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The impact of environmental protection policies on greenhouse gas emissions in Tanzania: An empirical analysis

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Abstract

The aim of this study was to investigate the impact of environmental protection policies on greenhouse gas emissions in Tanzania. Total natural resources rent, foreign direct investment, gross domestic product and environmental protection policy were applied as determinants of greenhouse gas emission. Ordinary least squares - Heteroskedasticity corrected was appropriate for the current study's analysis of time series data from 1990 to 2021. The environmental protection policy entered the model as a dummy variable with 0 before policy adoption and 1 during and after adoption. No effect on greenhouse gas emission resulted from foreign direct investment and economic growth. Total natural resources rent had a negative significant impact implying that the 1997 environmental protection policy and other afterward laws and regulations affected natural resources in that could significantly reduce greenhouse gas emissions. The country also experienced higher greenhouse gas emissions in the years after the environmental protection policy of 1997 was adopted compared to the period before its adoption. This was likely due to the fact that from 1997 onward, economic growth was higher than the years before the policy was adopted. The study introduced a dummy variable in the model to reflect the effect of policy on emission.

Keywords: Pollution control adoption, air pollution, environment and trade

JEL classification: Q52, Q53, Q56

1. Introduction

Human activities are increasing globally due to the increase in world population as well as global technological advancement. Some of these activities pollute the environment and cause hazardous effects on human life. According to the World Health Organization (2016), a quarter of all global deaths are linked to environmental risks. Countries are striving to reduce greenhouse gas emissions because of their global warming effects. Governments and policymakers are striving to achieve a net zero emission by 2050 (Hailemariam & Erdiaw-Kwasie, 2022). The United Nations climate summit in Glasgow in November 2021, called COP26, highlighted at length the importance of having net-zero greenhouse gas emissions by 2050. For example, China proposed a two-stage carbon emission goal in 2020 indicating that by 2030 and 2060 it will make all efforts to attain 'carbon peak' and 'carbon neutrality' respectively (Guo & Che, 2023). Greenhouse gas emissions have strong negative externalities on the process of economic development, an indication of market failure. Although many countries are committed to reducing greenhouse gas emissions to zero by 2050, statistics show that emission of gases have increased dramatically and therefore global warming has emerged as a major policy concern around the world (Hailemariam & Erdiaw-Kwasie, 2022; Alam et al., 2021; Chakraborty & Maity, 2020; Diffenbaugh & Burke, 2019). Total greenhouse gas emissions are projected to reach 75 Gigatons CO_2-equivalent by 2060 (OECD, 2020).

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In the East African Community, heads of state agreed to develop policies and strategies to address the adverse impacts of climatic change. The East African Community Climate Change Policy was introduced in 2011 to provide an integrated, harmonized, multi-sectoral framework for responding to climate change (EACCCP, 2011). The EAC Partner States were required to immediately adopt the policy and implement it.

Tanzania is experiencing rapid economic growth with urbanization and industrialization leading to significant challenges in pollution management from wastewater, air pollution, noise, and vibration, chemical waste, and land pollution (NEMPSI, 2022). Air pollution is one of the forms of pollution experienced countrywide although the magnitude of pollution varies from location to location depending on the economic activities. According to statistics collected from the public on environmental pollution complaints from 2019 to 2022, Dar es Salaam accounts for 88 percent of air pollution incidents, while Dodoma, Mwanza, Arusha, and Mbeya account for 2 to 4 percent. On average, Dar es Salaam has a higher income and consumption levels compared to other urban and rural areas (Waryoba, 2023), which implies more activities in Dar es Salaam than in other parts of the country.

Emissions from industries affect 66 percent of major cities including Dar es Salaam, Mwanza, Arusha, and Mbeya. It extends further to 40 percent of municipalities including Iringa, Singida, Temeke, Morogoro, Musoma, Ilemela, Kigoma, and Kigamboni (NEMPSI, 2022). The common industries that generate air pollutants include coal and oil-fired thermal plants, cement production industries generating particulate matter, waste recycling, recovery industries generating emissions but also heavy metal air pollutants depending on the raw waste processed. The major challenge of industrial pollution is lack of efficient air pollution control equipments in industries and their locations near urban populations (NEMPSI, 2022). However, there is no enough data on environmental protection expenditure in Tanzania. For example, in the years 2017 and 2018, the environmental protection expenditures were TZS 11.3 billion (0.01 percent of GDP) and TZS 10.2 billion (0.008 percent of GDP) respectively (IMF, 2023) and these are the only two data available from the source.

Tanzania among other countries is striving to reduce greenhouse gas by protecting the environment and reducing climatic change impact by formulating different policies and laws. Among those policies that specifically emphasized controlling greenhouse gas emissions are; the National Environmental Action Plan (NEAP) of 1994, the Sustainable Industrial Policy of 1996, The National Environment Policy (NEP) (1997), The National Forest Policy (1998), the legal framework for dealing with greenhouse gas emissions is Environmental Management (EMA) Act No. 20 of 2004. However, Tanzania signed multilateral agreements and protocols on environmental protection including the Convention on Biological Diversity (CBD), 1996, UN Convention to Combat Desertification (UNCCD), 1994, United Nations Framework Convention on Climate Change (UNFCCC), 1996, Kyoto Protocol to the UNFCCC, 2002, the Ramsar Convention,2000, Basel Convention on the Control of Trans-boundary Movements of Hazardous Waste and their Disposal, 1993, Bamako Convention on the Ban of the Import into Africa and the Control of Trans-boundary Movements of Hazardous Wastes within Africa, 1993, Vienna Convention for the Protection of the Ozone Layer, 1993, Stockholm Convention on Persistent Organic Pollutants (POPs), 2004, Montreal Protocol on Substances that Deplete the Ozone Layer,1993 to mention but a few. It is, however, not known how far these policies, agreements, protocols, and laws have helped in reducing greenhouse gas emissions in Tanzania.

2 Theoretical Backgrounds

According to Guler & Ozarslan (2023), the relationship between the environment and economics can be evaluated in the context of externalities. Environmental pollution is a negative externality that leads to market failure in environmental economics. The relationship of negative externality between individuals and firms within the scope of economic theory can be examined in a particular theoretical framework with the help of an analytical model (Guler & Ozarslan, 2023). However, to arrive at the theoretical model, some assumptions have to be made for example we assume complete information, perfect completion, no pre-existing pollution, current pollution, and the presence of fixed pollution technologies.

$$-C'_j(e_j) = D'_i(E) \quad (1)$$

where, e_j is the emissions produced by j-th firm, and therefore $C'_j(e_j)$ is the cost of environmental pollution caused by j-th firm emissions. $D'_i(E)$ is the welfare loss encountered by i-th individual due to emissions up to E.

The emission cost for every firm in the market is shown in Equation 2 below. The point where the first-order derivatives are equated to each other in the equation is considered the first condition for efficient allocation, which is the output of the social objective function aimed at reducing emissions.

$$-C'_j(e_j) = -C'_k(e_k) = \ldots = -C'_n(e_n) \quad (2)$$

Emission costs increase if the actual emissions are greater than the expected values ($e_j > \hat{e}_j$). Another condition is that the marginal reduction costs of the firms in the market are equal. The first derivative of the cost function in equations 1 and 2 is called the Marginal Abatement Cost (MAC) (Phaneuf & Requate, 2017; Guler &Ozarslan, 2023). In this scenario, individuals try to compensate for their welfare losses, and firms that pollute the environment face the cost of reducing pollution while internalizing negative externalities. Although coarse theorem can effectively solve local problems relating to efficient allocations, there is a need for government policy intervention in the market since the market alone cannot fully internalize the problem. Therefore, environmental protection policies are needed since they are closely related to societies' welfare and the cost structures of the firms while solving efficient allocation problems.

3 Literature Review

Greenhouse gas emissions particularly carbon dioxide is mostly caused by human activities. That is why GDP growth influences CO2 emission (Dominick, 2014) making factors behind GDP like foreign direct investment (Waryoba, 2017) important explanatory variables of greenhouse gas emission. One of the first studies to examine the link between human activities and carbon emissions was Ehrlich & Holdren (1971), and later Hailemariam & Erdiaw-Kwasie (2023). Various studies investigated how different practices can impact greenhouse gas emissions. Because an automatic reverse of environmental pollution may take a very long time (Dominick, 2014). For instance, progress toward a circular economy significantly improves environmental quality by reducing CO2 emissions (Hailemariam &Erdiaw-Kwasie, 2023). Greenhouse gas emissions can be reduced by improving material flow efficiency and extending the useful life of products and materials (Cimen, 2021; Munaro et al., 2020).

Environmental protection tax is another practice for reducing greenhouse gas emissions. Du & Zhou (2022) found that the improvement of sulfur dioxide emission charge standard can effectively inhibit industrial sulfur dioxide emission, which verifies the existence of environmental effects of pollution levy policies. Wu & Chen (2023) examined the impact of fiscal environment protection expenditures on agricultural carbon emissions in China using panel data of 31 provinces (cities) from 2007 to 2020. The empirical tests show that fiscal environment protection expenditures have significant negative impacts on agricultural carbon emissions; fiscal environment protection expenditures have a heterogeneous impact on agricultural carbon emissions in different regions, which shows that it has a significant impact on the eastern and central regions and provinces with relatively "high" carbon emissions, while it has insignificant impact on the western regions and provinces with relatively "low" carbon emissions. Further, the results of mechanism analysis show that the impact of fiscal environment protection expenditures on agricultural carbon emissions is mainly manifested in its inhibiting effect on agricultural diesel, fertilizer, and film use of carbon emissions. According to Laborde et al. (2021), carbon emissions from agricultural production account for nearly 15 percent of the total human carbon emissions. Guo & Chen (2023) used panel data from 30 Chinese provinces from 2009 to 2020 to investigate the connection between carbon emission intensity and investment in environmental protection. It was found that investment in environmental protection has a nonlinear inverted U-shaped relationship with carbon emission intensity, that is, with the increase in environmental protection investment, its effect on carbon emission has changed from promoting to inhibiting. The results corroborate with the study by Sijin & Xiaocong (2022), Sheng & Zhang (2021); Lin & Yang (2022); Huang & Gao (2016), and Simionescu & Gavurova (2023).

Yang, Tang, and Zhang (2020) conducted a study in China on the direct impact of environmental regulation on carbon emissions and its indirect effects on carbon emissions through foreign direct investment (FDI), energy consumption, industrial structure, and technological innovation using special econometric model and the provincial panel data of 2003–2017. The results show that the direct impact of environmental regulation on carbon emissions is significant and positive. Environmental regulation could indirectly influence carbon emissions by influencing, FDI, energy consumption, and technological innovation.

There are mixed results from different scholars as to whether environmental protection policies and legal frameworks have significant impact on greenhouse gas emissions reduction. For example, Huang (2014) and Xiu (2014) found that the policies have a significant impact on reducing greenhouse gas emissions, just like in Du (2013), Xiu & Liu (2014), Huang, Li & Chen (2014), Huang & Guo (2017), Zhang et al. (2019) and Zhang (2016). Some scholars point out that strict environmental regulation may increase business costs and weaken an enterprise's competitiveness (Maria & Werf, 2013; Grafton et al., 2014; Allaire & Brown, 2016; and Sterner et al., 2016). Liu et al., (2023) conducted a study in Asia Pacific Region using panel data from 1991 to 2021 concerning the relationship between environmental policy stringency, innovation, and carbon emissions. They found that a positive shock in environmental policy stringency has a significant negative impact on carbon dioxide and vice versa in both the short and long term.

Assamoi and Wang (2023) conducted a study in China and the United States taking data from 1985 to 2021 using NARDL. The empirical results show that improvement in EPU deteriorates environmental quality in both countries. However, a negative change in EPU reduces emissions in China and increases them in the United States. In addition, a positive change in environmental policy stringency will lead to fewer emissions, while a negative change will worsen environmental damage. Simionescu and Gavurova (2023) checked whether income inequality enhances pollution in the EU-13 countries from 2002 to 2021 using the Fully Modified Least Square (FMOLS) estimators and method of moment's quantile regression. The result shows that in most cases, the Gini index and gender pay gap negatively impacted Greenhouse Gas Emissions. For robustness check, from 2006 to 2021, the environmental protection investments of the general government reduced greenhouse gas emissions only in the long run.

4 Methodology and data

4.1 Research Design

The study followed a quantitative research method since the use of modeling necessitated the regression analysis application. Several models can be utilized, for instance, Nonlinear Auto Regressive Distributed Lad model (NARDL) (Liu et al., 2023; Asamoi and Wang, 2023), panel asymmetric ARDL (Li et al., 2023), quantile fixed-effect panel data (Albulescu et al., 2022), non-linear panel ARDL model (Yirong, 2022), Systematic General Method of Moments (Hassan & Rousseliere, 2022; Wang et al., 2020), panel threshold (Ouyang et al., 2019), autoregressive distributed lag ARDL model (Sarkar, et al., 2018; Isam, et al., 2021; Rahman & Alam, 2021; Islam et al., 2017; Wahid et al., 2017), vector error collection model (Alom et al, 2017; Sharmin & Tareque, 2018), vector autoregressive models (Amin, Ferdaus & Porna, 2012; Islam, Irfan & Shahbaz, 2022), and mixed models (Sharmin, 2021) just to mention a few. The current study used an Ordinary Least Squares (OLS)-Heteroskedasticity corrected model in the analysis. The following expression was used to verify the variable relationships

$$ghg_t = \propto + \beta_1(nrr)_t + \beta_2(fdi)_t + \beta_3(pol)_t + \beta_4(gdp)_t \quad (3)$$

where, ghg represents Greenhouse Gas emissions, nrr is natural resources rent,fdi is foreign direct investment, pol represents the policy dummy, and gdp is the gross domestic product.

4.2 Data and Data Sources

Different studies have used various variables to analyze the cause of CO_2 emissions. For example, studies that used energy intensity are Salim et al., (2017), Islam et al., (2020), Amin et al., (2012), and Sharmin & Tareque, (2017). Those that used population as one of the variables causing CO_2emissions are Zang, Tang & Yang (2020), Guo & Chen, (2020), and Zang, Way & Way, (2022). Studies that used technological innovation as a variable that indirectly determine how environmental protection policies affect greenhouse gas emissions are Zang, Wang & Wang (2022), Zang, Yang & Tang, (2020), Jiun, Wang & Zang, (2020), Ai, Reng & Xiong, (2021), Zang (2021), Yan et al., (2020), Liu, Li & Yin, (2018), Bel & Joseph, (2018) and Cae et al., (2019) among the recent studies. Studies that used total energy consumption as a variable in measuring greenhouse gas emissions among other studies include Zang, Yang & Tang, (2020), Hassan & Chongbo, (2020), Dale (2021), Sarkar (2021), Hassain (2011), Hazeab, et al.,(2017), Wang & Fang (2018), Kan, et al., (2020), Franco, (2021), Hassain, (2020), Ahmad & Zhao, (2018), Valencia-Herera,(2020), Ahmad et al., (2020), Ali, Law & Zannnah, (2016), and Alan, Udin& Islam, (2017).

Recent research that used greenhouse emissions as a dependent variable are Dale, (2020); Tsai, Chang & Chang, (2016) and Wu& Chen (2017). Many other studies used variables like Fossil fuel consumption, GDP, Population, Affluence, Urbanization, Industrial structure, Foreign Direct Investment (FDI), non-renewable energy consumption, and environmental regulation among other variables. This study used variables that are indirectly affected by environmental protection policies to determine how those policies are effective in reducing greenhouse gas emissions in Tanzania. The reason for using these variables is that no data for Tanzania measures the stringency of the policies or the environmental protection policy index. The explanatory variables used in this study are foreign direct investment, fdi measured in USD, and total natural resources rent, nrr measured in percentages of GDP. The control variable was GDP growth rate, gdp while the explained variable is greenhouse gas emissions, ghg was measured in kilotons (kt) of CO2 Equivalent. Data sources were the World Bank data, and Climate Watch data.

4.3 Results and Discussion

4.3.1 Pre-estimation Tests

Figure 1 represents time series graph of variables used in this study namely greenhouse gas emissions (ghg) measured in kilotons of CO2 Equivalent, natural resources rent (nrr) as percentages of GDP, foreign direct investment (fdi) in USD and GDP growth rate.

Figure 1: Time series graph of variables

Source: World Bank and Climate Watch Data (2023)

Data for greenhouse gas emissions show that emissions have been increasing since 1990 from about 40,000 kilotons of CO2 equivalent in 1990 to about 90,000 kilotons of CO2 equivalent. This shows that emissions have increased more than double in thirty years in Tanzania. Natural resources rent contributed a large percentage of GDP in the period between 1990 and 1997 which ranged between 10 to 14 percent, however, the contribution declined to an average of 5 percent from 1998 to 2018, and then in 2020 the rent started to increase. Foreign direct investment was very low in the years from 1990 to 1998. Thereafter it started increasing and fluctuating largely from 1999 to 2021. GDP growth rate was below 5 percent between 1990 and 2000 and it then maintained an average of 6 percent from 2001 to 2019 which then declined probably due to the effects of the corona virus. Table 2 presents the pre-estimation tests. Panel (a) presents a correlation analysis of the variables to test the existence of strong linear associations among independent variables to avoid spurious regressions. The analysis shows that there were no strong correlations among independent variables since all variables reported a correlation coefficient of less than -/+ 0.7 in absolute terms. According to the rule of thumb a correlation coefficient of ≥ 0.7 or ≤ 0.7 is considered problematic.

Table 2: Pre-estimation tests

(a) Correlation analysis

Emissions	Rent	FDI	GDP	
1	-0.6068	0.7661	0.3863	Emissions
	1	-0.542	-0.5095	Rent
		1	0.4746	FDI
			1	GDP

(b) Normality test

Variable	Jarque-Bera test	p-value
Emissions	2.57057	0.276572
GDP	3.71334	0.156192
Rent	5.47323	0.0647893
FDI	2.36428	0.306622

(c) Unit root test

Variable	Critical Value	Test Statistics
Emissions	-1.03199	-2.87023
GDP	-0.454433	-3.0044
Rent	-0.271055	-2.0663
FDI	-2.66932	-3.28468

Two-tailed critical values for n = 32: 5% 0.3494, 1% 0.4487

Source: Authors' computation

The Jarque-Bera test was carried out to uncover the normality of variables as shown in panel (b). It was found out that all variables had p values greater than 0.05 indicating that the variables were normally distributed. But even when the criteria are relaxed to 10 percent levels of significance, only natural resources rent seem to contend with normally test. That is, being not normally distributed, the rest remain normally distributed. The Augmented Dickey-Fuller (ADF) test was used to determine whether each variable had a unit root. The results from panel (c) show that

the null hypotheses of the existence of unit roots are strongly rejected, indicating that all variables were stationary at level form. The test statistic of individual variables was greater than the estimated critical values. This was expected because the values were in terms of rate rather than level values.

Yang, Tang & Zhang (2020) found out that the relationship between environmental regulation and carbon emission is positive and significant. This study found out those environmental policies significantly increased greenhouse gas emissions in Tanzania. Angelis et al. (2019) found evidence that the environmental policy rigidity index, used to explain environmental regulation, exhibits negative and enormously significant coefficients. Simionescu & Gavulova (2023) found out that the environmental protection investments of the general government reduced GHG emissions only in the long run. Table 3 shows the results from the regression analysis on how the independent variables affect the greenhouse gas emissions in Tanzania. The results show that total natural resources rent has a negative and significant impact on reducing greenhouse gases.

Table 3: Heteroskedasticity-corrected OLS

	coefficient	std. error	t-ratio	p-value
Const	0.567631	0.373899	1.518	0.142
Lnnrr	0.077617	0.031723	2.447	0.0221
Policy	0.100481	0.034455	2.916	0.0076
Lnfdi	−0.000326890	0.002862	−0.1142	0.91
Lngdpr	0.011799	0.013202	0.8937	0.3804
lngdpr_1	−0.00705290	0.008173	−0.8629	0.3967
lnghg_1	0.943831	0.037094	25.44	7.13E-19
R-squared	0.995243	Adjusted R-squared		0.994054

Source: Auhor's calculation, (2023)

It was observed that a one percent increase in total natural resources rent will increase greenhouse gas emissions by about 0.08 percent. The effect is statistically significant at 5 percent levels of significance. This is contrary to what is expected. The possible explanation is that the extractive industries have little emissions compared to production industries which are not affected by the natural resource rent. Nevertheless, the natural resource rent is likely to be lower among investors that they consider no loss in continuing to extract the minerals. Therefore, it is high time now for the government through the ministry of minerals and energy to revise its policy on natural resource rent. Otherwise, natural resource extraction poses a big environmental threat to the development of our country. Because companies involved in the extraction of natural resources are contributing negatively to environmental conservation in Tanzania. Foreign direct investment is important in reducing greenhouse gas emissions in Tanzania due to technological aspect. New technology is replacing obsolete technology in the production process. However, this is possible if the investor is not shifting pollution to the host country. Normally, developing countries are regarded as the dumping sites of obsolete technology from developed nations. This implies that regulations are strong enough to influence FDI to significantly reduce greenhouse gas emissions. Xu, Zhou & Li (2016) explored the relationship between foreign direct investment, environmental regulation and energy consumption which revealed a negative influence of environmental regulation on foreign direct investment in both long and short term. According to Chung (2014) and Zhou et al., (2016) polluting industries tended to invest more in countries with lesser environmental regulation. Tanzania has to increase stringency in protecting the environment in order to continue influencing FDI to contribute on reducing greenhouse gases.

Table 4: Collinearity Test

Variable	**Rent**	**FDI**	**Policy**	**GDP**	**Lag GDP**	**Lag Emission**
VIF	**3.995**	**3.108**	**7.275**	**3.391**	**2.847**	**2.195**

Source: Authors' computation

The GDP growth rate has no significant impact on reducing greenhouse gas emissions in Tanzania. The study contradicts the findings by Guler and Ozarslan (2023), Wang, Wang and Zhang (2022) who found out that economic growth has a significant impact on carbon emissions. The policy introduced in 1997 shows that it significantly

increased greenhouse gas emissions instead of reducing them. Multicollinearity test was conducted to detect if there were collinearity problems and it was found that the model has no collinearity problems since the value inflation factor for each variable was less than 10 as shown in Table 4. For Multicollinearity problem the variance inflation factor should 10 and above.

5 Conclusions

This study analysed the impact of environmental protection policies on greenhouse gas emissions in Tanzania. Out of six variables used, only natural resources rent and environmental protection policy dummy were significant in influencing greenhouse gas emission. Total natural resources rent had a significant but positive impact on greenhouse gas emissions. This implies that environmental protection policies indirectly impact greenhouse gas emissions through natural resources rent. Foreign direct investment had a significant but positive impact on greenhouse gas emissions in Tanzania. The years through which the policy was adopted seem to have higher greenhouse gas emission than the years before the policy was adopted. The policy was adopted in the period privatization was taking place to spur economic growth. So, privatization policy seems to be more powerful thereby outweighing the influence of environmental protection policy. If more investment is done in the country and without strict environmental protection policies, more emission will be expected even with the current environmental policy being present. Reinforcement of the environmental protection policy is what the current practice is missing. Nevertheless, the available instruments are mostly concerned with land and water pollution rather than air pollution which is in the center of the current study's focus. Therefore, it is imperative that air pollution control be seriously taken into consideration in the ongoing environmental protection practices.

The current study, however, was limited to data availability. With 32 observations, the current study's findings posed a risk of validity problem. The findings of the current study are likely to change with increasing number of observations. Therefore, future studies should include more observations to check for robustness of the current study's findings. The policy dummy is likely to mislead the findings because it is true that years after 1997 had higher economic growth signifying the presence of more economic activities which influence emission. As a matter of facts, it is of methodological significance to consider other policy indicators rather than the binary approach employed in the current study.

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