The Relationship Between Population Growth And Environmental Quality in Zimbabwe: time series analysis (1985-2020)
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ABSTRACT

There is a growing belief that so much man-made pollution has deteriorated the quality of the environment. Therefore, it is on the strength of this assertion that this research examines the relationship between population growth and environmental quality in Zimbabwe using the Ordinary Least Squares model (OLS). Using carbon dioxide emission (CO_2) as proxy for environmental quality and time series data extracted from the 2020 version of the World Development Indicators for the period 1985 to 2020, the study reveals a negative and significant effect of population growth on environmental quality. The researcher recommends effective family planning programmes, investing towards the education of girl child, developing growth points in rural areas in order to control overall population growth.

Key words: Population growth, environmental quality, carbon dioxide emissions, Zimbabwe, time series

1. Introduction

Environmental quality as defined by OECD (2001) refers to state of environmental conditions expressed in terms of environmental pollutant indicators for instance methane, nitrous oxide and carbon dioxide making up the vast majority. Environmental quality involves the quality of air, water and soil. Some of the major global concerns in environmental economics and development economics are the implications of growth in population, maintenance of quality of the environment as well as sustainability of the finite resources for the future generation. Because of the growing population, demand for renewable and non-renewable resources such as air, water, timber is increasing resulting in the inability of renewable resources to continue regenerating. Ahmad (2009) postulated that population growth means increased human activities and this affects the quality of the environment through a number of ways which include, cutting down of forest, burning of fossil fuels to generate energy fuel to mention a few. Larger amounts of emissions into the air or in water, entails loss of quality of the environment. Thus, quality of the environment can be measured making use of environmental pollutants. The researchers made use of the carbon dioxide emission as the proxy indicator.

World Bank (2017) postulated that for the past ten years, the average value of Zimbabwean population growth rate was 1.01% with a minimum of 0.23 % in 2003 and a maximum of 1.78% in 2013. Such a rise in population growth was as a result of increased fertility rate and massive rural-urban migration. Population growth fuels hunger, health risk, poverty, environmental depletion, water scarcity and political instability. However, the latest value from 2019 is 1.4 % and according to Nyoni and Bonga (2017) such a decrease was due to improved use of contraceptives, low fertility rates and improved education to the girl child.

World Bank (2019) defined to carbon dioxide emissions as gases emanating from the combustion of fossil fuels and during the manufacturing of certain products for instance, chemicals, cement, fertilizer among others. It is the main greenhouse gas emanating from human activities. Rirchie and Roser (2017), discovered that global warming is primarily caused by emissions of greenhouse gases (GHG), resulting in climate changes, rising temperatures, changes in ecosystem and gradual deterioration of the ozone layer. O'Neill *et al* (2010), argued that relatively little concern has been addressed towards determining potential population growth policies to influence sustainability of finite resources and global climate changes.

The old constitution of Zimbabwe (changed in 2000) did not contain any specific clause that facilitated the protection and maintenance of the environment. It is against this fact that in 2002, the government of Zimbabwe implemented the Environmental Management Agency (EMA) and went on to draft a National Environmental Policy in 2003 in order to issue legitimate specifications regarding the protection and maintenance of the environment. Main purposes of the Environmental Management Agency were to monitor, regulate and making better the environmental impact assessment. Figure 1.1 below shows the relationship between population growth and carbon dioxide emissions.
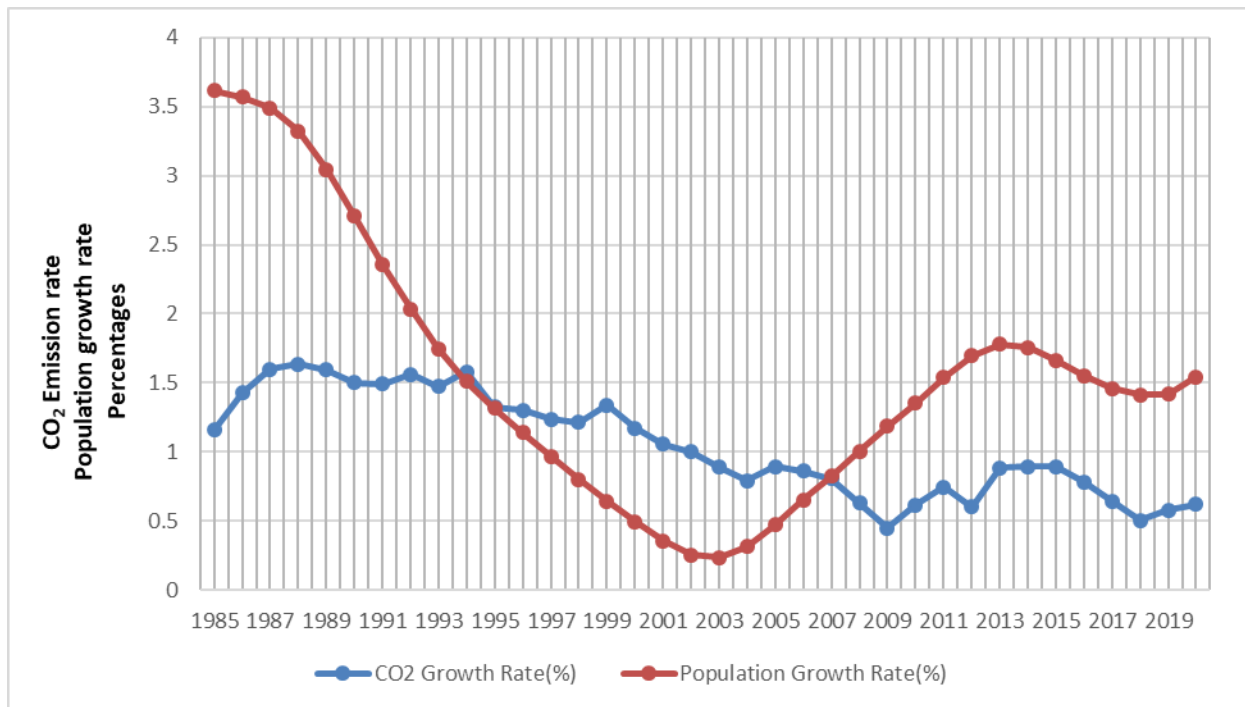
Figure 1.1: Population Growth Rate and Carbon Dioxide Emission rate for Zimbabwe

Source: World Bank, 2020 Revision

The trends in carbon dioxide emissions are depicted in Figure 1.1 as well the population growth rate. From Fig 1.1, it can be noted that as the population rises, carbon emission rate would also rise by a certain amount. For instance, during the early 1980s, in 1985 specifically, population increased by almost 0.05 % as a result, carbon emission rate per capita increased by more than 0.1. Triggering such a positive change could be increased human activities such as cutting down trees for timber, increased burning of fossil fuels for energy and increased manufacturing. During the period when population was decreasing, around 1986 to 2003, from 3.5% to 0.2%, the emission rate also decreased respectively and this was triggered by some of the policies employed by the state inorder to reduce population as well as the land reform programme which resulted in many Zimbabweans being engaged in farming activities which would trap the carbon dioxide emission resulting in reduced amounts. In the current periods from 2018 to 2020 population of Zimbabwe is accumulating from 1.41%, to 1.5% in 2020. According to Lawal and Abubakah (2019) this population increase means increased demand on the finite natural resources.

Problem Statement

The problem being investigated is premised on the fact that Zimbabwe recorded weather extremes such as heat waves, climate-related disasters include tropical cyclones Eline, Japhet, Dineo, Idai which resulted in floods and loss of life, increased water-borne diseases, destruction of social and economic infrastructure, droughts and prolonged intra-seasonal dry spells. The major player in all these disastrous climate changes is due to global warming; it occurs when air pollutants particularly carbon dioxide trap the suns radiation and then causes the heat into space, leading to deterioration of the ozone layer then causes atmospheric temperature to rise. O'Neill *et al* (2010), argued that relatively little concern has been addressed towards determining potential population growth policies to influence

sustainability of the natural air and global climate changes. With rapid increase in population of Zimbabwe as highlighted in Fig 1.1, this has raised concerns about the future in that sustainability may not hold with larger population. The pressures that the above places on natural environment threaten future sustainable lifeforms, with among the most severe environmental repercussions of human population growth being climate change. As a result, it is critical that the study look into the relationship between Zimbabwe's population increase and environmental quality.

The major goal of the study is to determine the relationship between population increase and quality of the environment as measured by carbon emissions in Zimbabwe. The study is premised on the hypothesis that there is no interaction between population increase and environmental quality.

A number of studies were carried out with regards to the nexus between population growth and the environment around the world. The fields included in the studies are development economics, health economics and environmental economics. Ahmad *et al* (2005) researched on the interaction of growth in population and environmental degradation in Pakistan and Lawal and Abubakah (2019) examined the effects of population growth on carbon dioxide emission in Nigeria.

Although some studies have been done before, their value may not resonate well in the context Zimbabwe as some were done using cross-sectional data, some were done decades ago and this implies that a lot of changes could have taken place for instance changes in population, environment quality and climatic conditions. Therefore, it is against such changes that the research will provide information for policy making in the field of environmental economics particularly for Zimbabwe.

The remaining sections of the study have literature review, methodology, results presentation and interpretation and lastly, conclusions and recommendations of the study.

2. Review of Related Literature

This section presents both the theoretical and empirical literature. There are few theories presented in order to give a grasp of the relationship between population expansion and environmental quality. The major theory in regard is the Malthusian theory of population; other theories after it are Environmental Kuznets Curve Hypothesis and Pollution Haven Hypothesis (PHH).

2.1.1 Malthusian Theory of Population

Malthus (1798) looked at consequences of population expansion and natural resources. He propounded that as the population grows, more pressure will be exerted on finite resources, imposing more strain on the environment. He also said that the speed at which the numbers of humans are growing outpaces the rate at which food supplies are growing. The theory suggests that increase in population tends to possess positive relationship with environmental degradation. The theory postulates that, increased man –made activities triggered by population rise, will likely to have some adverse effects on the carrying capacity of the environment.

The theory resonates well in the context of this study. Over the study period, it may be expected that as population increases, more human activities are expected as well such that more pressure is being exerted on the non-renewable resources leaving no room of adequate

resources for the upcoming generation, therefore the theory may be applicable to the context of Zimbabwe.

2.1.2 The Environmental Kuznets Curve Hypothesis (EKC)

The Kuznets proposed the theory in (1955). The Kuznets Curve for the Environment illustrates how economic growth can improve the quality of the environment-human interaction. The EKC hypothesis assumes that as the economic activities increase, the environment will experience a loss in quality but as economic growth continues to increase, the quality of the environment ought to improve. Dinda (2005) argued that increasing in economic activities increases environmental damage as a result of various reasons such as greater use of the available natural resources such as air, water, minerals, use of grimy technologies implemented, more concern on profits obtained regardless of the damages to the environment. Once a required threshold of growth is reached, a certain amount of income is placed towards the improvement of the environment, resulting in a bell curve (U-shaped) as shown in the diagram below.
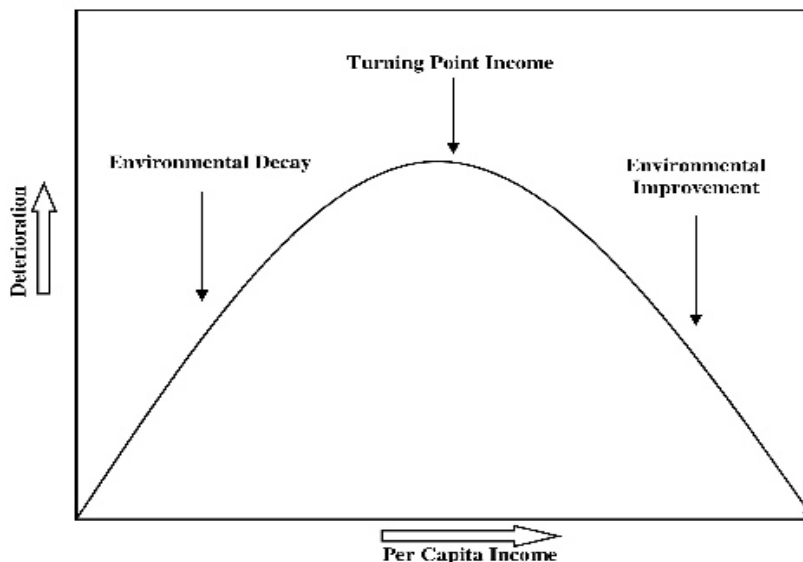
Fig.2.1: The Environmental Kuznets Curve (EKC)

Source: Todaro and Smith, (2011)

2.1.3 The Pollution Haven Hypothesis (PHH)

The Pollution Haven Hypothesis (PHH) examines environmental degradation. The theory was done by McGuire (1982). It assumes that accuracy of the environmental regulations determines quality of the environment. The PHH postulates that due to trade openness and presence of foreign investors, low developed countries are prone to be pollution havens.

The model assumes that developed countries have robust environmental protection rules. As a result, polluting companies from rich countries shift to developing countries, where laws are expected to be less stringent. This hypothesis, like the EKC, contends that in developing countries, increasing GDP and employment growth take precedence over environmental preservation.

Ahmad *et al*. (2005) examined the impact of population expansion on the environment in Pakistan. The research spanned the years 1972 through 2001. The researchers used the Malthus hypothesis and the Boserup theory to explain the relationship between population growth and the environment in their study. The researchers employed the time series data. In the long run, population increases were found to be causing a rise in the rate of carbon emissions. The findings showed that population has a negative impact on the quality of the environment.

Population growth and environmental stress were studied by Ahmad (2009). The researcher used both Malthusian theory and the Boserup theory in the investigation. The study's findings revealed that the deterioration of the environmental resources was as a result of ever-increasing populations, ever-increasing resource demands, and ever-increasing pollution thus lowering environmental quality.

Ziramba (2015) examined the factors that influence carbon dioxide emissions in Africa. Six Southern African countries were included in the study, with Zimbabwe being one of them. The researcher employed time series data. In his study, the researcher used the Auto Regressive Distributed Lag (ADRL) model. The amount of economic growth, population growth, and foreign direct investment were found to be the most important predictors of carbon dioxide emissions in these countries.

In Nigeria, Ajayi and Adedeji (2020) investigated the interaction of growth in population, international trade and deterioration of the environment. Time series data was applied. The data collected was from 1960 to 2017. The researchers made use of the ARDL method to determine the relationship. The Pollution Haven as well as Environmental Kuznets Curve hypotheses were used. In the long run, the empirical data in Nigeria confirmed the existence of the EKC hypothesis. The study found that international trade and increase in population possesses a short- and long-term positive impact on environmental degradation, and that economic growth is significantly positive in short-run and negative in the long-run on environmental degradation.

Wang *et al* (2020) did research on the social and economic aspects that influence China's environmental quality. The researchers used a sample of 163 industrialized and developing nations from 1996 to 2016 to conduct their research. The IPS and ADF Fisher Chi-Square tests were used to determine the variables' stationarity. Pedroni's cointergration test was used to identify the order of integration before using the panel ADRL method in determining the association of the regresses and the regressors. Study's findings revealed that population expansion, economic growth, and foreign direct investment are all contributing to a decline in environmental quality.

3. Methodology

The model employed by Ajayi and Adedeji (2020) in their research study on the relationship between population increase, economic growth, trade liberalisation, and carbon emissions was adapted for this study. The research study was carried put in Nigeria using time series data of 1960-2017. The researchers applied the ARDL approach to determine the association of the variables. Variables such as domestic investment and budget deficit were eliminated from the analysis due to study objectives and data inaccessibility. Three other variables were added to this research namely Industrial Sector (IND), Trade Openness denoted by TO and the Transport Service (TS). Therefore, the model employed in this research is as follows.

$$CO_2 = \alpha_0 + \alpha_1 PG + \alpha_2 IND + \alpha_3 TO + \alpha_4 TS + \alpha_5 GDP + \alpha_6 GDP^2 + \varepsilon$$

Where:

CO_2: Carbon Dioxide emission as annual growth % (proxy of environmental quality)

PG: Population Growth Rate annual %

IND: Industrial Sector, Value Added as annual % growth

TO: Trade Openness as an annual growth %

TS: Transport Services as annual growth % for commercial services

GDP: GDP per capita annual growth %

GDP^2: Squared GDP per capita annual growth%

α_0: The intercept

α_1- α_6 : variable coefficients,

ε : Residual error term

3.2.1 Population Growth (PG)

World Bank (2019) defined population growth as rate of increase in the total number of people including number of birth rates and number immigrants recorded annually. The population is calculated by adding together all residents, regardless of citizenship. Casey and Galor (2016) argued that population growth is a major driver of carbon dioxide emissions. Increase in population growth and more demand for oil, gas, coal, and other fuels means more carbon dioxide is released into the atmosphere, trapping warm air inside. Therefore, the variable is expected to carry a positive sign against carbon dioxide emission.

3.2.2 Industrial Sector (IND)

Mining, manufacturing (sometimes stated as a separate subgroup), building, power, water, and gas are all included (World Bank, 2019). It is measured by using value addition, which is a sector's aggregate output less aggregate inputs. The industrial sector encompasses sectors such as transportation and manufacturing which are generating much carbon dioxide emission. Barca and Bridge (2015) argued that the growth of industries has caused massive air pollution exerting pressure on the quality of the environment. Global warming and green house effects are as the result industrialization. Therefore, the variable is expected to carry a positive sign against the carbon dioxide emission.

3.2.3 Trade Openness (TO)

It refers to the sum of all the exports and imports as a percentage of gross domestic product (World Bank, 2019). Expansion of trade can have a clear negative influence on the environment, creating pollution and depleting natural resources (Naranpanawa, 2011). Under trade openness, a country specialises in the production of good or goods with which it has competitive advantage. For the reason that there are possible increased benefits, a country is likely to exhaust its resources in favour of the returns such that high levels of emissions are likely to be triggered since the country will be fighting to increase output (Ajayi and Adedeji, 2020). As a result, trade openness is expected to poses a positive influence on emissions in carbon dioxide.

3.2.4 Transport Services (TS)

The World Bank (2019) regarded transportation services as all movable forms of transport such as air, land, inbuilt waterway, space, and rail line conducted by people from involving the carriage of travellers, the transportation of products (freight) and emergency vehicles performed by residents of one economy for residents of another economy. It is measured as a percentage of the value of commercial services. According to Ospina et al. (2018), while transportation ought to be crucial driver of economic growth, it is also a major source of carbon emissions because it consumes a lot of oil and energy. Therefore, the variable is expected to possess a positive relationship with carbon dioxide.

3.2.5 Gross Domestic Product (GDP)

In the study, the researcher employed this variable as a proxy for economic growth, and real GDP per capita was used. Real GDP, according to the World Bank (2019), is aggregate value of output by local registered suppliers adjusted for inflation. It is determined by dividing the midyear population by the gross domestic product and converting the result to annual percentage increase. Ajayi and Adedeji (2020) argued that, as the economy grows, more economic activities such as production, manufacturing, exporting mention a few. This would mean that more energy in used resulting in increased rate of pollutant emissions from the industrial sites where production will be taking place thus a positive relationship is expected between carbon emission and economic growth.

3.2.6 Squared Term of Gross Domestic Product (GDP^2)

For the purpose of the study, real GDP per capita was used to come up with the data for the squared GDP. It is measured as the national income adjusted for inflation (World Bank, 2019). Selden (1994) outlined that the environmental challenges that the economy maybe be currently facing, it may be due to historical past events. The variable it used to test if the Environmental Kuznets Hypothesis holds for the economy of Zimbabwe. If the EKC holds, there will be a negative between this variable and carbon dioxide emissions (Kuznets, 1955). This means that as per-capita income continues to rise, the economy will prioritize improvements in environmental quality. The rate of carbon emission will fall and environmental quality would eventually improve.

3.2.7 Carbon Dioxide (CO$_2$)

The variable is the one used as the dependent variable and as the proxy indicator for environmental quality. According to World Development Index (2019), carbon dioxide refers to emissions resulting from combustion of biomass fuels and during the manufacturing of products such as cement, fertilizer and pesticides. According to Wang *et al*, the principal pollutant produced during the combustion of solid, liquid, and gas fuels, as well as biomass burning, is the primary contributor to global warming and is blamed for the progressive increase in world temperature. The study conducts CO$_2$ metric tonnes per capita in annual growth rate form from the World Bank Development Index in this analysis (2019). Carbon dioxide emissions at high levels imply poor environmental quality.

Secondary, annual data obtained from the World Bank 2019 revised version was used for this study. Time series data was used stretching from 1985 to 2020.

4. RESULTS PRESENTATION AND ANALYSIS

Various diagnostic tests were undertaken before the final regressions to avoid spurious regressions, results of which can be provided upon request. Below are the final results of this study.

Table 4.1: Regression Results

Dependent variable	CO^2			
Independent Variable	Coefficient	Standard Error	T-Statistic	P-Value
C	-2.602186	1.638031	-1.588606	0.1230
PG	1.965947	0.827599	2.375483	0.0244
IND	0.376645	0.097187	3.875477	0.0006
TO	-11.37778	5.098888	-2.231425	0.0335
TS	4.743311	3.731492	1.271157	0.2138
GDP	0.455116	0.183328	2.482519	0.0191
GDP^2	-0.020404	0.026843	-0.760127	0.4533

(Refer to appendix C)

R^2=0.799372 $\qquad\qquad\qquad\qquad$ Adjusted R^2 = 0.757862

Probability (F-Statistic) = 0.000000 $\qquad\qquad$ F-Statistic = 19.25763

D-W Statistic = 1.962657

As a result of the above table's findings, the estimated equation from the model described in chapter three can then be estimated as follows;

$$CO_2 = -0.020404 + 1.965947PG + 0.376645IND - 11.37778TO + 4.4743311TS \\ + 0.455116GDP - 0.020404GDP^2$$

4.1 Interpretation of the results

To measure the goodness of fit, R^2 is used. The results show that about 79.94% of the variations of carbon dioxide are explained by population growth, the industrial sector, trade openness, transport services and GDP per capita. The error term captures the remaining 20.06% which is explained by variables outside the model.

The variables whose probability is less than 0.05 are statistically significant and these include population growth, investment, gross capital formation, trade openness and economic growth.

On population growth, the variable is significant. There is a positive relationship between population growth and carbon dioxide emissions. This means every unit increase in population corresponds to a rise in carbon emissions. Casey and Galor (2016) discovered that as the population increases, pressures on human activities such as production, extraction of minerals and oils increases. When all these are being consumed, emit carbon dioxide into the atmosphere triggering a rise in global warming which deteriorates the atmospheric nature.

The results show that industry growth (IND) has a negative relationship with environmental quality. The industrial sector increases the rate of carbon dioxide emission such that a 1% increase in industrial growth, results in a 0.37664 increase in the rate of carbon emission. This implies that industrial services are among the worst generators of air pollution in Zimbabwe. The industrial sector's significant increase in carbon emissions is due to the burning of fossil fuels for energy as well as certain chemical reactions, primarily to generate

finished items from raw materials (Barca and Bridge, 2015). quite a number of industries have been said to be using coal and other unsustainable ways of energy production distorting the quality of the environment.

Trade liberalisation (TO) is positively related to the environmental quality of Zimbabwe and is significant. The rate of carbon dioxide emission decreases as trade openness increases postulating a negative relationship between these two variables such that I% increase in trade openness, results in 11.37778 decrease in carbon dioxide emission. According to the Pollution Haven Hypothesis (PHH) trade openness is negatively related to the environmental quality especially in less developed countries but however, the results obtained by the researcher entails the opposite. This may be due to the fact that Zimbabwe might be importing better technologies that may result in sustainable ways of production which results in reduced carbon emission.

According to the findings of the research, economic growth (GDP) growth environmental quality in Zimbabwe. This has been proved by the positive relationship between GDP and carbon dioxide emission such that a one unit increase in economic growth, results, in 0.455116 increases in carbon emissions. This means that growth in developing countries such as Zimbabwe, results in increased rate of carbon emission. A ccording to Ajayi and Adedeji (2020), economic growth means more economic activities such as manufacturing, exportation, production and this leads to high emission rates of carbon dioxide and other gases especially in developing countries where innovations in new environmental-friendly methods of production are still lagging behind. However, the EKC hypothesis tends to hold in the economy of Zimbabwe since the squared economic growth has turned to be negatively related to carbon emission. Like the EKC Hypothesis suggest, when economic growth increase, the demand for a smarter environment increases also.

5. CONCLUSIONS AND RECOMMENDATIONS

This section concludes the research on the relationship between population growth and environmental quality in Zimbabwe, as well as the project's overall conclusion.

The major objective of the study was to examine the relationship between population growth and environmental quality in Zimbabwe. Scope of study stretched from 1985 to 2020 making use of time series data.

Based on the results obtained, in developing nations such as Zimbabwe, population growth accelerates carbon emission and this is explained by positive coefficient. Based on the findings, the following are the recommendations that can be adopted.

Results have shown that there is a positive interaction between population growth and carbon dioxide emissions which imply that population growth plays a significant role in contributing towards higher carbon emissions. Given those human activities such as use fossil fuels, it is of no doubt that population growth is a major contributor to global warming through the carbon dioxide emission. Increasing girls' education declines fertility rates reducing population growth. Literacy is the most efficient weapon for girls to evade early marriages and achieve self-actualization, and the more a girl stays in school, the less probable she is to produce offspring during her adolescent period.

Women's economic opportunities expansion, result in a decrease in population growth. Women's economic empowerment, according to Taylor and Pereznieto (2014), refers to strategies for assuring that young ladies obtain equitable domination on opportunities and

also to have the ability to use those opportunities to gain more authority over other parts of their lives. This enables them to control birth rates by having a business mind-set. Quite a number of Microfinances have emerged in Zimbabwe with aim of empowering young girls and women for instance Zimbabwe Women's Microfinance Bank is also another institution with the aim promote women by providing loans for small businesses or project such that they work to improve their livelihoods. This implies that keeping women busy results in a significant decrease in population growth hence promoting environmental quality.

Another strategy to slow population increase is to provide access to birth control and family planning services. Providing parents with schemes for planning a family can improve their educational and career prospect hence reducing population increase as a result, carbon emissions rates reduces over time. Therefore such measures to mitigate population focusing on the girls or women side should be implemented by the government of Zimbabwe in order to mitigate high levels of emission and improve the quality of the environment.

More importantly, to reduce population growth in cities, the government should enhance productivity in rural areas through supporting rural agriculture and development of growth points. Such a strategy alleviates poverty as there will be increased production as well as employment creation. This will also boost rural development as well as tackling rural-urban migration.

Future researchers may focus on determinants of environmental quality, finding the impact of agricultural productivity on environmental quality in Zimbabwe. Since Zimbabwe is an agro-based economy, such a study will be worthy researching on in order to see how the two are related in countries depending mostly on agriculture.

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