DEFORESTATION, ECONOMIC GROWTH, POPULATION, POVERTY, INCOME AND NATIONAL DEBT: A CROSS COUNTRY ANALYSIS

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ABSTRACT

This study will examine a multiple regression analysis of the relationship between the rate of deforestation, economic, institutional and social variables in a cross-section of countries. This study will use OLS (Ordinary Least Square) regression and correlation analysis to develop strong model of how the variation of independent variable explain the dependent variable (deforestation). The suggested independent variable in this study are rural population growth, human poverty index, corruption perception index, external national debt, growth of GDP and GDP per capita. Based on the result of multiple regression analysis, a conclusion can be drawn, that the model is very weak to explain the rate of deforestation. One of the answer for this problem is the p- value of ovtest is low which is 0,034, it is lower than 5%, meaning that there are some important variables are not included in this model. Another reason is because of hettest value is low as well which is 0.023, it is lower than 5%, indicate that the heteroskedasticity is present.

Key words: rural population growth, human poverty index, corruption perception index, external national debt, growth of GDP and GDP per capita.

1. INTRODUCTION

Deforestation directly impacts social and environmental conditions, and is thus an issue of crucial concern. Case studies have been undertaken in numerous different countries with the aim of better understanding the phenomena and developing better forest management techniques.

Widespread deforestation and the declining condition of the world's forests have resulted in an environmentally, economically and aesthetically impoverished landscape. Determining the rate of deforestation depends, of course, on the definition of a 'forest'. FAO originally defined a 'forest' as a non – agricultural land with a tree cover of at least 20 percent (Lamb, 2003:204). From this definition, one can derive a definition of 'deforestation'. This process has been defined as the deliberate conversion of forested areas to those considered to be non – forested.

The underlying cause of deforestation is best described by multiple factors and drivers acting simultaneously rather than by single causal force. Geist stated that the interplay of institutional, political, cultural, socio economic and demographic variables constitute a robust underlying driver for deforestation (Geist, 2002).

Mathews (2001:190) argued that the rates of natural forest loss had probably worsened in almost all tropical countries. Papua New Guinea, Indonesia, the Philippines and Brunei are prime examples. Mathew's study considered not only developing countries, but a few developed countries like Australia and South Korea.

2. LITERATURE REVIEW AND THEORETICAL REVIEW AND THEORETICAL FRAMEWORK

2.1. Deforestation and Population

Some development institutions regard population pressure as the major factor causing deforestation. Nobody can deny the serious impact that population growth has over the destruction of environmental resources (Revington, 1992). Population growth exerts obvious pressure over natural resources through land conversion for agricultural, settlement and other purposes. The Asian Development Bank also mentions that population pressure and the development process has a strong association with deforestation (Foster, 1997). However Angelsen and Kaimowitz (2001) have criticized the importance placed on population as a factor. They argues that many other pressures exist that generate a demand for natural resources.

Furthermore, Mertens (1994) asserted that: "Population and deforestation are two concepts that are too general to have real explanatory value by themselves. Population dynamics includes a whole range of changing structures and dynamic behaviors which are related in multiple ways to problems of deforestation".

From this, it can be seen that some authors do not give the same credence to the population/deforestation relationship. Mertens argues that even though there is change in demography indicating an increasing in population, it does not mean that population growth is necessarily the culprit (Mertens, 1994). In contrast, Angelsen and Kaimowitz (1999) argue that based on their empirical study, population and deforestation are positively correlated. The pair explains the positive relationship by inferring that a population increase will necessarily lead to a higher demand for fuel and firewood, land, food, and other forest products.

In summary, it can be argued that many factors contribute to deforestation. Harrison explains one of the causes of deforestation as follows (Harrison in Marcoux, 2000 – emphasis added):

It is very easy to come away with the view that population growth is the only cause of deforestation… but it is an oversimplification. Suppose, technology gradually improved yields in line with population growth, there would be no need to clear more forest to feed more people. Deforestation takes place because population growth is outstripping change in technology. The speed of both relative to each other is what counts. It is meaningless sophistry to claim that one is more fundamental than the other, or to call the one a 'root' cause and relegate the other to a mere 'exacerbating factor'.

We may say, therefore, that deforestation is not caused solely by population growth, but by the outstripping of population growth in comparison to advancements in technology. Poor technology, therefore, is the co-culprit. Population growth is more likely a 'push factor', encouraging forest clearing for agriculture and settlement.

2.2. Deforestation and Poverty

Some studies have explored the relationship between poverty and deforestation, particularly in the rural areas of developing countries (CIFAN, 2005). It is argued that poverty is an underlying cause facilitating deforestation because it is a condition that restricts peoples' economic options and decreases their income generating opportunities. Population pressure, hand in hand with poverty, creates chronic undernourishment and food insecurity. With limited alternatives available to poor people, they resort to the forests as a short term solution to cope their economic problems (CIFAN, 2005).

In addition, Robinson (1988) argued that deforestation can occur not only because of ignorance, but largely because of poverty and greed (Robinson, 1998:11). Jhamtani (1987:76-77) explains that the most popularly touted explanation, until recently, was population growth and poverty, causing the poor to use more fuel wood and more swidden agriculturists to open forest land. Marcoux also stated the same argument - that "forest degradation and deforestation are rapid in developing countries, which are also often affected by poverty, resulting from land scarcity and rapid population growth" (Marcoux, 2000).

Rudel and Roper (1996) conducted research on deforestation concentrating on the difference between capital and poverty-driven deforestation. According to these authors, "[c]apital-driven deforestation refers to private or public investments to increase the frontier for economic, political, or social reasons, and poverty- driven deforestation refers to the ecological marginalization of farmers who have lost their resource entitlements" (Rudel an Roper 1996:160). Angelsen and Kaimowitz (1999), however, criticized the poverty thesis. They argue that there is little evidence for the relationship between poverty and deforestation. Rich people may be involved in forests clearing and utilize poor people as their employees. Poverty, therefore, should be considered an endogenous variable.

2.3. Deforestation and Corruption

Corruption can be defined as "the abuse of public office for private gain" (the WorldBank 1997). A further definition is "the sale by government officials of government property for personal gain or deriving a benefit for oneself and others" (Callister in Palmer, 2000). Barbier (2003:2) indicates that there is a linkage between corruption and forest conversion. He argued that corrupt governments are persuaded by the lobbying pressure and political contributions of agents that benefit from different forms of resource conversion. Barbier (2003 :4-6) further explains that corruption has been a driving force behind the misuse of forests and has direct effect on the rate of deforestation.

Rent-seeking behavior also contributes to deforestation. It encourages, for example, military backing and the development of illegal logging networks. Palmer has clearly stated (2000:28) that rent-seeking behavior and a culture of corruption in developing countries commonly spreads to all level of government. The governmental status quo is maintained and perhaps even higher levels of deforestation are encouraged. Moreover, it will strengthen by underlying cause of deforestation such as market and government failures (misguided policy).

In relation to illegal logging activities and deforestation, Palmer (2000 :13-14) identified two types of corruption that have strong linkages with rent-seeking behavior - grand and petty corruption. 'Grand' corruption may involve politicians and top government officials who deal with a large bribes. 'Petty' corruption involves a local government official and deals with small bribes.

It can thus be seen that the relationship between corruption and rent-seeking behaviour is conducive of higher rates of deforestation, and has become a serious problem in a number of developing countries.

The corruption condition within a country can be measured by a CPI score (Corruption Perception Index). Transparency International explains that CPI (TI 2005): "[R]anks countries in term of the degree to which corruption is perceived to exist among public officials and politicians. This composite index draws on corruption-related data in expert surveys carried out by a variety of reputable institutions. It reflects the views of business people and analysts from around the world, including experts who are locals in the countries evaluated."

It can be explained that the higher the index, the higher corruption within country. A high level of probity is denoted by a score of 10, whereas a score of 0 suggests that the country is highly corrupt.

2.4. Deforestation, Economic Growth and Income level

Angelsen and Kaimowitz (1999:89-90) indicated that higher economic growth and national income can be expected to decrease pressure on forests. Often, however, the opposite relationship between economic growth and deforestation can be observed. In many instances, economic growth has contributed to forest depletion.

Some researches have explored the relationship between deforestation and income level (or income per capita). In Angelsen Kaimowitz (1999:89), Barbier found that in developing countries a higher income level had strong correlations with greater deforestation. However, Culas (2003 :4), the effect of income level (GDP per capita) and Economic Growth (GDP growth) on deforestation may be not at the same direction, in the long run , they may vary.

Some authors have claimed that deforestation decreases as income rises beyond a certain threshold, although there is disagreement as to where this threshold lies and as to the

true causal relationships affecting the preservation of forests (Panayotou ,1994). In this case, the relationship between income level and deforestation, as depicted by the models, was inconclusive.

2.5. Deforestation and External National Debt

Foreign debt variable is sometimes examined in the literature as one of main factor affect deforestation, particularly in developing countries. Kahn and McDonald in Culas (2003) hypothesized the causal relationship between deforestation and External National Debt as myopic behavior that causing excessive deforestation in sort run to meet their past debt's obligations and current constraint. Culas (2003) explain further that debt should be taken into account as an explanatory variable for deforestation in the models, because mostly the third world countries have significant foreign debt. In the sort run they try to cover external debt through produce forests products and selling them to obtaining export revenue.

Some studies try to examine the correlation between deforestation and external debt such as research on timber production in Latin American by Tole (1998). Some of researcher found positive correlation between them, in contrast from other study, Capistrano argued (1990) that there is no correlation between external indebtedness and deforestation. He found a weak set of result and clearly there is no significant link between production of timber and high foreign debt. It can be seen that there is no consistent causal relationship. Therefore the explanation conflict between research findings provides a difficult theoretical background for further study.

3. DATA SELECTION

This analysis will investigate the effect of six independent variables on the annual rate of deforestation. The five variables chosen were selected to represent social, economic and institutional factors that may affect the level of the deforestation. Below, it is an outline of the codes for the six chosen independent variables, and one dependent variable:

Deforestation	(defo)
Rural Population	(ruralpop)
Human Poverty Index	(hpi)
Corruption Perception Index	(CPI)
GDP growth	(GDPg)
GDP per capita	(GDPp)
External National Debt	(Debt)

Data was collected for all variables from a variety of major international organizations. Deforestation data was obtained from FAO Global Forests Resources Report 2000-2005 (average annual percentage reduction).This data has been often used in past deforestation analysis and the most recent comprehensive, authoritative statement on global forest change. However, even though the data for this study came from a well-known international organization, it is still prone to general inaccuracies.

Tole (1998: 20), for instance, explained that although it is the only resource available that covers deforestation across several countries, the quality of global deforestation data from FAO forest statistics is limited. In short, the independent variables were provided for the same period as completely as possible. The lists of all variables are shown below in Table 1.

Table 1
Source Information For Raw Variables

VARIABLES	PERIOD	UNITS	SOURCE
Deforestation	2000-05 avg	% Annual Loss of Forest Area	FAO
Rural population	2003	million	World Bank
Human poverty index	2003	score	UNDP
Corruption perception index	2003	score	UNDP
GDP growth	2003	percentage	World Bank
GDP per capita	2003	Current US $	World Bank
External National Debt	2003	Current US $	World Bank

Source: UNDP, World Bank, FAO

4. HYPOTHESIS

Based on available deforestation literature, theory, and the literature review undertaken, five hypotheses have been formulated for investigation. These are as follows:
An increase in population will increase the rate of deforestation (i.e. positive correlation).
A higher human poverty index will increase the rate of deforestation (i.e. positive correlation).
A lower corruption perception index will increase the rate of deforestation (i.e. negative correlation).
A growth in GDP will increase the rate of deforestation (i.e. positive correlation).
Lower GDP per capita (income) will increase the rate of deforestation (i.e. negative correlation).
Hypotheses 1, 2 and 4 all suggest a positive correlation between deforestation and suggested independent variables, whereas hypotheses 3 and 5 imply a negative correlation.

5. STATISTICAL DESCRIPTION OF THE VARIABLES

This study used 48 observations (48 countries) for which represented the dependent variable. Over the period 2000-2005 that experienced in reducing total forest cover annually. The country's samples which will be examined in this study are mostly from developing countries. In general, using at least 30 samples is the critical number for running quantitative analysis (Tacconi, 2006) , therefore, 48 samples are considered large enough for conducting quantitative analysis.

Data was analysed utilizing the STATA statistical software (package) to provide basic statistical values including standard deviation, mean, maximum and minimum values. Table 2 shows the values for all of the number of observations for every variable.

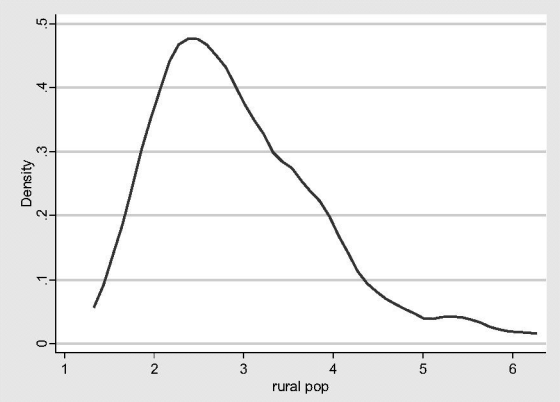
Table 2
Statistical Interpretation- Raw Data

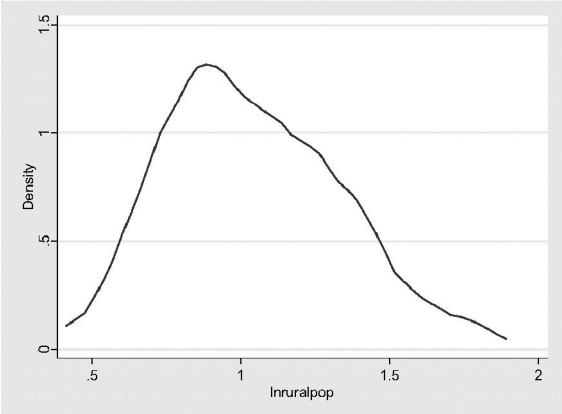
VARIABLES	OBS	MEAN	STD. DEV.	MIN.	MAX.
deforestation	48	0.98	0.8	0.1	3.3
hpi	48	30.1	17.3	7.4	64.4
cpi	48	2.9	0.86	1.7	5.9
Rural pop.	48	2.95	0.9	1.7	5.9
debt	48	21608.7	43086	2.55	235431
Gdp growth	48	3.7	1.5	0.5	7
Gdp per capita	8	1475.9	1714.5	97	8007

Source: data processed

From Table 2 we can see that the standard deviations were generally high. That means there was variation about the mean. Based on the initial data, the distribution of all variables about their mean are not normally distributed and generally, it is skewed to one side. It can be explained further that there were gaps between the mean and minimum and maximum values. For example, external debt variable has a mean of 43086, and a minimum value of 0.01 but a disproportionately large maximum value of 235431. It can be seen in the graph below. By transforming external debt variable data into log, it becomes better distribution.

External debt graph:





kdensity in no log kdensity in log

In order to conducting statistical regression analysis effectively, all the data needs to be normally distributed. Based on the density curves for all variables (dependent and independent variables), there was no single variable which normally distributed. Therefore , they need to be transformed into natural logarithms (log or ln). Table 3 below shows the better distributions of all variables (in log) if it is compared to data with no log.

The next step is that a correlation analysis is conducted using Pearson's correlation tool, after transforming data to log. This analysis wants to know whether the dependent and independent variables have a linear relationship. It is also to assess the presence and the strength of the correlation. The relationship between two variables is measured as an r-value which varies between -1 (perfect negative relationship) and +1 (perfect positive relationship). If the r-value is close to 0, it means that there is no linear relationship between two variables.

Tabel 3
Statistical Interpretation – Transformed Data

VARIABLES	OBS	MEAN	STD. DEV.	MIN.	MAX.
Ln_deforest	48	-0.4	0.96	-2.3	1.19
Ln_hpi	48	3.2	0.68	2.00	4.16
Ln_cpi	48	1.0	0.27	0.53	1.77
Ln_ruralpop	48	1.0	0.28	0.53	1.77
Ln_debt	48	8.3	2.65	O.93	12.3
Ln_Gdp growth	48	1.2	0.51	-0.69	1.9
Ln_Gdp percap	8	6.7	1.07	4.57	8.98

Source: data processed

The result of the correlation from all variables can be seen in Table 4. With regards to deforestation, not all the signs (showing the direction) of the correlation satisfied all hypotheses, especially, the sign for rural population variable. Based on the theory, the expected sign for rural population is positive, meaning that an increase in rural population will increase deforestation. However the result is shown an opposite direction (negative). Therefore, it can be explained almost all independent variables showed the expected direction as the stated hypotheses above. The correlation between deforestation and human poverty index, corruption poverty index, rural population, external debt, growth of GDP and GDP per capita are 0.30, 0.27, 0.20, 0.15, 0.23, and 0.35 respectively. It can be argued that there is no single independent variable which has a strong correlation with the rate of deforestation, because all the r-values, of independent variables are bellow 40%.

Table 4
Correlation analysis for all variables

	deforst	**hpi**	**cpi**	**ruralpop**	**debt**	**gdpgr**	**gdpp**
lndeforst	1.00						
lnhpi	0.29	1.00					
lncpi	-0.27	-0.40	1.00				
lnruralp	-0.20	-0.45	0.94	1.00			
lndebt	0.15	-0.04	-0.16	-0.13	1.00		
lngdpgr	0.23	0.31	0.19	0.14	-0.22	1.00	
lngdpp	-0.35	-0.82	0.57	0.59	-001	-0.19	1.00

Source: data processed

From Table 4, it is clear there are some variables that have a colinearity problem which are rural population and cpi variables (r = 0.94) ,and between GDP per capita and human poverty index (r = -0.82). All the r_values of all the independent variables are below 40 %, meaning that there is no strong correlation between all the independent variables (lnhpi, lncpi, lnruralp, lndebt, lngdpgr, lngdpp) and deforestation (lndeforst) or in other word there is a statistically non-significant correlation.

Table 5
Summary Of Simple Regression Against Deforestation

variables	Co-ef	SE	P>T-stat	R^2	Ajdj-R^2
lnhpi	0.40	0.19	0.041	0.087	0.067
lncpi	-0.94	0.49	0.07	0.07	0.05
lnruralp	-0.70	0.48	0.16	0.04	0.02
lndebt	0.05	0.05	0.31	0.02	0.00
lngdpgr	0.44	0.27	0.11	0.05	0.03
lngdpp	-0.31	0.12	0.01	0.12	0.12

Source: data processed

Table 5 provides a summary of simple regression against deforestation for each of six independent variables. Multicolinearity is not the case in this result because it is only a single linear relationship between the independent and dependent variable. This simple regression has a purpose to know how well each individual independent variable can estimate the change of dependent variable. If there is a linear relationship between the variables, it is possible to examine the accuracy of the standard error, coefficient determination and t – distribution.

It can be seen that only GDP per capita variable has a probability of less than 5 % (p value = 0.01), meaning that it is statistically significant. Therefore, only the coefficient of GDP per capita can be interpreted in relation to the rate of deforestation. If there is a change in one unit of ln_gdpp (GDP per capita), if will affect the dependent variable by – 0.31 units. In other words, an increase in the level of income in one unit will decrease the rate of deforestation by 0.31 units. However, the R –squared for this regression is only 0.12. Even though it is a small number, we can interpret that the GDP per capita can explain the change of deforestation rate by 12 % .

Table 6
Multiple regression of all independent variables

variables	Co-ef	SE	T-stat	p>T
lnhpi	0.22	0.43	0.07	0.95
lncpi	-2.42	1.46	-1.66	0.10
lnruralp	1.87	1.38	1.35	0.18
lndebt	0.057	0.05	1.13	0.26
lngdpgr	0.51	0.29	0.09	0.09
lngdpp	0.189	0.24	0.44	0.44
constant	0.25	2.49	0.92	0.92

Source: data processed

Table 6 explains about the multiple regressions of all independent variables at 5 % level of significant. We can see from the probability column, there is no independent variable at all which has a probability less than 5 %.This means there is no single independent variable which has statistical significance. Moreover, all the t-values of all independent variables are less than 1.676 (t-critical value from table at 5% level of significant).Therefore, we cannot interpret all the coefficient numbers, of all independent variables. This means there is a statistically non – significant causal relationship between the independent variables and the dependent variable. There is enough evidence that the null hypothesis is accepted.

Table 7
Multiple regression analysis output

		CRITICAL VALUE
observation	48	-
R^2	0.24	-
Adjusted R	0.13	-
F (6 , 41)	2.12	2.25
Prob > F	0.07	> 5 %

Source: data processed

From Table 7, it can be seen that R - squared is only 0.24, meaning that only 24 % the independent variables can explain the variation of deforestation over the 2000-2005 period. Adjusted R – squared is only 0.13, even less than R squared. In other words, the model is weak to explain the change of deforestation. To check whether the variables are normally distributed or not, we need to do a F-test. From Table 7, F- Value is 2.12, it is less than F- table value which is 2.25 and the probability is more than 5 % which is 7 %. So, we can say the null hypothesis can not be rejected. So overall, if we look at R – squared, Adjusted R- squared and F- value, it can be concluded that there is a statistically non-significant model.

6. TEST FOR MULTIPLE REGRESSION MODEL OUTPUT

There are certain assumptions about the 'error term' which need to be satisfied in order to gain reliable and unbiased estimator of the coefficient variable. There is a need to check whether the assumptions on no omitted variables (correct specification on the theoretical model) and homoskedasticity (constant variance of the error term) are satisfied.

In the case when some important independent (explanatory) variables are not included into the model, we could say that the model is misspecified. This might have serious consequences for the estimated coefficients. To test if the model has a correct specification one can employ the Ramsey RESET test via the command ovtest. In this case the null hypothesis is Ho: model has no omitted variables. Lower the p- value, the more evidence one has against the null hypothesis.

The result of the ovtest is p value = 0,034, it is lower than 5%, meaning that there are some important variables which are not included in this model. So we should reject the null hypothesis (model has no omitted variables). It is clear that the model might lack some important variables.

To obtain the reliable estimators of the coefficients in the model, the error term must satisfy the assumption of the constant variance for every observation. In this case the errors are called homoskedastic (Keller, 2005: 245). There are a number of consequences

of the heteroskedastic errors. One of them is that the standard errors of the coefficients reported in the output are estimated incorrectly hence the t- statistic reported in the STATA output is incorrect as well. As a result, the hypothesis testing about the coefficients may be misleading. To test for the presence of the heteroskedasticity in particular can use the Breusch-Pagan/Cook-Weisberg test. In this case the null hypothesis is Ho: error s are homoskedastic. The higher the p- value (greater than 0.1 0r 0.05), the more evidence one has not to reject the null hypothesis, meaning that the errors are homoskedastic.

The result of the hettest is p value = 0.023, it is lower than 5%, indicate that the heteroskedasticity is present. It means that there is not a constant variance of the error term. So the null hypothesis (errors are homoskedastic) should be rejected. To obtain the reliable estimators of the coefficients in the model, the error term should satisfy the assumption of the constant variance for every observation.

7. CONCLUSION

In summary, it can be argued that many factors contribute to deforestation and it is a complex problem that can not be adequately explained by one study. This paper tries to examine a multiple regression analysis of the relationship between the rate of deforestation, economic, institutional and social variables in a cross-section of countries. This study used OLS (Ordinary Least Square) regression and correlation analysis to develop a strong model of how the variation of the independent variable explains, the dependent variable (deforestation). The suggested independent variables, in this study are rural population growth, human poverty index, corruption perception index, external national debt, growth of GDP and GDP per capita.

Unfortunately, based on the result of the multiple regressions analysis, combining all the independent variables shows a statistically non significant model. It can be seen from the coefficient determination (R^2 value) is only 0.23, meaning that the model can explain the variation of the dependent variable 23%. Moreover, adjusted R squared (0.13) is less than R squared . In addition, F- value is 2.12, it is less than F- table value which is 2.25 and the probability is more than 5 % which is 7 %. So, it can be concluded that the null hypothesis can not be rejected.

The conclusion that we can draw based on the result of multiple regression analysis is that the model is very weak to explain the rate of deforestation. One of the answer for this problem is the p- value of ovtest is low which is 0,034, it is lower than 5%, meaning that there are some important variables are not included in this model. Another reason is because of hettest value is low as well which is 0.023, it is lower than 5%, indicate that the heteroskedasticity is present. The answer also may lie in the validity and the reliability of the data. Even though the data for this study came from a well-known international organization, it is still prone to general inaccuracies. For instance,

mentioned that although it is the only resource available that covers deforestation across several countries, the quality of global deforestation data from FAO forest statistics is limited.

We can say overall that all the proposed hypotheses in this study are falsified. All the suggested independent variables in this study which are rural population growth, human poverty index, corruption perception index, external national debt, growth of GDP and GDP per capita clearly can not explain the change of deforestation rate.

8. LIMITATIONS

The results of the study reflect the availability of data. In this study there were no valid and the reliable data. Even though the data for this study came from a well-known international organization, it is still prone to general inaccuracies. The example mentioned is the only resource available that covers deforestation across several countries. Furthermore, the availability of good quality of global deforestation data from Food and Agricultural Organization forest statistics is limited.

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