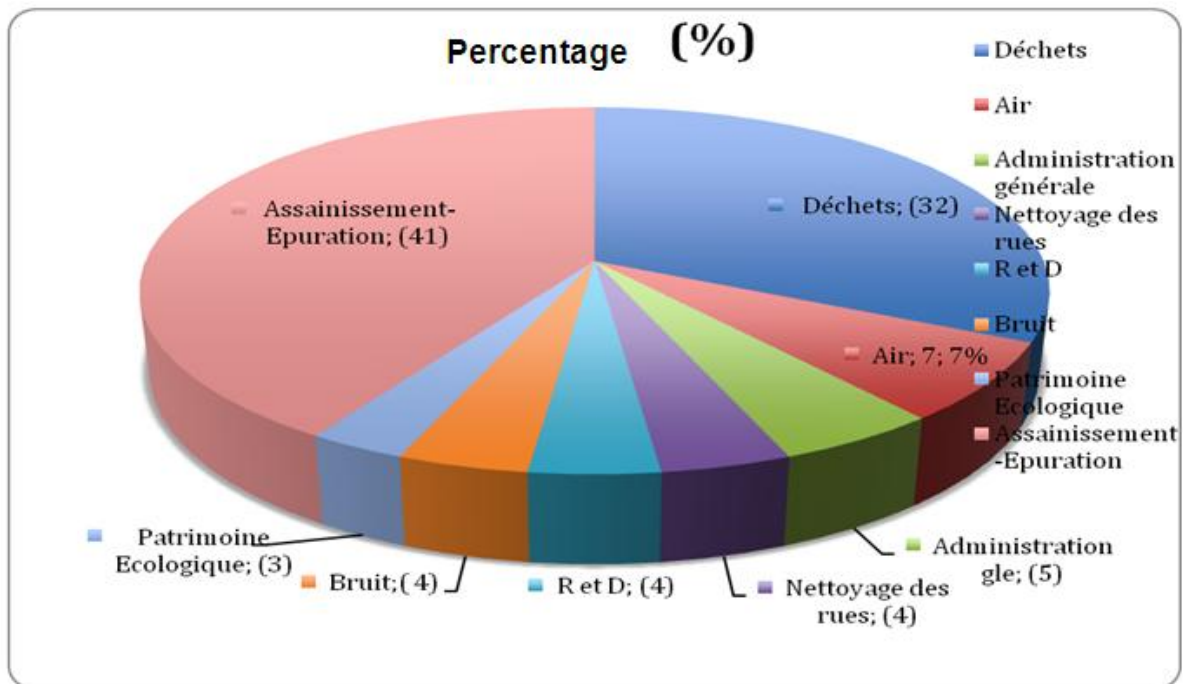


Fig. 3. Involvement of targets in putting well-being and environmental protection at the heart of the process

Source: Author's Construction using XLSTAT

Variables such as agriculture, health, water management, age, marital status, and management of cultural and sacred sites proved to be very significant for the compensation model and overall, following econometric tests for the validity of the model.

Through numerous activities, man modifies his environment and is directly or indirectly responsible for the disappearance of many living species. A procedure has been established to ensure that such experiences no longer generate as many negative repercussions.

5. CONCLUSION AND RECOMMENDATIONS

This work focuses on testing the global sectoral ecology of industrial investments, specifically that of the Chad-Cameroon pipeline. We present the essence of one of the most significant investments ever made in sub-Saharan Africa and its negative impact on the neighbouring populations and the environment. From the above, it emerges, on the one hand as an asset, as the operation of the Chad-Cameroon pipeline has economically generated significant wealth and capital transfers [30]. On the social and environmental level, there has been the

construction of some social infrastructure and the creation of protected areas in some regions. On the other hand, there are still significant social and environmental gaps. We, therefore, propose a remedial approach to the damage [31-40].

More than 10 years after the start of the JTP's operation, we can see that, apart from the flattering promises made before the construction period, there is only one source of impoverishment left in the parts of the countries where it has been established. There are problems of changes in the well-being of the population (health, marginalisation of women, degree of vulnerability, and income-generating activities) and the environment (water resources, management of cultural and sacred sites, and land restoration). The inadequacy of compensation, the dissatisfaction of local populations, and the neglect of proposals made by NGOs attest to the pre-eminence of the economic aspect over the social and environmental [41-47].

In this way, the Cameroonian government must ensure the rigorous adoption of robust safeguard measures for threatened indicators: water, cultural and sacred sites, employment by facilitating the integration of qualified indigenous

people into projects. This rigour would also reside in the application of regulatory instruments and bargaining solutions that lead to an efficient level of depollution. The use of the Pigouvian tax is logical because it is an important tool. The practice of sustainable development would generate benefits in terms of environmental security, human well-being, and competitiveness. The choices made today in terms of infrastructure with the establishment of the industrial structuring projects which are exploding in the country are based on sustainable development. They influence present opportunities and future options.

The civil society of local residents who are still disadvantaged should be involved. The experts' assessment of the loss of ecosystem services prevents the achievement of the MDGs on poverty reduction, environmental protection, food insufficiency, the resurgence of endemic diseases and gender inequality.

Establish economic policies for the country with a new vision on livelihood security and economic prosperity. The aim is to transform Cameroon's ecological capacity into an asset for sustainable development and prosperity.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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APPENDIX

List of ONG:

- Groupe Externe de Suivi de la Conformité Environnementale (ECMG).
- World Wildlife Fund (WWF).
- Wildlife Conservation Society (WCS).
- Institut de Recherche et de Développement (IRD) etc.
- FEDEC constituted by the Cameroon Oil Transportation Company (COTCO) proposes an environmental improvement program partnership with the Foundation for the Environment and Development of Cameroon (FEDEC);
- And other environmental NGOs...

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