Journal of Urban and Environmental Engineering, v.13, n.2, p.353-359

ISSN 1982-3932
doi: 10.4090/juee.2019.v13n2.353359

Journal of Urban and Environmental Engineering

www.journal-uee.org

CONTRIBUTION OF GEOGRAPHIC INFORMATION SYSTEMS TO THE IDENTIFICATION OF GOODS IMPACTED BY THE CONSTRUCTION OF THE YAOUNDÉ-NSIMALEN HIGHWAY: URBAN SECTION

Eric Wilson Tegno Nguekam[1*], Bernard Foahom[2] and Camille Kamtchoua Mbetjock[3]

[1]*Agricultural Research Institute for Development/Research Center specialized in Forest and Environment, Meyomessala, Cameroon*

[2]*Agricultural Research Institute for Development-Nkolbisson, Yaoundé, Cameroon*

[3]*Higher Institute of Management and Applied Sciences / Hermès, Yaoundé, Cameroon*

Received 16 November 2018; received in revised form 16 September 2019; accepted 18 October 2019

Abstract: Cameroon through its Strategy for Growth and Employment (DSCE), has set up the construction of the Yaoundé-Nsimalen highway project. As part of the assessments of its potential effects on the environment, an ESIA was carried out, according to the framework law on the management of the environment. The acquisition of housing has resulted in an " anarchic " installation in the urban and peri-urban area. The construction of a highway as planned overlays on these facilities and poses a problem related to the liberation of spaces previously occupied. The purpose of this study is to identify, locate and classify the impacted goods by the highway construction project through Geographic Information Systems (GIS). Our methodology consisted first, making a satellite identification of the impacted goods, then a field campaign and finally a processing of the data collected. This study was also limited to the identification of two types of property, the buildings and parcels of land. Thus, it has been possible to distinguish and locate six categories of buildings, eight categories of parcels of land defined according to the Cameroon law No. 85/009 of 04 July 1985 on the expropriation for public purpose and the terms of compensation and according to Order No. 0082 / y. 15.1 / MNUH / D of November 20, 1987 laying down the bases for calculating the market value of buildings expropriated for reasons of public utility. The result of this study shows that mapping is a very practical tool for identifying and materializing the impacts that a project may have on components of environment. The GIS revealed a potential disappearance of 1502 building spread over 867 parcels of land.

Keywords: Environment, Impact, Expropriation, Compensation plan, Geographic Information System

* Correspondence to: Eric Wilson Tegno Nguekam.
E-mail: etegnonguekam@gmail.com

INTRODUCTION

Taking the environment into account in the management of human affairs is a relatively new activity. Until recently, only technical constraints and financial possibilities determined the components of a project. During the 1960s, the environment emerged as an issue of growing concern. It was gradually erecting itself as an obstacle to boundless development. Faced with this situation, the future development of our societies could only be accomplished through the use of environmental assessment processes and tools. Among the options available for this purpose, the Environmental and Social Impact Assessment (ESIA) was such a tool for planning and managing human activities (Leduc *et al.*, 2000)

The Environmental and Social Impact Assessment (ESIA) is a systematic review to determine the positive and negative effects that a project may have on the environment. Depending on the size of the project, it may be summary or detailed (République du Cameroun, 2013). The framework law on environmental management in Cameroon requires any project promoter to carry out this study which ends with the obtaining of a certificate of environmental compliance (République du Cameroun, 1996).

Her ambition to become an emerging country by 2035, Cameroon has defined through the Strategy Paper for Growth and Employment a template to follow (Cameroun, 2009). Emphasis is placed on the transport sector, which plays an important role at national and sub-regional level by ensuring the circulation of goods and services for administrative management and territorial development. The road sub-sector is thus subject to new medium and long-term strategic orientations aiming to increase the asphalt road network from 10% in 2010 to 17% by 2020 (BAD, 2015). The country has therefore initiated the Yaoundé-Nsimalen highway project. This project is aimed at improving the conditions of access to the Yaoundé-Nsimalen International Airport, considerably reducing the journey time between the city of Yaoundé and the outskirts of Nsimalen, to make urban traffic more fluid in the city of Yaoundé and to increase interregional exchanges (MINHDU & REC Sarl, 2017).

This type of major project is subject to a detailed ESIA (MINEP, 2005) and includes a component of compensation and resettlement of the property or persons affected by the project. Persons Affected by the Project (PAPs) are defined as any person whose property, access to property and income-generating opportunity would be affected by the highway (BAD, 2012).

The rural exodus and the natural increase of the population have led to a considerable extension of the city of Yaoundé and the issue of housing has become a primary concern for this population (Kumar & Barrett, 2008). Ignorance on one hand and the unavailability or non-actualization of master plans of urban development on the other hand have favoured an anarchic settlement of the population in urban areas (Tchekote & Ngouanet, 2015). Faced with such a situation, the construction of a motorway in urban section poses the problem of the liberation of previously occupied spaces and sites and the displacement of populations (FNAU & VTIF, 2015). On the other hand, the analysis of some reports of compensation plan and resettlement of road projects in Cameroon has shown the absence or the low use of the GIS in the identification and the location of the goods and people affected (DIALLO & KOUROUMA, 2007). The use of cartography is generally limited to the presentation of the study area and its environment. However, GIS are often used in impact assessment to delimit constraints or, conversely, potentialities and sensitivities of the environment and potential impacts on the environment. (Leduc *et al.*, 2000)

The objective of this study is to show the contribution of GIS in the realization of ESIA, particularly in the inventory of the goods impacted in this project of the construction of Yaoundé-Nsimalen highway. Specifically, it will identify, locate and classify the goods likely to be affected by the project.

STUDY AREA

Located in the central region, the city of Yaoundé is the area where the project of the urban section of the Yaoundé-Nsimalen highway is located. It extends between latitudes 3 ° 42 and 3 ° 58N and longitudes 11 ° 24 and 11 ° 34 E. Its relief consists of a set of hills and valleys with an altitude varying between 700 and 1200 m. The climate of Yaoundé is Equatorial Guinean type, with temperatures of 18 ° C to 28 ° C in wet season and 16 ° C to 31 ° C in dry season (MINHDU & REC Sarl, 2015).

Yaoundé, the political capital of Cameroon is organized in seven councils under the responsibility of mayors. Three of these councils are directly concerned by the project for construction of the highway in urban section, namely Yaoundé 1, Yaoundé 2 and Yaoundé 3. The highway in these districts crosses successively neighbourhoods Ahala, Obobogo, Nsam, Dakar, Olezoa, Mfoundassi, Djoungolo, Bastos and Tsinga (MINHDU & REC Sarl, 2017). **Figure 1** shows the administrative and geographical location of the highway, and its right of way.

MATERIALS AND METHOD

The contribution of GIS in ESIAs can be seen at several levels. The interpretation and processing of satellite

images can lead to the production of thematic maps for spatial visualization of information related to impacts (Diallo & Kourouma, 2007). The methodology adopted in

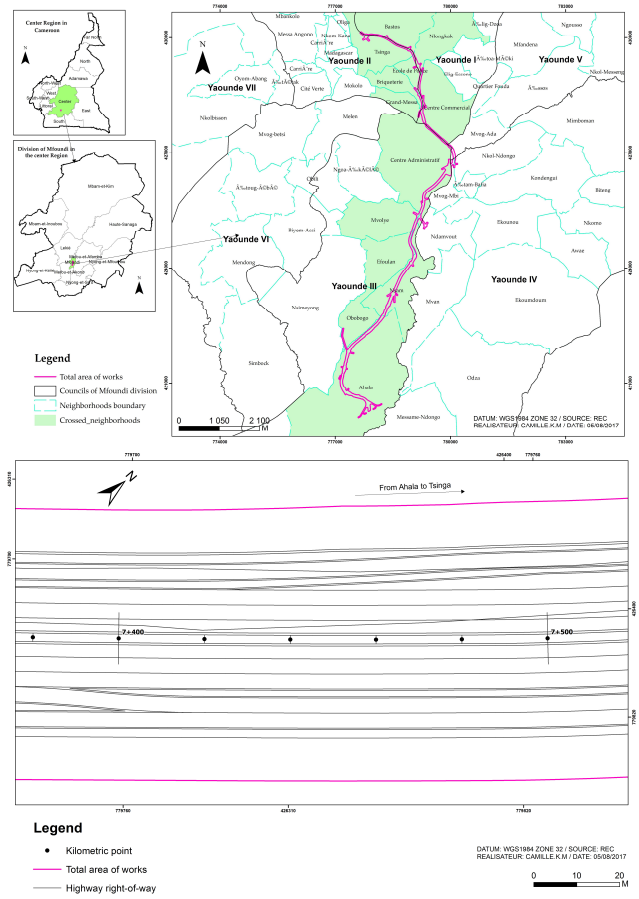

Fig. 1 Administrative, geographical location and right-of-way of the highway (MINHDU & REC Sarl, 2017).

this work consisted of the combination of a satellite pre-identification of the goods and a field work for a proper geolocation of identified goods, and finally a systematic data processing.

Satellite pre-identification was done by the superposition method. This method is characterized by the transposition on a cartographic support of the parameters involved in the study having a strong spatial connotation (Leduc *et al.*, 2000). For this, the footprints of the road were superimposed on a Google Satellite image to visualize the interactions between objects and rights of way (Mehul Tuvar, 2013). Objects in contact or included in the rights of way have therefore been digitized to serve as a guide for the field campaign. ArcGIS10.3 and QGis 2.14 software were used for these operations.

A preparatory phase took place before the field campaign. It consisted in the design of data collection tools and the production of field plans. For navigation and field-finding problems, mobile devices (Samsung Galaxy Xcover 3) with map mapping application (SW Maps) were used (WMGN, 2018).

For the field work, after the recognition of the highway and rights of way using smartphones, geographical positions of goods likely to be affected by the construction of the highway were recorded. The record of these goods was based on their position in relation to the highway rights-of-way and was based on field plans and GPS receivers.

An evaluation on the standing of the buildings was done in accordance with the provisions of the law N° 85/009 of the 04 July 1985 relating to the expropriation for public utility, according to the criteria hereafter:

- Very high standing
- High standing
- Ordinary Standing
- Semi-hard construction
- Wooden construction

The delimitation of the pieces of land consisted in the GPS recording of the various visible terminals. The position of the invisible terminals was indicated by the different owners. The land situation of each piece of land was also recorded. This allowed to classify them as follows:

- Titled and built lands (TC)
- Untitled and built lands (NTC)
- Titled and non-built lands (TN)
- Non-titled and non-built lands (NTN)

Data processing and analysis

The data collected in the GPS memory was transferred to the computer. Thus the digitization of pieces of land was done by joining the plot points and according to the notes taken during the field campaign. The resolution of the GPS being 3 meters, it was necessary to use the satellite image to adjust the fingerprint and fill the table attribute. As far as the buildings are concerned, the work to be done consisted first of all in updating the layer, by adding the building that were spotted during the field campaign and that were not on the map, and filling in the attributes.

Materials

To achieve the set objectives, each phase of the realization of our study required a specific material.

- The creation of cartographic shape files was done using GIS software such as ArcMap 10.3 and Qgis 2.14;
- The location of the impacted assets and their classification was done during the field mission. Data was collected using a Garmin 32294 B GPS receiver, data collection sheets; smartphones for navigation.
- For the processing of the collected data and the production of thematic maps, we used ArcMap 10.3 and the spreadsheet Excel 2016

RESULTS AND DISCUSSION

Pieces of land identified

A number of lands likely to be affected by the highway project have been identified. They are classified in eight categories according to their number, total areas and affected areas. (**Table 1**). **Figures 2a–2c** show in a section, the lands affected by the project; **Figs. 2b–2d** show the parts actually affected.

Over the 12.7 km length of the project, 867 pieces of land were counted and categorized into 8 classes. Of these 867 lots, 39% (both built and non-built) are titled; 38.7% of them are untitled; 20.3% have not been fully identified and the remains (2%) consist of wetlands, parks and farms GIS through their computer tools of analysis made it possible to evaluate the surfaces of each identified pieces of land. It appears that these lands occupy a total area of 574104 m². Obtaining the actually affected part was made through the "Clip" tool present in the ArcMap 10.3 software, which allows to circumscribe an entity located in another entity (ESRI, 2016). It is on these affected areas that calculations will be based on the assessments of the costs to be compensated, according to Order No. 0082/y.15.1/MNUH/D of November 20, 1987 laying down the bases for calculating the market value of buildings expropriated for reasons of public utility. It is also possible, thanks to the software GIS, to have directly information on the owners of the land, its characteristics and others, through the exploitation of the semantic data attached to the land layer (**Fig 3**).

Impacted buildings

Buildings impacted by the highway project have been identified and classified according to the law n ° 85/009 of 04 July 1985 relating to the expropriation for public utility and the modalities of compensation. From this law, there are six categories of buildings as presented in the **Table 2**. **Figure 4** shows the location of some identified building, according to their standing.

Table 1. Summary table of pieces of land identified

Category	Number	Area (m²)	Affected area (m²)
Titled and built lands	313	745340.84	233233
Untitled and built lands	292	125999.35	97477
Titled and non-built lands	24	86231.29	38155
Non-titled and non-built lands	45	62139.25	26873
Non specified lands	176	236047.89	87947
Wetlands	10	95051.1	67994
Farms	5	20362.52	12559
Car parks	2	45676.8	9866
Total	867	1416849.04	574104

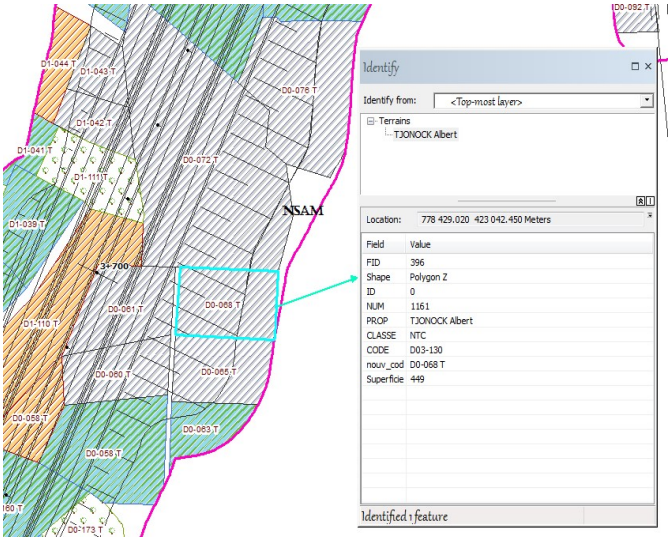

Fig. 3 Characteristics of a selected parcel of land

Table 2. Summary of impacted building

Categories	Number	Percentage (%)
Very high standing	4	0.3
High standing	46	3.1
Average standing	177	11.7
Ordinary standing	978	65.1
Semi-hard	174	11.6
wooden	123	8.2
Total	**1502**	**100**

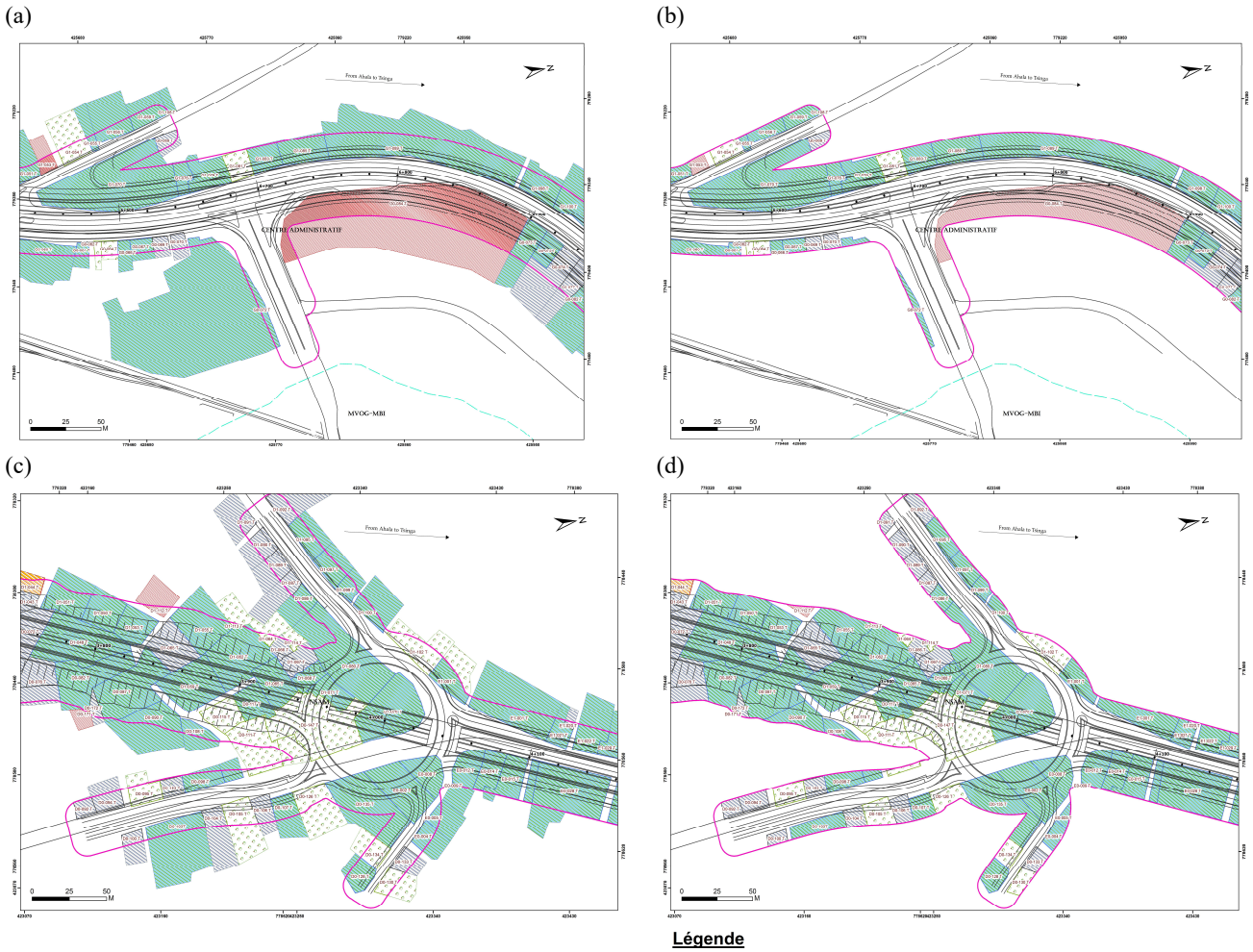

Fig. 2 Location of some lands impacted by the project

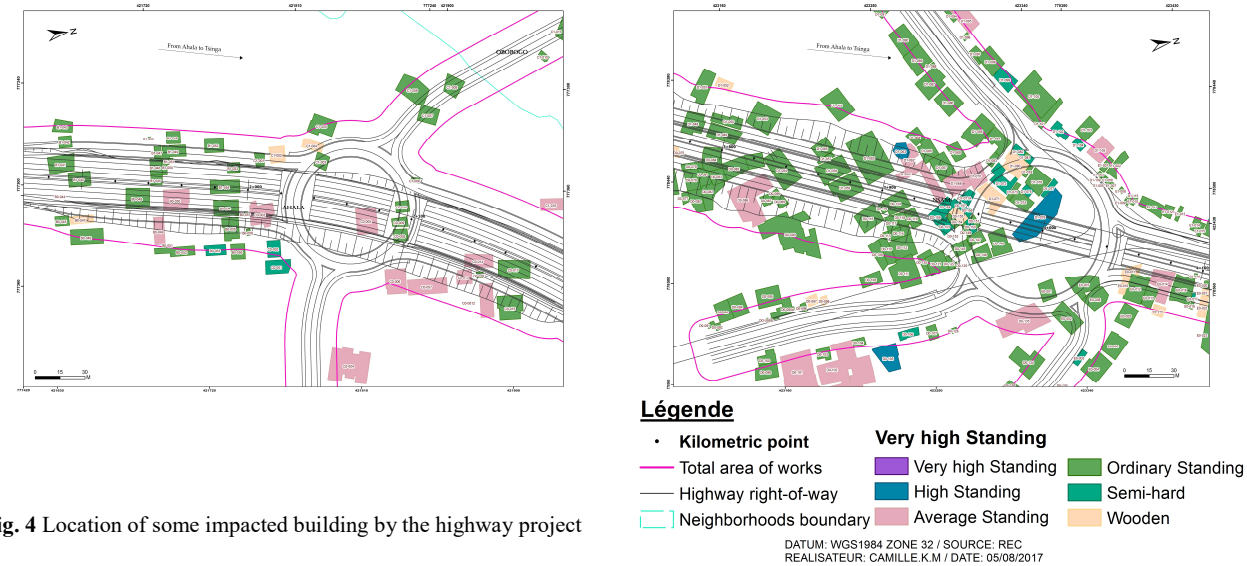

Fig. 4 Location of some impacted building by the highway project

The advantage of GIS at this level is that, the database created can help to directly access specific information such as the location of a building, the owner of the buildings, the characteristics of this building, its use (households, businesses, public buildings), its standing. It will be also possible to easily extract buildings that are located exclusively in the or out the highway right-of-way. Following queries for selection by location were used to perform this operation. The results of these queries are presented in **Fig. 5**:

- *Select features from* ***Buildings*** *that intersect* ***Highway right-of-way****,* for building that are in the highway;
- *Select features from* ***Buildings*** *that intersect* ***Total area of work***, for building that are out the highway but still in the area of works

These are data that will be taken into account when defining compensation costs, which is also depending on the legislation in place.

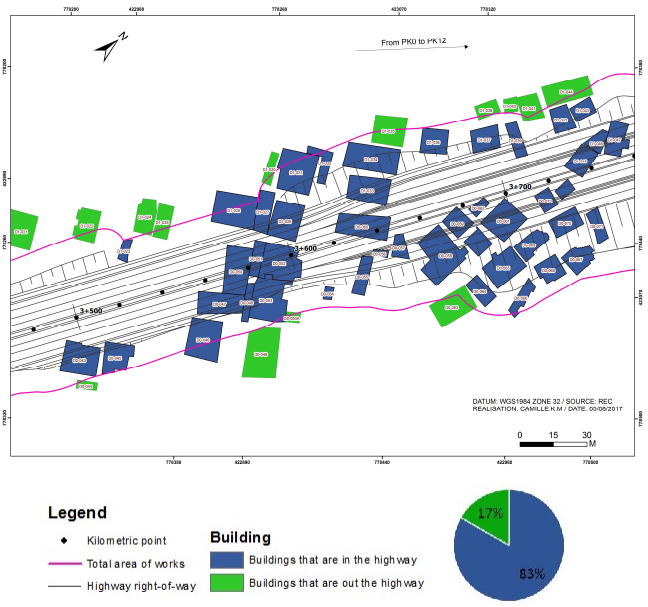

Fig. 5 Results of queries for selection by location

CONCLUSION

The methodological approach adopted during this study shows that the satellite images of Google associated with the observations and measurements made during the field missions constitute an effective way for discriminating the different types of goods impacted by a large-scale project subject to an ESIA. In this study were then identified: the buildings divided into six categories and the parcels of land in eight categories. All these cartographic and statistical results constitute an objective source of information for the assessments and estimates of the indemnities to be made as part of the process of expropriation for reasons of public utility relating to this project. The results obtained shows that the GIS tool makes it possible to visualize and identify the vulnerable components facing the implementation of a project. For this case, it is possible to determine where the property is located and to whom it belongs. In addition, this tool allows a rapid update of the analyses in case of spatial modification of the footprints of the project.

ACKNOWLEDGMENT We would like to thank the Rainbow Environment Consult that selected us to carry out this activity and for funding the field activities, as helped improve this work. We also want to thank Dr Bernard Foahom for his technical advices in the reporting of this activity.

REFERENCES

BAD (2015) *Cameroun Note sur le secteur des transports*. Groupe de la Banque Africaine de Développement.

BAD (2012) *Résumé de l'Etude d'Impact Environnemental Et Social du projet d'aménagement de la route Kumba - Mamfe au Cameroun*. Banque Africaine de Développement / Département Infrastructure (OITC).

Cameroun (2009) *Document de Stratégie pour la Croissance et l'Emploi*.

Diallo, D. & Kourouma, D.L. (2007) Système d'Information Géographique (SIG) et évaluation environnementale en Guinée: Quand est-il des projets routiers? In: *Colloque de Génève* (Colloque de Génève, Suisse), 18. Suisse.

ESRI (2016) Découper—Aide | ArcGIS for Desktop.

FNAU & VTIF (2015) Villes et autoroutes : Vers une réconciliation (im)possible? Enfouir, recycler, métamorphoser. In: *Villes et autoroutes: Vers une réconciliation? Enfouir, recycler, métamorphoser Villes et autoroutes : Vers une réconciliation* (Villes et autoroutes : Vers une réconciliation, Paris). Paris.

Kumar, A. & Barrett, F. (2008) *Diagnostics des infrastructures nationales en Afrique Coincés dans les embouteillages : Le transport urbain en Afrique*.

Leduc, G.A., Raymond, M. & EBSCOhost (2000) *L'Evaluation des Impacts Environnementaux.* Editions MultiMondes, Sainte-Foy.

Mehul Tuvar (2013) Add a google earth satellite image into arc map. Formation.

MINEP (2005) *Arrêté fixant les différentes catégories d'opérations dont la réalisation est soumise à une Etude d'Impact Environnementale*.

MINHDU & REC Sarl (2017) *Etude d'impact environnemental et social du projet de construction de l'autoroute Yaoundé-Nsimalen section urbaine*. MINHDU, Yaoundé.

MINHDU & REC Sarl (2015) *Etude d'impact environnemental et social du projet de construction de l'autoroute Yaoundé-Nsimalen section urbaine : plan d'action de recasement ;* MINHDU, Yaoundé.

République du Cameroun (2013) *Décret fixant les modalités de réalisation des Etudes d'Impact Environnemental et Social*.

République du Cameroun (1996) *Loi-Cadre relative à la gestion de l'envirronnement.*

Tchekote, H. & Ngouanet, C. (2015) Périurbanisation anarchique et problématique de l'aménagement du territoire dans le périurbain de Yaoundé.

WMGN (2018) logiciels:sig_mobiles:sw_maps [Wiki du Master Géographies Numériques].

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