International Journal of Scientific Research and Engineering Development-– Volume 2 Issue 3, May –June 2019

Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Disturbances in the Supply of Electricity and the Current Extent of Deforestation: The Case Study of Lubumbashi City, DR Congo

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Abstract

Deforestation is commonly explained by population growth is economic. Many authors corroborate the thesis that the impact of the speed of economic and demographic growth on deforestation can be offset by good land management at the local level (bottom-up approach). In this work we show that the quality of electrical service at the urban scale can also explain deforestation. In total, 1460 households were surveyed in 7 communes of the city of Lubumbashi. Household survey data were subjected to a one-way analysis of variance (ANOVA) to highlight the differences between the averages of the different municipalities.In addition, a Tukey post-hoc test was applied to determine the difference between the 5% significance level means. R 2.15 and Past software were used for statistical analysis. The results of this work reveal a malfunction of the electricity network characterised by cuts with an average of 3 days of cut per week and 17 hours of cuts per day at the city level. This pushes households to use charcoal as a source of energy for cooking with an utilisation rate of more than 90% regardless of the type of neighborhood and on the outskirts of the city the forests are regressing to meet the demand for energy charcoal. This leads us to argue that the state can curb deforestation by improving the quality and the rate of electricity supply, which would prevent households from consuming charcoal for energy needs (top down approach).

Key words: Disturbance, electricity supply, deforestation, Lubumbashi

1. Introduction

Access to electricity is an important factor for economic and human development (Shouman, 2017). 1.6 billion people do not have access to electricity, 5% in Latin America, 8% in the Middle East and 17% in Asia (IEA, 2014), more than 620 million people in sub-Saharan Africa, or more than two-thirds of the population live without electricity (World Bank, 2009). Thus, Africa remains the least electrified region of all developing regions (Smith et al., 2019, Pereira et al., 2019). The use of wood covers about 85% of sub-Saharan Africa's energy needs (excluding South Africa) (Bonan et al., 2017, Smith et al., 2019). In DR Congo, the national electrification rate is currently 9% and only 1% if only the rural world (76.8% of the Congolese population) is taken into account (Banza, 2018). This makes wood energy represents 85% of the country's energy consumption (WHO, 2013).Although the access rate to electricity is 61.6% at the urban scale in Lubumbashi, the electrical service is of poor quality characterized by long-term and unpredictable power cuts (Banza et al., 2018). To alleviate this situation the population of Lubumbashi is forced to use alternative sources of energy for cooking. In this context Marien (2009) reports that the city of Lubumbashi consumes about 1 million bags of 100 kg / year of charcoal.Kabulu et al. (2018) estimate a minimum annual consumption of 50 kg of charcoal per household. This means that on the outskirts of the city the forests are regressing to meet the demand for charcoal.In this context Kaleba et al. (2018) indicate a loss of 11% of clear forest in the Lubumbashi Plain between 2001 and 2011 with deforestation as the dominant conversion dynamics. To date, overpopulation and economic development remain two common explanations for global environmental problems such as pollution, climate change and deforestation (Grogan and Sadanand 2013; Cook 2014; Tanner & Johnston 2017). In this study we link the disruption of electric power supply with the use of charcoal as an alternative source of energy for cooking, which in turn explains the intensification of forest regression.

2. Methodology

2.1. Study area

This study was conducted in Lubumbashi (south - east of the country, at 11 ° 40 'S and 27 ° 29' East), the second largest city in the Democratic Republic of Congo after the capital Kinshasa. Administratively, the city is made up of 43 neighborhoods grouped in 7 communes (Banza, 2018) of which: Lubumbashi, Kenya, Kampemba, Katuba, Kamalondo, Ruashi and Annex. These communes, like the neighborhoods, are very dissimilar in size, population, land use, and so on. The current city of Lubumbashi is confronted with several difficulties: the existence of under-equipped and unstructured peripheral districts, confusion in the roles and responsibilities of the actors concerning town planning and urban management, an excessive spreading of the city by the creation of subdivisions without a master plan, coherence, access roads and equipment reserves (GroupeHuit, 2009).

2.2. Data collection

The data came mainly from surveys. The sample size must be representative of the population. The size of the sample taken should be neither too high nor too low: it should represent the population in order to allow the researcher to interpret and generalize from it (Maleske, 1995). To obtain the appropriate sample size for the study, the confidence interval chosen is 95% and a margin of error of 5%. To determine the sample size, we were guided by Taherdoost (2017); he says that the accuracy and quality of the research will be influenced by inappropriate, insufficient or excessive sample sizes. The estimation table constructed by Krejcie and Morgan (1970) was widely used by researchers to estimate sample size (Taale&Kyeremeh, 2016;Yakubu et al., 2018) and the following formula was used:

$S = X^2NP\ (1\text{-}P) / (d^2\ (N\text{-}1) + X^2P\ (1\text{-}P))$ (1)

Where:

S = required sample size; X^2 = the value of chi-square for a degree of freedom at the desired level of confidence; N = the size of the population; P = the proportion of the population (assumed to be 0.50 as this would provide the maximum size of the sample); d = the degree of precision expressed as a proportion (0.05).

Krejcie and Morgan (1970) used the formula above to construct a table to determine the sample size at 1 degree of freedom (dof). This method is effective and representative of the chosen population (Yakubu et al., 2018). Very recently Banza (2017) has shown that in Lubumbashi the access rate to the SNEL network is about 62%. In 2017, the number of households in Lubumbashi was close to 230000, which gives 142600 the number of households with access to the electricity grid. We decided to use the whole city of Lubumbashi because we want to study the behaviour of the whole population of the old planned neighborhoods and the new spontaneous neighborhoods.The margin of error is 5% using the two-end test and a 95% confidence interval. X2 1dof = 3.841. Using the formula (1) the ideal sample size is 1460. We carry the sample size at 1470 (for the 7 communes of Lubumbashi) to allow us to have 210 households per commune and thus include as many households with varied socio-economic level.In Lubumbashi, most households are grouped and sometimes there are several households in the same plot (Banza, 2017). In this context each of these families was considered as a separate household. Random sampling was used for data collection. The samples were taken using the 'Random Number Generator' application on the mobile device (Alam& Bhattacharyya, 2017). This app selects a range of homes in a group of one to 100. The number one house will be supposed to be the first on the right side of the road and the number two will be the first one on the other side of the road.

2.3. Data processing

Quantitative data will be subjected to a one-way analysis of variance (ANOVA) that compares several means and determines whether at least one average is different from the others (Durin, 2006). If normality or equality of variances is not verified, the data has been transformed into log10. In addition, a post hoc test of Tukey was applied to determine the difference between the means of the result with a significant difference ($p < 0.05$) (Banza and Mbangu, 2019). To compare the averages of the different communes, the data were submitted to the Chi-square test (Manzambi et al., 2000). R 2.15 and Past software were used for statistical analysis.

3. Results and discussion

Figure 1 shows the type of energy used for cooking in the different municipalities of Lubumbashi. Embers are used by over 90% of households in Lubumbashi regardless of the municipality. The mixed use of ember-electricity is found in the communes of Lubumbashi and Kampemba with respectively 3.7% and 0.4% of households.

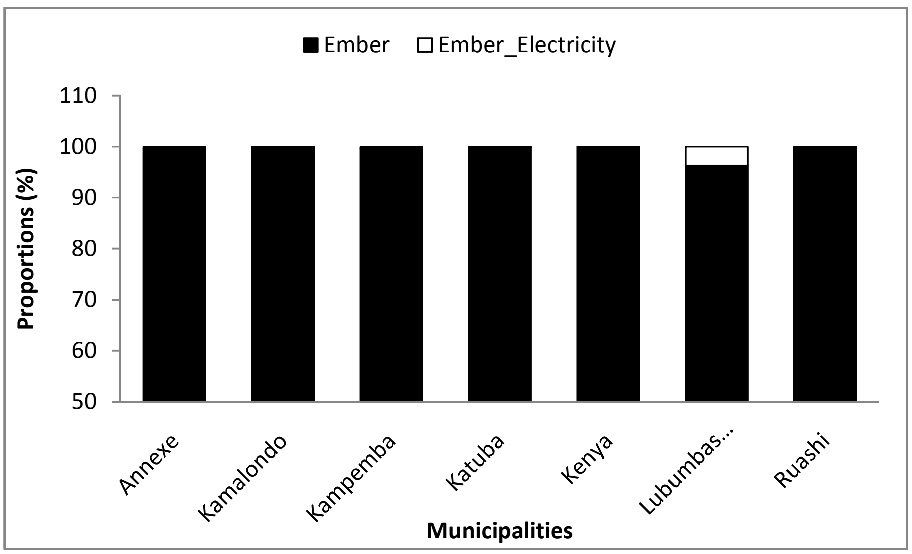

Figure 1-Energy used for cooking in the various municipalities

Figure 2 shows the average number of days of load shedding per week across the city. Ruashi commune had the highest average (6.2 days) and the lowest average was found in Kamalondo commune (1.6 days).

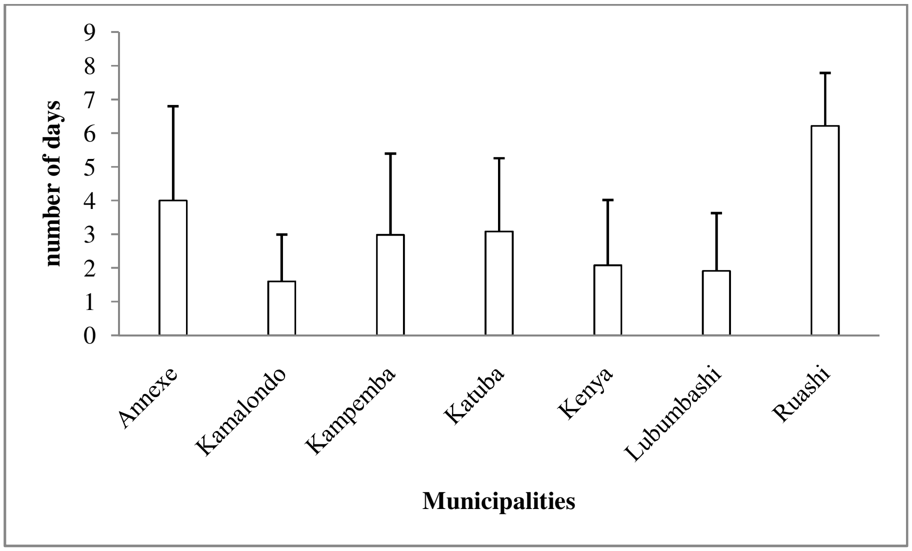

Figure 2-Number of load shedding days per week

Figure 3 shows the relationship between the energy used for cooking and the number of load shedding days per week. The examination of this figure shows that regardless of the household category, ember is used more than 98%. While mixed use is found at 1.9% in the category of households that do not experience load shedding.

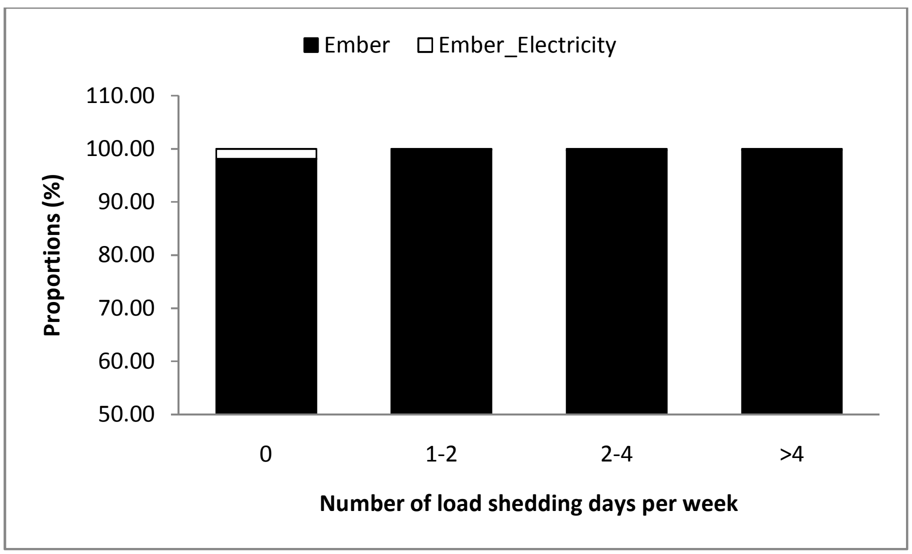

Figure 3-Type of fuel used for cooking according to the number of days of load shedding per week.

The chi-square test shows that the use of ember as the main source of energy for cooking is explained by the number of days of load shedding per week and this relationship is highly significant ($p < 0.05$, table 1).

Table 1. Relationship between the energy sources used for cooking and the number of days of load shedding per week

Type of energy	Number of load shedding days per week			
	0	1-2	2-4	>4
Ember	98.10	99.86	99.75	99.79
Ember_Electricity	1.90	0.14	0.25	0.21
χ^2= 42.8323, dof = 3, p= 2.67110^{-09}				

Figure 4 shows the number of cut-off times per day for the household category at zero load shedding days per week. The highest average was found in Ruashi commune (15 hours) and the smallest in Lubumbashi commune (5 hours). The average number of hours of cut per day for all categories of households is 17 hours at the city level.

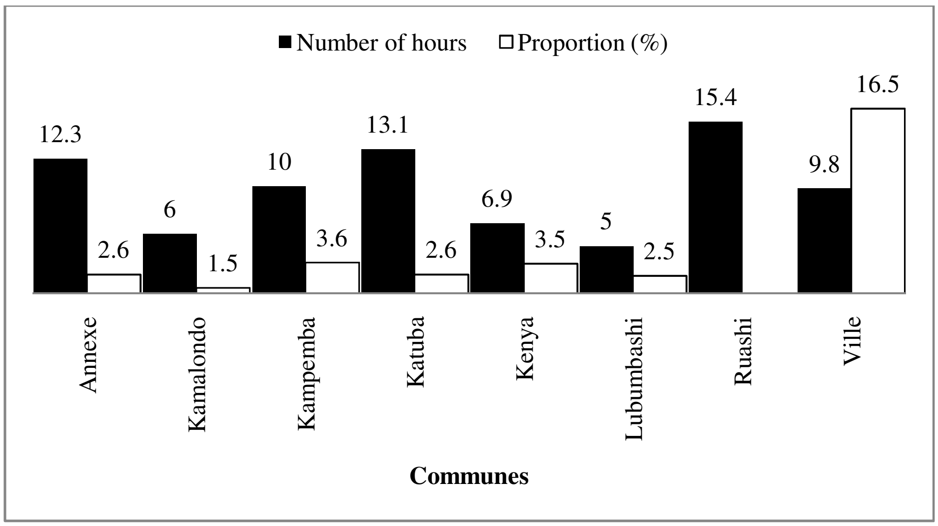

Figure 4-Number of cut-off hours per day for households with zero break days per week.

Figure 5 shows the proportion of respondents participating in each activity at each hour of the day. About 8 hours a day are devoted to sleep and a similar number is devoted to work, whatever the type of activity. Cooking and eating were the second most common activity of the day, with most of the time spent on the first, taking longer when done with traditional fuels.

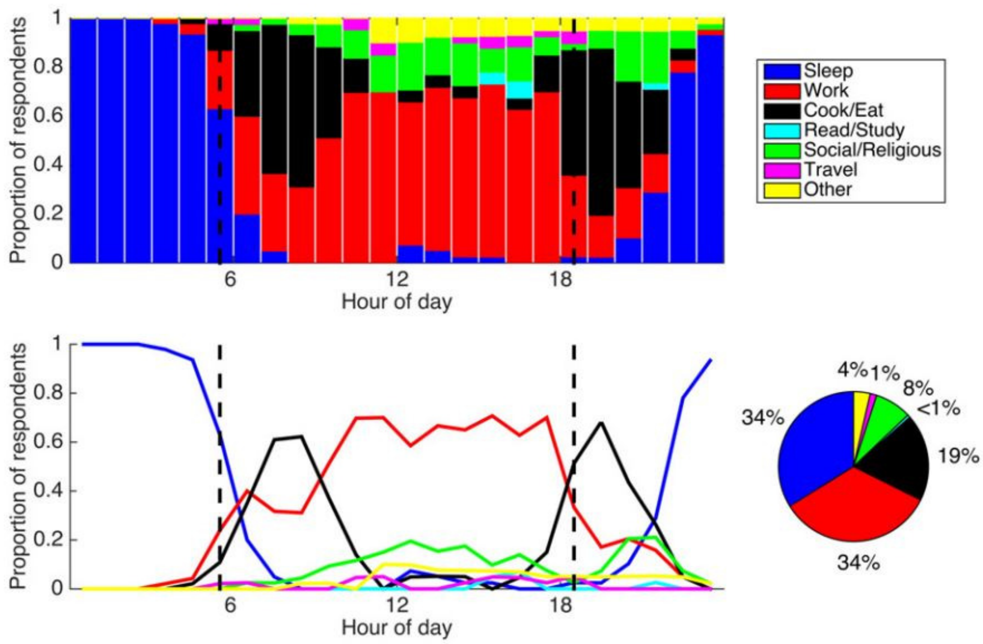

Figure 5- The daily activities of the respondents. The black dashed lines represent the approximate times of sunrise and sunset. Basic activities such as sleeping, working, preparing and consuming food occupy nearly 90% of respondents' time, so there is little time left for other activities.

This study reveals the main reasons why electrified households in Lush are using charcoal as the main source of energy for cooking. These reasons are: a poor quality service characterized by long-term breaks and several days a week, i.e. respectively 17 hours and 3 days for all household categories. On the other hand, the household category at zero load shedding days per week (16.5% of households surveyed) knows a supply characterized by unpredictable cuts and on average 9.8 hours of cut per day. This justifies the use of charcoal as an alternative energy source for cooking, which increases the speed of the rate of regression of the forest on the outskirts of the city (Kaleba et al., 2018; Kabulu et al., 2018).On average, respondents reported spending 4.5 hours per day on food preparation and consumption, not to mention time spent collecting fuel. Two distinct peaks of cooking time correspond to working time gaps; this suggests competition between the two activities, suggesting that if cooking times were reduced, more time could be devoted to productive or other activities. Respondents reported that less than 10% of their time was spent solely on social activities, with family or friends, and even less time reading or pursuing similar interests. One of the key benefits of access to electricity is the freedom to choose when to do certain activities (Reddy and Nathan 2013, Hirmer and Cruickshank 2014); do not limit oneself to the hours of the day to work and study or reduce cooking times, for example. Figure 5 clearly shows daylight dependency for productive work and cooking times that affect the ability to do other activities. Solving them would have a tangible impact on the lives of urban dwellers.

Tanner and Johnston (2017) show in their work that the electrification of remote areas would help reduce deforestation and deforestation. This assertion is not sustainable in Lubumbashi in the context of this study, because the city is already experiencing an energy deficit the current network is already overloaded and therefore the extension of the network to the peripheral areas would only aggravate the situation problem and favour the spread of the city. This is corroborated by Banza (2017). This study shares with Tanner and Johnston (2017) the same view that electricity as demography and economic growth can also explain deforestation in the sense that the use of charcoal as a result of the poor quality of Electricity supply is responsible for deforestation in the outskirts of the city. This study also corroborates the statement of Yekini et al. (2015); the electricity supply crisis in Africa has forced the majority of urban and rural households to depend critically on firewood and charcoal to meet their energy demand. The state can therefore curb the use of charcoal as cooking fuel by improving the quality of electricity supply at the urban scale and thus reduce the speed of deforestation on the outskirts of the city.

4. Conclusion

The study reveals that there is a link between the use of charcoal as the main source of energy for cooking and the disruption of electricity supply, characterized by long and unpredictable power cuts. This is responsible for increasing the regression of the area of the forest on the outskirts of the city. To curb this deforestation, the State can improve the quality and the rate of electricity supply, which would prevent households from consuming charcoal for energy needs.

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