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Article

Environmental assessment of the Chad-Cameroon oil and pipeline project in the Kribi region of Cameroon

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Trans-national projects of the magnitude of the Chad-Cameroon oil and pipeline project must always have some negative effects on the quality and quantity of the environment. Following an environmental impact assessment (EIA) a series of mitigation measures must be put in place to minimize the intensity of the negative effects of the project on the environment. The paper seeks to assess the impact of the construction of the Chad-Cameroon oil pipeline on the biophysical environment and to appraise the mitigation measures adopted. It uses a combination of primary and secondary data sources to collect information on 3 towns and 10 villages in the Kribi region based on 10 impact variables. The data so obtained were analysed using appropriate quantitative techniques. The results of the analysis show that most of the biophysical impact variables had negative effects on the environment. The paper summarizes the environmental impact analysis by grouping the impacts into high, medium and low categories. The project has high negative impacts on wildlife habitats and the loss of biodiversity, medium impact on erosion on excavated areas and low impact on deep land cuts, oil spills from the pipeline, atmospheric pollution, damage to the marine environment and solid waste disposal. The paper attributes this to the mitigation measures adopted by the project. The paper emphasizes the need for a review of various environmental commitments made by the various parties to the project and to appraise their implementation. A proper balance between the benefits expected from such projects and the environmental costs can only be obtained through impact studies and careful monitoring. Lessons are drawn that can aid the sustainability of such projects.

Key words: Environmental impact, biophysical environment, impact variables, environmental costs, environmental impact assessment, monitoring, Kribi region, Chad-Cameroon oil pipeline.

INTRODUCTION

The earliest idea of a pipeline to carry crude oil was put forth in Parkersberg in U.S.A. There has since been enormous technological development in the construction of pipelines as a fast and most reliable means of transporttation of oil.

Generally, some scholars have specifically studied some oil pipeline projects though their studies have not focused on the environmental implications (Weltsch, 1996; Lalazarian, 1997; Dias de Avila-Pires, 1999; Doeffer, 1992). The negative environmental impacts of oil pipelines have been established by some scholars (Uibopuu, 1995; Roberts, 1996; Ogbu, 1996; Ifeadi and Awa, 1987). The studies on oil pipelines are generally few but recently, there is an apparent need to examine the environmental impact of such projects as one of the inevitable criteria for achieving sustainable development in both the developed and developing countries.

The EDF [Environmental Defence Fund (1999)] noted that the Chad-Cameroon oil pipeline project has both local and global potential environmental impacts. Hough (2001) acknowledged that there are also environmental issues surrounding the offshore offloading facility on Cameroon's Atlantic coast. Similar concerns about the pro-ject have been raised by Stevenson (2004); Ongbwa (2002); Nguiffo and Breitkopf (2001). A recent study by the University of Warwick (U.K.) calculated that the value of the renewable resources of the coastal zone of Cameroon directly affected by the oil pipeline would be nearly about

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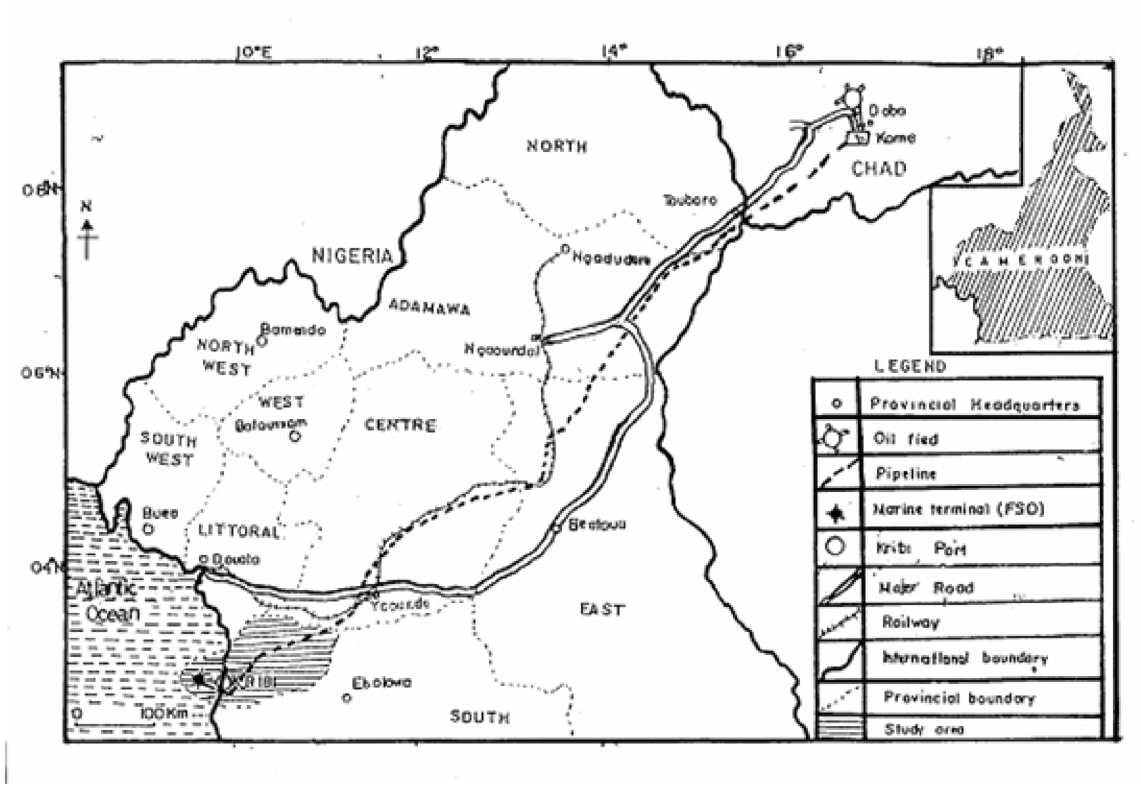

Figure 1. Location of the study area and the Chad-Cameroon oil pipeline (Source: Banyuy, 2006).

104 dollars per capita per year, compared with the benefits of the pipeline estimated at 4 dollars per capita per year over its thirty-year operation. This study also emphasized that maximum protection is needed because pipeline leaks would create a large net loss for Cameroon as a whole (Price et al., 1999).

The general aim of the paper is to identify the components of the environment affected by the construction of the Chad-Cameroon oil pipeline in the coastal region of Kribi and to examine the mitigation measures and management strategies that have been adopted to avoid or reduce the intensity of the negative impacts. In more specific terms, the paper seeks to assess the impact of the construction of the pipeline on the biophysical environment; and to appraise the mitigation measure adopted in order to draw lessons for similar project.

PROBLEM BACKGROUND AND THE STUDY AREA

The study area is located within latitude, 20°55'N and 3°55'N and longitude 9°59'E and 11°E (Figure 1). This coastal region of Cameroon is characterized by a rolling landscape with elevations ranging from 500 - 1000 m above sea level. There is a narrow coastal plain colonized by mangrove forest. The rest of the hinterland is fragile rain forest. Metamorphic rocks constitute the geology of the interior low plateau while the coastal plain is composed of sedimentary rocks (Dames and Moore, 1997). The sea floor slopes gently to the west and water depths are suitable for the location of a floating storage and offloading vessel (FSO) some 10 km offshore (Dames and Moore, 1997). The climate is equatorial with an average annual rainfall of 3000 mm (Moby, 1979).

The regional capital is the town of Kribi. The magnificent beaches in Kribi attract several tourists. Bipindi and Lolodorf are secondary towns. Out of these urban centres are rural settlements engaged in agriculture, fishing, and hunting. The local people, therefore, mostly depend on the natural environment for their livelihoods. As such, the environmental effect of constructing a pipeline and other installations in the area need to be investigated. The study area is traversed by the Chad-Cameroon oil pipeline. This underground pipeline passes through ecologically fragile rain forest areas (Walsh, 1997). The project therefore threatens valuable ecosystems (Figure 2).

RESEARCH METHODS

There are different methods and approaches to environmental impact assessment of development projects (Goodland and Edmundson, 1994). According to Smith (1993), the five principal types of methods are checklist, interactive matrices, overlay mapping, network and simulation modeling. This study adopted the use of a checklist to identify the impacts of the oil pipeline on a list of biophysical resource variables (biotic and abiotic components). The varia-

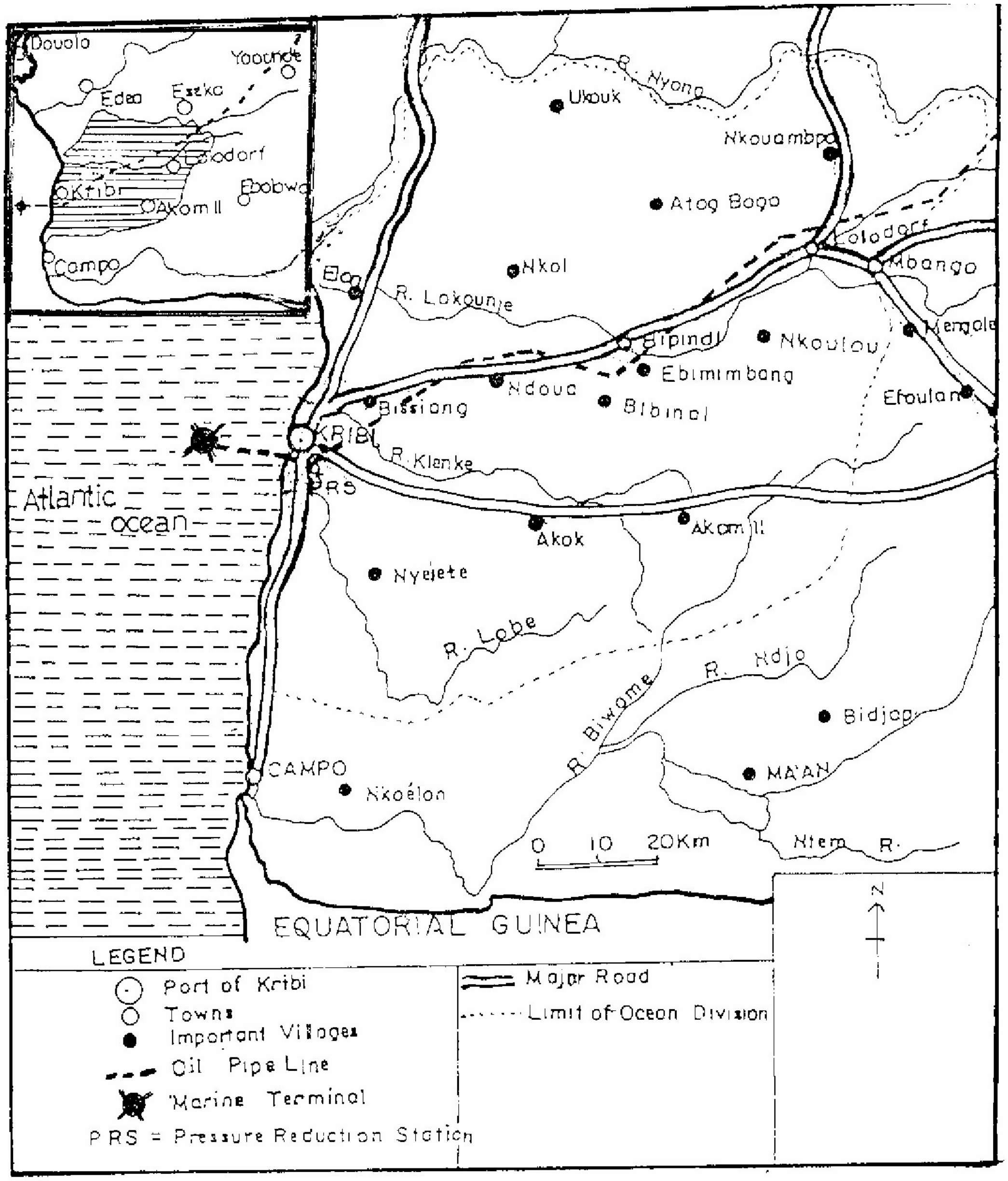

Figure 2. Location of towns, villages and the Chad-Cameroon oil pipeline in the Kribi region (Source: Banyuy, 2006).

bles were derived from the checklist of potential issues to be dealt with in an environmental assessment as stipulated by the project environmental document. This checklist designed on a five-point response continuum scale was based on the Likert Scale. Strong positive impact was coded 5, positive impact was coded 4 while no impact observed, negative impact and strong negative impact were coded 3, 2 and 1 respectively. The quantification of the impacts into five categories enabled a determination of the degree to which each item contributes to the impact of the oil pipeline.

Three towns and ten villages were selected for investigation based on their proximity to the pipeline route. These are presented in Table 1.

Questionnaires (Checklists) were administered to randomly selected respondents in these sites. The Checklists were based on the impact of the oil pipeline during and immediately after construction. The distance of the pipeline investigated is 130km. This constitutes 12.15% of the entire distance covered by the pipeline. Data collected using the checklist method was supplemented by field observations, secondary sources and informal interviews. Data on various mitigation measures on the negative impacts and the management strategies were obtained from the Chad-Cameroon Project head office in Douala.

The impact of the Chad-Cameroon oil pipeline on the biophysical environment was analysed for villages and towns. All together ten variables were assessed on the Likert five-point response continuum scale. An addition of all the variables totaled 15 points.

These were divided by 5 to obtain a mean of 3. Thus any mean above 3 indicates a positive impact and below 3 a negative impact. A mean of exactly 3 implies that no impact was observed. Each item was assessed in quantitative terms in order to determine the

Table 1. Summary of data collection sites.

	S/N	Sites	Number of questionnaires (checklist)
Towns	1	Kribi	28
	2	Bipindi	30
	3	Lolodorf	30
	Total		88
Villages	1	Bidjouka	25
	2	Saballi	20
	3	Nkwabou	20
	4	Ndoua	20
	5	Madoug II	15
	6	Bissiang	15
	7	Mill	15
	8	Mboamanga	10
	9	Ebome	10
	10	Mpangou	10
	Total		160

degree of impact which the pipeline exerts on the biophysical environment using a combined frequency analysis, and principal component analysis. The main variables investigated were: evidence of deep land cuts, and excavation for material, erosion of excavated areas, depletion of land for other uses, damage to wildlife habitat, loss of biodiversity, oil spill, atmospheric emission (pollution), damage to marine environment and abandonment of solid waste.

DATA PRESENTATION AND DISCUSSION

From Table 2, evidence of deep land cuts (A1) scored 55.3% on no impact observed while in 40.7% of the cases, the impact observed was negative. When all the cases were put in consideration, a mean of 2.6 and a standard deviation of 0.6 give the impression that this item had a negative impact on the physical environment. Where the pipeline cuts across the interior lower plateau around the Mbikiliki hills along the Kribi-Lolodorf road, there was more evidence of deep land cuts than in the coastal lowlands.

Land excavation for materials (A2) scored 64.1% on the negative impact column 34.3% on no impact observed, 0.4% on strongly positive and 1.2% on positive impact. With a mean of 2.4 and a standard deviation of 0.5, this item is evidently impacting negatively on the physical environment.

Erosion from excavated areas (A.3) also registered a higher percentage of 63.7 on the negative column, while 34.7% of the cases registered no impact. With a mean of 2.4 and a standard deviation of 0.5, this item also indicates a negative impact on the physical environment. It is evident that the respondents who never observed any land excavation for materials (34.3%) never also observed any erosion from excavated areas (34.7%). Depletion of land for other uses (A4) has a mean of 2.6, standard deviation of 0.6 and variance of 0.4. Majority of the respondents never observed any impact (51.6%), whereas, 46% of them observed a negative impact on the physical environment. Generally, this item also exhibits a negative impact on the physical environment.

For damage to wildlife habitat (A5), strong negative impact was recorded in 68% of the cases, while 30.4% of the cases registered negative impact. With a mean of 1.4 and standard deviation of 0.6, this had a very negative impact on the environment. This is because damage to wildlife habitat could not be determined in only 0.4% of the cases, while only 0.4 and 0.8% were registered on the strong positive and positive impact respectively.

Because of much damage to wildlife habitat, 71.8% of the respondents noticed a strong negative impact on the loss of biodiversity (A6) and a further 26.6% gave a negative impact impression. Thus, this item also had a very negative impact on biodiversity. A mean of 1.3, standard deviation of 0.6 and a variance of 0.4, simply confirms the very negative impact of this item on the environment.

The situation with the oil spill (A7) is however different. In 94% of the cases, no impact was observed while negative and strong negative impacts had a negligible percentage score of 2.4% each. A mean of 3.0, standard deviation of 0.4 and a variance of 0.2 gives the impression that no impact was observed in most of the cases.

For atmospheric emission (A8) the respondents observed a negative impact in 95.6% of the cases, while no impact observed and positive impact scored 1.6% each. Strong positive impact had a score of 0.4 and strong negative impact scored an average of 0.8%. With a mean of 2.1, a standard deviation of 0.3 and a variance of 0.3, this item also had a negative impact on the environment.

Damage to marine environment (A9) scored 51.2% on no impact observed, meaning that more than half of the respondents did not observe any impact. However, the impact was negative for 46.8% of the cases. That is, the respondents who might have been very vigilant especially within the coastal environment. The strong positive and positive impact columns scored an average 0.4% and 0.8% respectively, while 0.8% went to the very negative impact. With a mean 2.5, standard deviation of 0.6 and

Table 2. Absolute and relative frequency, distribution of the biophysical impacts for rural and urban areas.

Code	Variable	Strong Positive Impact	Positive Impact	No impact observed	Negative Impact	Strong negative Impact	Mean	STD Dev.	Variance
		5	4	3	2	1	*x*	(s)	(v)
A1	Evidence of deep land cuts	4 (1.6%)	2 (0.8%)	137 (55.3%)	101 (40.7%)	4 (1.6%)	2.6	0.6	0.4
A2	Land excavated for material	1 (0.4%)	3 (1.2%)	85 (34.3%)	159 (64.1%)	- -	2.4	0.5	0.3
A3	Erosion of excavated areas	1 (0.4)	3 (1.2%)	86 (34.7%)	158 (63.7%)	- -	2.4	0.5	0.3
A4	Depletion of land for other uses	4 (1.6%)	- -	128 (51.6%)	114 (46.0%)	2 (0.8%)	2.6	0.6	0.4
A5	Damage to wildlife habitat	1 (0.4%)	2 (0.8%)	1 (0.4%)	75 (30.4%)	168 (68%)	1.4	0.6	0.3
A6	Loss of biodiversity	4 (1.6%)	- -	- -	66 (26.6%)	178 (71.8%)	1.3	0.6	0.4
A7	Oil spill	3 (1.2%)	- -	233 (94%)	6 (2.4%)	6 (2.4%)	3.0	0.4	0.2
A8	Atmospheric emission (pollution)	1 (0.4%)	4 (1.6%)	4 (1.6%)	237 (95.6%)	2 (0.8%)	2.1	0.3	0.1
A9	Damage to marine environment	1 (0.4%)	2 (0.8%)	127 (51.2%)	116 (46.8%)	2 (0.8%)	2.5	0.6	0.3
A10	Abandonment of solid waste	1 (0.4%)	3 (1.2%)	235 (94.8%)	8 (3.2%)	1 (0.4%)	3.0	0.3	0.1

variance of 0.3, we can conclude that this item had a significant negative impact on the environment Abandonment of solid waste (A10) from the analysis scored 94.8% on the no impact observed column. The strong positive impact and strong negative impact scored negligible percentages of 0.4% each, while 1.2% of the cases were noted to have positive impact and a 3.2% score for the negative column. With a mean of 3.0, standard deviation of 0.3 and a variance of 0.1, the impression is that no serious impact was actually observed.

From the discussions above one can conclude that majority of the items had a negative effect on the environment while in some few cases, the respondents found no impact. From the frequency analysis for towns (Table 3) and villages (Table 4) one can notice a slight difference in the perception of the different respondents. For evidence of deep land cuts (A1), villages scored a 71.3% on the no impact observed column while the towns scored 26.1% on that very column but had their highest percentage of 63.6% on the negative impact column. While towns had a mean of 2.4, villages scored a mean of 2.7. Though the impact was generally negative, most respondents in the villages found it difficult to identify the impact.

Land excavation for materials (A2) and erosion from excavation areas (A3) in towns recorded 71.6 and 69.3% respectively as opposed to 60 and 60.6% respectively, for the villages, under negative impact. The stan-dard deviations for the two variables were 0.6 for towns and 0.5 for villages, whereas, the mean score was approximately 2.4 for the two variables in both areas. Thus, the negative effects of these variables were felt at almost the same intensity in both towns and villages.

Depletion of land for other uses (A4) showed a negative impact on the physical environment on 43.7 and 73.8% of the cases respectively in towns as well as 68.1 and 70.6% on the same column for villages. The mean score were 1.4 each for both items in the towns and 1.3 each for both items in villages. The general impression is that, these items had a strong negative impact in the two areas but with a greater intensity in the rural areas.

Damage to wildlife habitat (A5) and loss of biodiversity (A6) scored strong negative impact of 68.2 and 73.8% of the cases respectively in towns as well as 68.1 and 70.6% on the same column for villages. The mean score were 1.4 each for both items in towns and 1.3 each for both items in the villages. The general impression is that, these items had a strong negative impact in the two areas but with a greater intensity in the rural areas.

For oil spill (A7), the impact could not be determined in 94.3% of the cases in the towns as compared to 93.8% of the cases in the same column for the rural areas. The negative scores are very negligible, which is 2.5 and 31%

Table 3. Absolute and relative frequency distribution of the biophysical impacts for towns only.

Code	Strong Positive Impact	Positive Impact	No Impact Observed	Negative Impact	Strong Negative Impact	Mean	STD Dev.	Variance
	5	4	3	2	1	$\bar{x}$	(s)	(v)
A1	4 (4.6%)	1 (1.1%)	23 (26.1%)	56 (63.6%)	4 (4.6%)	2.4	0.8	0.6
A2	1 (1.1%)	2 (2.3%)	22 (25%)	63 (71.6%)	-	2.3	0.6	0.3
A3	1 (1.1%)	2 (2.3%)	24 (27.3%)	61 (69.3%)	-	2.4	0.6	0.3
A4	4 (4.6%)	-	38 (43.3%)	44 (50%)	2 (1.1%)	2.5	0.8	0.6
A5	1 (1.1%)	2 (2.3%)	1 (1.1%)	24 (27.3%)	60 (68.2%)	1.4	0.7	0.5
A6	4 (4.6%)	-	-	19 (21.6%)	65 (73.8%)	1.4	0.9	0.8
A7	2 (2.3%)	-	83 (94.3%)	1 (1.1%)	2 (2.3%)	3.0	0.4	0.2
A8	-	2 (2.3%)	2 (2.3%)	82 (93.2%)	2 (2.1%)	2.0	0.4	0.1
A9	1 (1.1%)	1 (1.3%)	7 (8%)	77 (87.5%)	2 (2.3%)	2.1	0.5	0.2
A10	-	3 (3.4%)	83 (94.4%)	1 (1.1%)	1 1.1%)	3.3	0.3	0.1

N.B: The values within the brackets are relative frequency distribution in percentages.

Table 4. Absolute and relative frequency distribution of the biophysical impacts for villages only.

Code	Strong Positive Impact	Positive Impact	No Impact Observed	Negative Impact	Strong Negative Impact	Mean	STD Dev.	Variance
	5	4	3	2	1	$\bar{x}$	(S)	(V)
A1	-	1 (0.6%)	114 (71.3%)	45 (28.1%)	-	2.7	.05	0.2
A2	-	1 (0.6%)	63 (39.4%)	96 (60%)	-	2.4	05	0.3
A3	-	1 (0.6%)	62 (38.8%)	97 (60.6%)	-	2.4	05	0.3
A4	-	-	90 (56.3%)	70 (43.7%)	-	2.6	05	0.2
A5	-	-	-	51 (31.9%)	109 (68.1%)	1.3	1.2	1.5
A6	-	-	-	47 (29.4%)	113 (70.6%)	1.3	0.5	0.2
A7	1 (0.6%)	-	150 (93.8%)	5 (2.5%)	4 (3.1%)	2.9	0.4	0.2
A8	1 (0.6%)	2 (1.3%)	2 (1.3%)	155 (96.8%)	-	2.1	0.3	0.1
A9	-	1 (0.6%)	1 (0.6)	39 (24.4%)	-	2.8	0.4	0.2
A10	1 (0.6%)	-	-	7 (4.4%)	-	3.0	0.3	01.

NB: The values within the brackets are the relative frequency distribution in percentages.

Table 5. Correlation matrix of biophysical environmental impact for towns.

Variable	A1	A1	A3	A4	A5	A6	A7	A8	A9	A10
A1	1.000									
A2	.361	1.000								
A3	.211	.733*	1.000							
A4	.260	.647*	.532*	1.000						
A5	.446	.629*	.419	.455	1.000					
A6	.557*	.580*	.469	.529*	.919*	1.000				
A7	.060	-.139	.279	-.283	-.007	-.032	1.000			
A8	.613*	.403	.515*	.236	.535*	.605*	.237	1.000		
A9	.611*	.522*	.403	.323	.626*	.675*	.014	.682*	1.000	
A10	.470	.279	.152	.326	.418	.496	.081	.485	.479	1.000

Significant coefficient ±0.50 at 95%confidence level.

3.1% on the negative and strong negative columns respectively for villages as opposed to 1.1 and 2.3% for towns. With a mean of 2.9 for villages and 3.0 for towns, one can conclude that no serious oil spill had occurred for the respondents in these two areas to observe an impact.

The variable atmospheric emission (pollution) scored 93.2% on the negative impact column for towns but a 96.8% score on negative impact for villages, giving the impression that the atmospheric emission was highly observed in the rural areas, where most construction took place. The mean, standard deviation and variance were 2.1, 0.3 and 0.1 respectively for villages as opposed to 2.0, 0.4 and 0.1 respectively for towns.

Damage to marine environment (A9) could not be observed in 75% of the cases in the villages, whereas 87.5% of the cases observed a negative impact in the towns. This is because most of the respondents in the coastal towns of Kribi had observed some damages done on the marine environment during the period of construction. The mean score was 2.1 for the town and 2.8 for the villages.

Lastly, the abandonment of solid waste (A10) scored 94.4% on the no impact observed column in the towns. This score was very close to the 95% score on the very column for the villages. This gives the impression that the impact of this item had not been observed in the town and villages, with a mean, standard deviation and variance of 3.3, o.3, 0.1 and 3.0, 0.3, 0.1 respectively.

The relationship between each variable of the biophysical environmental impact assessed was established by Pearson's correlation technique. This resulted in a 10x10 matrix of interrelationship as shown in Table 5. An Observation of the correlation matrix (Table 5) shows that a good number of the variables are highly correlated with each other and may be difficult to interpret. It can be deduced from the table that 7 independent variables are positively correlated, while the remaining 2 variables are weakly correlated. A majority of the variables have a positive correlation while negative correlations are noticed only in four cases. However, only three variables have significant correlation coefficients. The variables are: evidence of deep land cuts (A1), land excavation for materials (A2) and damage to wildlife habitat (A5). In all, there are 17 significant correlation coefficients between all the variables. The explanations of the pattern may be difficult because of the existence of some redundancies, thereby making factor analysis, or the principal component analysis (PCA) inevitable. The PCA technique in this case is strengthened by the application of the orthogonal (varimax) rotation of the original components without change in the position of the original variables. The result of the orthogonal rotation enabled the determination of the distinctive loadings of variables so as to enable that each variable possesses the highest load on one and only one component or factor.

The varimax rotation of the PCA output in Table 6 shows how each category of biophysical environmental impact variables is related to each of the components. The degree of association of the category of variables and component are shown by the component loadings. The component loadings are high and registering above 0.70 in some cases but as low as 0.031 and 0.036 in some cases. In this study, significant loadings are those that are up to ±0.70 at the 95th level of confidence. The PCA has succeeded in reducing the 10 independent variables to three uncorrelated components which together account for 76.3% of the total variance within the variables. Thus, leaving only 23.7% of the total variance in the variables unexplained.

Component I explain 34.8% of the total variances and have significant loadings on 5 variables. The variables are A1 (evidence of deep land cuts), A6 (loss of biodiversity), A8 (atmospheric emission-pollution), A9 (damage to marine environment), A10 (abandonment of solid waste). It was discovered that at the lower plateau where the pipeline cuts across, there is evidence of deep land cuts, which have an influence on the topography. Such deep cuts were also observed in areas where the landscape

Table 6. PCA of the biophysical environmental impact for towns (Varimax rotation).

Variable	Component		
	I	II	II
A1	.812*	.081	.036
A2	.290	.865*	.069
A3	.121	.857*	.428
A4	.200	.772*	-.336
A5	.655	.530	-.071
A6	.733*	.517	.081
A7	.056	-.083	.953*
A8	.743*	.278	.364
A9	.782*	.321	.049
A10	.741	.051	.031
Eigenvalues % of Expl.	4.98	1.46	1.18
Variance Cum. % of	34.8	28.2	13.2
Expl.Var.	34.8	63.0	76.3

* Significant loadings exceeding ±0.70.

Table 7. Correlation matrix of the biophysical environmental impact for the villages.

Variables	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	1.000									
A2	.436	1.000								
A3	.423	.976*	1.000							
A4	.416	.311	.341	1.000						
A5	.147	.259	.251	.377	1.000					
A6	.184-	.297	.287	.292	.868*	1.000				
A7	-.009	-.089	-.157	.148	.158	.013	1.000			
A8	.082	-.109	-.145	.119	.034	.040	.118	1.000		
A9	.087	.189	.208	.347	.010	.023	-.142	0.67	1.000	
A10	-.018	-.095	-.215	.034	.149	.019	.774*	.187	-.157	1.000

* Significant co-efficient ±0.50 at 95% confidence level

was modified for the construction of project facilities. Since the pipeline runs approximately 11 km offshore, there was also some destruction within the marine environment. This is attributed to the use of heavy equipments that emitted a lot of hydrocarbon in the atmosphere, thereby causing atmospheric pollution. It also led to the loss of biodiversity. Thus the underlying factor (component) is identified as environmental destruction. The factor has an eigenvalue of 4.98.

Component II has significant loading on three variables and has eigenvalue of 1.46 and explains 28.2% of the total variance. The variables A2 (land excavation for materials), A3 (erosion from excavation areas) and A4 (depletion of land for other uses). During the period of construction, project constructors required construction materials such as laterite, sand and gravel to build roads, bridges and camps for the workers. They excavated these building materials from burrow pits, some of which were abandoned un-reclaimed after they were no longer required. This depletion of land for other uses encouraged erosion especially from the excavated areas. The un-derlying component is therefore focused on soil erosion, since the factor highlights different aspects that could en-courage the rate of erosion.

Component III is highly loaded on one variable, A7 (oil spill). This emphasises the danger to the environment of oil spills, whenever they occur. Consequently, the factor is labeled, the influence of oil spills on the environment. It has an eigenvalue of 1.18 and explains 13.2% of the total variance.

The biophysical impact relationships for the 10 variables were also established separately for the villages, using the Pearson correlation technique for the purpose of comparison.

An observation of the correlation matrix for the villages (Table 7) shows that the majority of the variables are weakly correlated with each other and therefore highly relevant for independent study. Only 3 independent variables are positively correlated as opposed to 7 in the cases of towns. In case of villages, there are 3 significant co-

Table 8. The PCA of the biophysical environmental assessed impact for villages (Varimax rotation).

Variables	Components I	II	III	IV
A1	.635*	0.45	.084	.277
A2	.933*	.155	-.075	-.056
A3	.929*	.155	-.175	-.048
A4	.429	.295	.111	.605*
A5	.138	.949*	.121	.058
A6	.152	.950*	-.029	.034
A7	-.013	.042	.924*	.028
A8	-.213	.034	.211	.644*
A9	.206	-.067	-.283	.677*
A10	-.071	.043	.934*	.016
Eigenvalues	3.06	2.08	1.32	1.17
%of Expl. Variance	24.6	19.5	19.0	13.3
Cum. % of Expl. Var.	24.6	44.1	63.1	76.3

rrelation coefficients as opposed to 17 for the towns.

The PCA was also computed separately for the villages and the results are shown in Table 8.

The varimax rotation of PCA shown in Table 8 reveals that it has reduced the 10 variables to 4 components as opposed to 3 components in the case of towns. What is very peculiar here is that the significant loading for the first 3 components have very high coefficients, each exceeding 0.90 in most cases. With a cut-off value of the factor loadings at ±0.60, three of the variables in component IV had significant loadings.

Component I explaining 24.6% of the total variance has signficant loading on 3 variables. These variables are A1 (evidence of deep land cuts), A2 (land excavation for materials) and A3 (erosion from excavated areas). The explanation is simple. If land was excavated to obtain gravel, laterite and sand for construction, there were signs of deep land cuts and such areas are bound to suffer from erosion. This component is therefore focused on soil erosion, with an eigenvalue of 3.06.

Component II also loads highly on 2 variables, namely A5 (damage to wildlife habitat) and A6 (loss of biodiversity). It was discovered that the villages in the hinterland are located within the thick ecological fragile rainforests. The construction of the pipeline across this forest therefore constituted a threat to this sensitive ecosystem with its unique wealth of plants and animals. As a result the damage to wild life habitat led to much loss of biodiversity. Consequently, the underlying factor is identified as ecosystem damage. This component explains 19.5% of the total variance, with an eigenvalue of 2.08.

Component III explains 19% of the total variance and has significant loading on two variables, namely A7 (oil spill) and A10 (abandonment of solid waste). This can be explained by the fact that the deposition of solid waste especially from construction equipment and transport vehicles led to minor oil leakages especially during the period of construction. This had a negative effect on the environment, thus the underlying factor is identified as the causes of minor oils spills. The eigenvalue is 1.32.

Component IV has significant loadings on 3 variables A4 (depletion of land for other uses), A8 (atmospheric emission-pollution) and A9 (damage of marine environment). It was discovered that during the period of construction, a lot of atmospheric pollution was caused by the heavy equipment used in modifying the landscape for the installation of project facilities. Thus there was depletion of land by project facilities even within the coastal environment. Consequently, this factor is identified as damage to the physical landscape. The component explains 13.3% of the total variance, with an eigenvalue of 1.17.

Conclusions and Recommendations

A relative frequency count and the computation of the absolute frequencies for the combined biophysical impact variables for both the towns and villages shows that most of these variables had a negative impact on the environment. It was only in the case of oil spills and abandonment of solid waste that most respondents found it difficult to observe an impact. When the data were analysed separately for the towns and villages it was discovered that the biophysical variables still had a negative impact but with slightly different intensities in the towns and villages for individual items. Using the principal component analysis separately too for the towns and villages the study identified three factors (components) for the towns and four components for the villages with their eigenvalues and percentages of total explanation of the variance:

*Town:
- environmental destruction: 4.98(34.8%)
- Causes of soil erosion: 1.46 (28.2%)
- Influence of oil spills on the environment: 1.18(13.2%)

* Villages:
- Causes of soil erosion: 3.06 (24.6%)
- Causes of minor oil spills: 2.08(19.5%)
- Effect of solid waste disposal: 1.32 (19%)
- Damage to physical landscape: 1.17(13.3%)

These impacts are summarized in Table 9. Generally, from the analysis most of the biophysical impacts were negative. This can be attributed to the mitigation measures put in place by the project. These measures are lessons to be drawn from the project. These are summarized as follows:

The project's offsite environmental enhancement programme (OEEP) created a new national park in the Campo reserve area. Pipeline routing and the sitting of pipeline facilities around the coastal areas of Kribi were undertaken to avoid various biologically important locations.

Table 9. Summary of biophysical impacts.

	Biophysical impacts		
Impacts	**High**	**Medium**	**Low**
Positive	-	-	-
Negative	* Damage to wildlife habitat and loss of biodiversity	* Erosion from excavated areas.	* Deep land cut * oil spill from pipeline * Atmospheric pollution * Damage to marine environment. * Solid waste disposal

The areas used for construction purposes were restrict-ted to minimum, thereby minimizing impacts on biodiversity and the loss of vegetation and habitat.

Control induced access by minimizing the construction of new roads in order to limit impact on wildlife, fisheries and forest resources.

Signs posted at all work sites and construction camps, warning workers against hunting and collecting medicinal and other valued plants (anti-bush meat policy).

An extra depth of burial provided for the pipeline especially where they exit the pump station to reduce soil temperature and their effects on soil organisms.

The topsoil removed and stockpiled. After construction, it is put back in place, providing fertile ground for the growth of the natural vegetation (secondary succession).

Mitigation measures on erosion from excavated area

Run off was diverted to stabilized outlets to reduce problems associated with concentrated flows and velocities from areas cleared of vegetation.

Temporal erosion control techniques such as sediment barriers and mulching were directed towards preventing soil erosion.

There was temporal or permanent stabilization of exposed soils, which was provided after grading and other earthwork activities have ceased.

Mitigation measures on deep land cuts

The project contractors in line with the specifications in the EIA document adopted a profound mitigation strategy of land reinstatement.

Mitigation measures on possible oil spill from pipeline

The pipeline is buried and marked to prevent damage to the pipeline

The wall of the pipe is made from high quality carbon steel to meet internationally accepted engineering and construction quality standards.

To combat concerns that local residents might try to tap into the pipeline for fuel, public consultation meetings in the area have emphasised that the oil in the pipeline is unrefined crude, which is unusual as fuel without special treatment

Mainline valves are installed in the pipeline approximately every 35 km so that it can be shut down at any point along the line, limiting the size of a spill should one occur.

To help prevent leaks due to corrosion, the pipeline is protected with an external coating and cathodic protect-tion is used.

A control centre, manned around the clock is equipped with computer supported leak surveillance systems which monitor pipeline pressure, oil flow rate and oil temperature.

Frequently airborne and foot patrol inspection, effect monitoring for signs of possible pipeline leakage.

To limit the environmental impact in case of a leak, the pipeline route has been selected to avoid, where feasible sensitive areas (nature resources, undisturbed forests, swamps etc).

In the event of the oil spill, a spill response plan will guide the emergency effort.

Mitigation measures on atmospheric pollution

The EIA control protocol was put in place especially at appropriate project phases in order to reduce the impact. Unfortunately, the control plan was not fully implemented by the Consortium.

Mitigation measures on damage to marine environment

Timing the construction of sub-sea portion of the pipeline to avoid the peak turtle nesting period in conformity with the Marine Turtle Protection and Monitoring Programme (MTPMP).

Mitigation measures on solid waste disposal

Recycling of potentially valuable scrap materials by the local communities. Un-recycled solid waste is land filled. In view of the research findings, there is need for a review of the various environmental commitments made by the various parties to the project and to appraise their implementation. If some of the negative impacts are reduced to minimum, it is because an environmental impact assessment was conducted before this project. Concerns about waste management have been repeatedly cited in official monitoring reports and have been voiced by the local population. Thus the management of hazardous waste constitutes an area for future research. A proper balance between the benefits expected from this project and the environmental costs can only be obtained through impact studies and careful monitoring of the pipeline and its coastal facilities.

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REFERENCES

Banyuy P (2006) The environmental impact of the Chad-Cameroon Pipeline within the Ocean Division of the Republic of Cameroon. Unpublished MSc. Thesis, Department of Geography, University of Nsukka.
Cooper K (1998) Colombia oil export. Case Number 137. COLOMOIL, Colombia.
Dames and Moore Company (1997) Environmental assessment: Chad export project: Cameroon portion. World Bank Public information Centre, Washington. D.C.
Dias de Avila – Pires, F. (1999) Oil exploitation and environmental conservation in the Amazon Basin. In: N. Nath; L. Hens; P. Compton and D. Devuyst (eds.) York 3:161-162.
Doeffer JW (1992). Oil spill response in the marine environment. Pergamon Press, Oxford.
Environmental Defence Fund (1999) The Chad-Cameroon oil and pipeline project: putting people and the environment at risk. EDF, Washington D.C.
Goodland R, Edmundson V (1994) Environmental assessment and development. An LALA –World Bank Symposium. Washington D.C.
Hough S (2001) Chad oil Pipeline to Cameroon and its impacts. TED case studies. No.650.
Lalazarian K (1999). Caspian Oil. TED case Study No. 404, Summer 1997
Moby E (1979). Climate. In: J-F Loung (ed.) Atlas of the United Republic of Cameroon. Editions Jeune Afrique. Paris. pp. 16-18
Nguiffo S, Breitkopf, S. (2001) Broken promises: The Chad-Cameroon and Pipeline project; profit at any cost? CED, Yaounde.
Ogbu C (1996). "Nigeria records 3,000 oil spillages". The Post Express Newspaper. pp. 8-16.
Ongbwa F (2002). The impact of the pipeline on people and environment in Ocean Province. In: K. Horta; S. Nguiffo and D. Djiraibe (eds.) The Chad-Cameroon oil and pipeline project: a call for accountability. CED, Yaounde, pp. 15-17.
Owabukeruyele W (2002). Hydrocarbon exploitation, environmental degradation and poverty in the Niger Delta Region of Nigeria. Lumes Programme. Research Paper, Lund University.
Price A, Klaus R, Sheppard C (1999). Cameroon coastal conservation and management plan: environmental assessment of the Chad-Cameroon pipeline project. WWF/University of Warwick, U.K.
Roberts J (1996). Caspian pipeline. The Royal Institute of International Affairs, London.
Smith L (1993). Impact assessment and sustainable resources management. Longman Group Limited, London.
Stevenson D (2004). The potential of the Chad-Cameroon pipeline project to promote sustainable economic development. Project Appraisal Document, The World Bank and International Financial Corporation, Washington D.C.
Uibopuu H (1995). "The Caspian Sea, a tangle of legal problems". The world today, 51(6): 13-14
Walsch K (1997). The world Bank and Chad and Cameroon oil and pipeline project. Environmental Defence Fund, Washington D.C. pp. 1-11.
Weltsch J (1996). Turkmen oil and natural gas: The viability of delivering prosperity to global markets. TED, case study No. 385.
Zachary G (2003). "Oil pipelines with low technology or no technology – Surveillance technologies are another example of digital divide". MIT Technological Review, Massachusetts.