Keeping an eye on environmental quality in Tanzania as trade, industrialization, income, and urbanization continue to grow

Mwoya Byaro1 · Gemma Mafwolo1 · Hozen Mayaya1

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Abstract
By applying the ARDL (autoregressive distributed lag) bounds testing method, this study examines the short- and long-term dynamic relationship between carbon dioxide (CO2) emissions, economic growth (gross domestic product), industrialization, trade, and urban population in Tanzania from 1990 to 2020. The study found that economic growth, trade, industrialization, and the urban population all contributed to the increase in environmental degradation (i.e., carbon dioxide emissions). However, we found that financial credit (i.e., domestic credit to the private sector) reduces carbon dioxide emissions, and its effects are significant in EKC (environmental Kuznets curve) model. Our findings revealed that economic growth (i.e., income) was responsible for both short- and long-term increases in carbon dioxide emissions in Tanzania. Economic growth is harmful to the environmental quality above a threshold value of 6.23%. Furthermore, the environmental Kuznets curve hypothesis is confirmed for Tanzania. Our findings suggest that policymakers should monitor and use the threshold levels to manage carbon dioxide emissions and to protect the environmental quality. Further, a strong focus should be placed on formulating environmental policies (i.e., carbon tax policy) as industrialization, urban population, economic growth, and trade continue to grow in future, restricting carbon dioxide emissions and safeguarding the environment.

Keywords Carbon dioxide emission · EKC · Environmental quality · ARDL

Introduction
Tanzania is one of the sustainable communities where people want to live now and work in the future (see for example, WHO 2012). Generally, people prefer to work in areas that are highly associated with a healthy environment. However, environmental quality remains a major obstacle to achieving Sustainable Development Goals, both in developed and developing countries (Efobi et al. 2019). As a result, it has a significant impact on people’s quality of life (Coan and Holman 2008; Kahn 2002). This stresses the United Nations (2015) to announce the Sustainable Development Goals (SDGs) that requires all countries to take immediate action to prevent climate change and its consequences. It is also important to note that environmental quality is still a mystery, especially for countries that compete in nation’s economic growth. In regard to this competition, political leaders are forced to make decisions that are subject to change in the future. As a result, policymakers in many developing countries are under pressure to increase these variables to the calculated thresholds (i.e., turning point) to achieve the desired impact on environmental improvement (Omri et al. 2019).

Despite some progress in environmental sustainability around the world, the quality of environmental reporting has not been universally accepted due to its difficulty in providing accurate and transparent information (Amran et al. 2014). Furthermore, non-financial disclosure has long been criticized for its lack of relevance and credibility (Baaloush et al. 2019; Kolk et al. 2008). No universal agreement exists on environmental quality and sustainability (Shaker 2015), but developing countries have been asked about these ground rules. As of February 2005, the Kyoto Protocol was the first agreement that attempts to control greenhouse gas emissions, with the aim of preventing climate change and its consequences.
emissions and provides a schedule for achieving those reductions (Akbostanci et al. 2011).

In general, environmental quality issues have gained attention in recent years because of the need to protect biodiversity, human health, and economic activities (Yameogo et al. 2021). Further, carbon emissions tend to rise faster in developing countries than in advanced economies (Bahera and Dash 2017). Similarly, the five key Sustainable Development Goals (SDGs) of 2030 address the environmental determinants of health and include issues of water, sanitation, hygiene, air quality, chemical safety, and climate action (PAHO 2021). All countries in the world are striving to reduce greenhouse gas emissions (i.e., CO2) and create a small proportion of carbon in the economy. Although the majority of African countries contribute less to greenhouse gas emissions, they are extremely vulnerable to climate change (See, Edmonds et al. 2020; Guillaumont and Simonet 2011). With this in mind, and for Tanzania to achieve sustainable development growth, it requires low or no environmental pollution that depends on its level of economic activities and institutional setting (See Byaro and Kinyondo 2020). For Tanzania’s economy to be more sustainable in terms of development, trade, financial development, industrialization, and urbanization can all contribute to its growth. Tanzania is classified as a low-middle-income country, and its economic performance has been impressive in recent years. Thus, keeping an eye on the quality of the environment cannot be ignored as the country continues to grow in terms of income, trade, financial industry, urban population, and industrialization. To this end, our study contributes to the existing literature in developing countries in a number of ways. First and foremost, this is the first study to examine the effects of trade, economic growth (i.e., income), and urban population on environmental quality in Tanzania over the year 1990 to 2020. Second, it adds the role of industrialization (i.e., manufacturing value added) and financial development in explaining carbon dioxide emissions as a measure of environmental quality in Tanzania. There is evidence that the link between economic growth, carbon dioxide emissions, urbanization, financial development, industrialization, and trade in developing countries has not been thoroughly studied (see Odugbesan and Rjoub 2020; Martinez and Maruotti 2011). Few studies from developing countries are based on country-specific analysis. For instance, a country-specific study in Tanzania examined the dynamic relationship between energy consumption, environmental pollution, and economic growth using a time series of data from 1975 to 2013 (Albiman et al. 2015). Third, some literature has shown that countries in sub-Saharan Africa (i.e., including Tanzania) would be the hardest hit by the effects of climate change (see Asongu and Odhiambo 2020a, 2020b). Last but not the least, our study uses the autoregressive distributed lag model (ARDL) to control the endogeneity of variables among economic growth, financial development, industrialization, trade openness, and urban population. Aside from the use of ARDL, our study was unique in that it used a set of threshold values to provide decision-makers with a clear picture of how to manage environmental quality in order to reduce carbon dioxide emissions (CO2 emissions). In a non-linear regression model, these threshold values are based on change points or thresholds. It provides a simple and clear technique for representing non-linear interactions between dependent and independent variables. Figure 1 below shows the normalized data between carbon dioxide emissions and economic growth from the year 1990 to 2020 in Tanzania. An increase in carbon dioxide emissions (metric tons per capita) corresponds to an increase in economic growth (i.e., GDP). As the economy grows, there is a chance that carbon dioxide emissions will raise. This can affect the atmosphere and cause global warming, which in turn causes climate change.

Fig. 1 Normalized data showing the link between carbon dioxide emissions and GDP in Tanzania
Overall, Tanzania has negligible carbon dioxide per capita emissions, estimated at 0.2 t per carbon dioxide emissions (World Bank Development Indicators Database 2021). This is very small compared to China where carbon dioxide emissions per capita in 2019 were 8.12 t per capita. However, it is still important for Tanzania in this early stage of development to examine whether carbon dioxide emissions can actually affect environmental quality or not. Some literature has also noted that agriculture, energy, waste, and industrial processes and product use all contribute to Tanzania’s greenhouse gas emissions (NBS 2019). Despite decades of high carbon dioxide emissions, for example, from 0.08 t per carbon dioxide emissions in 1990 to 0.27 t per carbon dioxide emissions in 2019 (World Bank Development Indicators Database 2021), Tanzania has made few efforts to control and implement necessary environmental policies. Over time, thermal power facilities have been built to increase carbon dioxide emissions (NBS 2019). Furthermore, old vehicles in traffic continue to emit high levels of environmental pollution in the country.

Our preliminary findings indicate that industrialization, trade, economic growth, and urban population all deteriorate environmental quality and have a significant and positive impact on carbon dioxide emissions in Tanzania from 1990 to 2020. The remainder of this study is organized as follows. The “Theoretical and empirical literature review” section reviews the literature. The methodology and data are described in the “Data and methodology” section. Empirical results and discussion are described in the “Results and discussion” section, while the “Conclusion” section concludes.

**Theoretical and empirical literature review**

Three streams of research have been identified in the literature about this topic. The first one is based on the environmental economics and relies heavily on a joint analysis of GDP and pollution. A large part of previous research has been devoted to testing the environmental Kuznets curve (EKC) hypothesis, which states that pollution and GDP are related in an inverted U-shape (see Muhammad et al. 2020; Grossman and Krueger 1991). The hypothesis further stipulates that in the early stages of economic growth, environmental degradation increases with per capita income, but after reaching a certain threshold level, it declines. The second line of inquiry is derived from studies in international economics and focuses on international trade, environmental pollution, and GDP growth. Although the empirical relationship between international trade, GDP, and environmental pollution is not clear, studies suggest that international trade can have an impact on the environmental quality due to an increase of income or production (see, for example, Frankel and Romer 1999; Frankel and Rose 2005). The third strand of literature examines the relationship between energy consumption and output related to economic growth, as higher economic development necessitates higher energy consumption (Halicioglu, 2009). However, environmental quality is not universally agreed in understanding and practice since many nations have been striving to accommodate their environment in regards to political, social, and economic needs.

Due to the lack of a uniform theoretical framework, previous research has tended to focus on the socio-political and economic factors that influence non-financial reporting (Braam et al. 2016). Similarly, environmental quality determinants are complex, subjective, and multidimensional that cannot be expressed in any theoretical perspective because it depends on complementary forces (Baalouch et al. 2019). Preserving environmental and natural resources is one of the most important factors in ensuring the sustainability of well-being over time. However, measuring environmental indicators are difficult: first, the size of the impact of current environmental factors on future well-being is uncertain; and second, there are few comparable indicators that meet agreed standards (WHO 2012). Furthermore, prior research has failed to provide an accurate measure of environmental disclosure quality due to a lack of convincing theoretical underpinning and the subjectivity surrounding the developed proxies (Baalouch et al., 2019).

Our study employs some empirical models based on Yameogo et al. (2021) together with other empirical studies (Li and Wei 2021; Opuku and Aluko 2021; Opuku and Boachie 2020; Boutabella 2014; Akbostanci et al. 2011; Tamazian et al. 2009). For example, Akbostanci et al. (2011) observed that variations in carbon dioxide emissions in the Turkish manufacturing industry were mostly due to changes in total industrial activity and energy intensity. Other previous empirical findings have shown that per capita income, financial development, foreign direct investment (FDI), and foreign trade positively contributes to environmental degradation (Zafar et al. 2020a, b; Omri et al. 2019; Salaluddin et al. 2018). Similarly, Ahad and Khan (2016) used the ARDL techniques to analyze the relationship among globalization, economic growth, energy use, and environmental quality in Bangladesh and showed that economic growth tends to improve environmental quality. In turn, Ibrahim and Law (2016) found trade openness to increase environmental pollution due to poor institutional framework. However, Li et al. (2015) examined this relationship in 134 countries and found a negative impact of trade on environmental pollution. Finally, the detailed literature is well explained in the discussion section.

**Data and methodology**

**ARDL model estimation**

We used the ARDL (autoregressive distributed lag) approach to determine the environmental quality in Tanzania. It
determines whether the data in their levels are stationary at level $I(0)$ or stationary at first differences $I(1)$ (Pesaran et al. 2001). This model has several advantages. First, it operates when the sample size is very small and sometimes it does not require pre-testing of the orders of integration (Pesaran and Shin 1999; Pesaran et al. 2001). Second, it addresses the model autocorrelation and endogeneity (Murray 2021; Sarkodie and Ozturk 2020; Byaro and Lemnge 2018). For instance, the issue of endogeneity is especially important to address because there is a causal relationship between industrialization and economic growth, as well as trade openness and economic growth. All of these variables are endogenous. To avoid spurious regression, it is necessary to deal with the issue of endogeneity using ARDL approach. Under this method, regressors are often going to lagged levels, or lagged differences and endogeneity are unlikely to develop as long as the errors are serially uncorrelated (see Eqs. 1). Third, it predicts both short- and long-term elasticity and uses different lag lengths for different variables. Fourth, the model identifies asymptotic critical value bounds, showing that variables are integrated at first differences $I(1)$ or at level $I(0)$ (Pesaran et al. 2001). The upper bound represents a critical values of $I(1)$, while the lower bound represents a critical values of $I(0)$. If the $F$-test statistics are higher than their respective critical values, a long-term association between the variables is established (Pesaran et al. 2001).

If the test statistic falls below the upper critical value, the null hypothesis of no cointegration cannot be rejected. If the $F$-statistic obtained falls between the lower and upper bound values, the results are ambiguous.

We used the ARDL model as follows:

$$
\Delta L(CO2)_t = a_0 + \sum_{i=1}^{q} a_i \Delta L(CO2)_{t-i} + \Delta \text{URBAN}_t + \Delta \text{IND}_t + \Delta \text{GDP}_t + \Delta \text{TRADE}_t + \Delta \text{CREDIT}_t + \gamma \text{ECM}_{t-1} + \mu_t
$$

where $\gamma$ is the coefficient of the error correction model (ECM). The ECM shows a speed at which the dependent variable adjusts to equilibrium and it must be negative and statistically significant.

**Data sources**

Annual time series secondary data from the year 1990 to 2020 on all variables was sourced from the World Bank Development Indicators Database (2021). Most annual time series models require a sample size of at least 30 years. In the context of ARDL modeling, we believe that 30 years is good news. This is the sole reason for including the time period from 1990 to 2020. Furthermore, the time period was chosen based on data availability, as data for some variables selected in this study are missing from the early 1980s.

Environmental issues also appear to involve many aspects, such as water pollution, carbon dioxide emissions, soil erosion, solid waste, and deforestation. However, due to time constraints and a lack of data on other aspects (i.e., water, forests, mineral resource, among others), this
study focused solely on carbon dioxide emissions (CO2 emissions) as a proxy for environmental quality. In addition, we used carbon dioxide emissions as an indicator of environmental quality (i.e., measured in metric tons per capita) because it is a major contributor to global warming and environmental deterioration. The indicator is widely accepted in previous research to represent environmental quality (see, for instance, Yameogo et al. 2021; Hakimi and Hamdi 2016). Economic growth is expressed in GDP per capita at a constant 2010 US dollars. Urban population growth is measured in annual percentages. Industrialization is expressed as manufacturing value added in constant 2010 US dollars; domestic credit to the private sector is measured as a percentage share of GDP; trade is measured as a percentage of GDP (gross domestic product).

### Results and discussion

Table 1 shows a summary of descriptive statistics of the variables. A Jarque–Bera test statistics with probability value of zero show that all variables confirm normality (i.e., normal distribution).

### Table 1 Descriptive statistics

| Variables | CO2 | CREDIT | GDP | TRADE | URBAN | INDUSTRY |
|-----------|-----|--------|-----|-------|-------|----------|
| Mean      | 0.14| 9.61   | 670.39| 42.17 | 4.95  | 8.54     |
| Median    | 0.14| 11.26  | 637.01| 42.77 | 5.14  | 8.66     |
| Maximum   | 0.23| 14.61  | 985.45| 65.69 | 5.39  | 10.98    |
| Minimum   | 0.07| 2.94   | 476.53| 23.98 | 3.97  | 6.27     |
| Std. dev  | 0.06| 3.94   | 173.34| 12.17 | 0.48  | 1.10     |
| Jarque–Bera | 3.08| 3.44   | 2.98 | 1.37  | 5.59  | 0.33     |
| Probability | 0.21| 0.17   | 0.23 | 0.50  | 0.06  | 0.84     |
| Observations | 31  | 31     | 31  | 31    | 31    | 31       |

**GDP** gross domestic product, **URBAN** urban population growth, **CO2** carbon dioxide emission.

Table 2 shows the unit root test whether the data is stationary or non-stationary at levels or stationary at first differences. We found almost all variables to be stationary at first difference except for the urban population which is stationary at level.

After investigating the unit root tests, we conducted the ARDL bound testing. Table 3 shows the results of the bound test (long-run relationship of variables). We conclude that there is a long-run relationship between carbon dioxide emissions, economic growth, trade, industrialization, domestic credit to the private sector, and urban population because the calculated F-statistics is greater than the upper bounds (i.e., 4.68).

After testing the bounds test, we selected the maximum lag in the ARDL approach as (2, 0, 1, 3, 3, 0) chosen automatically by the AIC (Akaike information criteria) in the top 20 models shown in Fig. 2. The lower the values of AIC, the better the model.

Table 4 summarizes the short- and long-run relationships among the variables. The findings show that most carbon dioxide emissions increases were attributed to economic growth followed by industrialization, urban population growth, and trade.

The short-run findings show that economic growth (i.e., GDP per capita), industrialization (i.e., manufacturing value
added in industry), urban population, and trade activities lead to an increase of carbon dioxide emission in the country. However, in the long run, only economic growth (i.e., income) leads to an increase in carbon dioxide emissions. Since the \( P \)-values for diagnostic tests are greater than 0.10 (i.e., Breusch-Godfrey serial correlation LM test and heteroskedasticity), the results are robust, and there is no serial correlation and heteroskedasticity present. A unit increase of GDP per capita (income) by 1% is associated with a 6.05% increase in carbon dioxide emission in the short run. Similarly, in the short run, increases in industrialization (i.e., manufacturing value added in industry) trade and urban population have positive and statistically significant effects on the increase in carbon dioxide emissions in Tanzania.

Even though Tanzania’s CO2 emissions are supposed to be small, such large coefficients of estimate in industrialization and GDP on carbon dioxide emissions are alarming. For instance, in the short run, an increase of 1% in urban population, trade, and industrialization increases carbon dioxide emissions by 0.12%, 0.28%, and 1.02%, respectively. Similarly, except for economic growth (i.e., income), trade, domestic credit to the private sector, industrialization, and urban population were found to have no long-run effect on carbon emissions. The error correction term is also negative and statistically significant as expected.

To check whether the results are robust, we ran additional analysis (see Table 5) using a non-linear threshold value estimate on the impact of trade, industrialization, economic

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**Table 4** Regression results for carbon dioxide emission

| Variable          | Coefficient | Std. error | t-Statistic | Probability |
|-------------------|-------------|------------|-------------|-------------|
| **A: Short-run model** |             |            |             |             |
| D(CREDIT)         | -0.17       | 0.13       | -1.23       | 0.23        |
| D(GDP)            | 6.05        | 1.41       | 4.28        | 0.001***    |
| D(INDUSTRIALIZATION) | 1.02       | 0.38       | 2.68        | 0.02**      |
| D(URBANIZATION)   | 0.12        | 0.03       | 3.35        | 0.01**      |
| D(TRADE)          | 0.28        | 0.12       | 2.29        | 0.04**      |
| ECM\(_{t-1}\)     | -0.54       | 0.27       | -1.97       | 0.03**      |
| **B: Long run model** |             |            |             |             |
| CREDIT            | -0.32       | 0.33       | -0.97       | 0.35        |
| GDP               | 1.78        | 0.44       | 4.03        | 0.001***    |
| INDUSTRIALIZATION | -1.11       | 0.96       | -1.16       | 0.27        |
| URBANIZATION      | -0.26       | 0.31       | -0.85       | 0.41        |
| TRADE             | 0.51        | 0.33       | 1.58        | 0.14        |
| Constant          | -12.12      | 3.79       | -3.19       | 0.01**      |
| **C: Diagnostic Tests** |             |            |             |             |
| Breusch-Godfrey serial correlation LM test | 0.36 |            |             |             |
| Heteroskedasticity | 0.93 |            |             |             |

*** indicate significance at 1% level, and ** indicate significance at 5% levels. ECM error correction term, \( D \) presents short run, and all variables are in natural logarithm.
growth, and urbanization on environmental quality (i.e., proxy for carbon dioxide emission). The importance of these threshold values is to provide a clear insight to decision-makers on the management of environmental quality to control carbon dioxide emissions.

Table 5 shows that carbon dioxide emissions rise when economic growth exceeds the calculated threshold value of >6.23%, polluting the environment. Carbon dioxide emissions rise slightly but not significantly when economic growth falls below the estimated threshold value of 6.23%.

When economic growth falls below the estimated threshold value of 6.23%, carbon dioxide emissions rise slightly but not significantly. This implies that economic growth above the threshold level of 6.23% is statistically significant for deteriorating environmental quality. In regard to industrialization, the industrial threshold level above 2.04% reduces carbon dioxide emissions. Industries can reduce carbon dioxide emissions by adopting energy efficiency, fuel switching, and use of renewable energy (i.e., solar and wind) and recycling of materials. The uses of renewable energy resources in industry provide a cleaner and more sustainable energy system. Zhou and Li (2020) pointed out that, industrial restructuring is important for lowering carbon dioxide emissions. This suggests that industrial restraint is a viable strategy for achieving green growth.

The threshold level of the urban population above (1.63%) in Tanzania reduces carbon dioxide emissions. Excessive urbanization might claim the benefits of high-level urbanization in terms of reducing carbon dioxide emissions (Zhang et al. 2017; Xiangyang and Guiqiu 2011). Urbanization will certainly accelerate the development of urban infrastructure, which in turn facilitates the use of energy and the generation of carbon dioxide emission (Du et al. 2012). Further, urban areas have large agglomeration in terms of development that can facilitate the use of clean energy and cut carbon dioxide emissions (Du et al. 2012; Zhang et al. 2017).

Trade openness at the threshold level value below (3.73%) increases carbon dioxide emissions, though not statistically significant. In this case, trade openness is linked to carbon dioxide emissions. It is clear that trade assists both rich and poor countries to grow faster and boost their economies. However, trade openness at the threshold level above 3.95% reduces carbon dioxide emissions. More industrial production output leads to increased trade, and such industrial processes result in emissions. Shahbaz et al. (2017) proposed new turning points in the relationship between trade openness and CO2 emissions. Using country-level, high-, middle-, and lower-income country panel-level data sets, they found that carbon emissions initially rise with trade openness, and environmental quality begins to improve after trade openness reaches a certain threshold level at a later stage of economic development. In the same vein, Grossman and Krueger (1996) pointed out that as trade expands as a result of improved technologies and good environmental policies, it reduces carbon dioxide emissions. The coefficients of economic growth, trade openness in Table 5, are positive, significant, and similar to the coefficients sign we obtained in Table 4, implying that the relationship between carbon dioxide emissions and trade and economic growth is significant and robust.

In addition to the threshold regression, we tested the environmental Kuznets curve (EKC) hypothesis for Tanzania. Table 6 shows the relationship between environmental
degradation (i.e., carbon dioxide emissions) and income per capita.

Since the coefficient of GDP (income per capita) is greater than 0 and the coefficient of income per capita squared (GDP$^2$) is less than 0, an inverted U-shape relationship between carbon dioxide emissions and income per capita (GDP) is revealed. According to this finding, the environmental Kuznets curve (EKC) hypothesis is confirmed for Tanzania in both the short and long term, and its coefficient estimates have the expected signs and statistical significance. This implies that environmental degradation rises with per capita income (GDP) during the early stages of economic growth and declines with per capita income after reaching a turning point.

Our overall analysis show that industrialization leads to high economic growth, and this can lead to increased greenhouse gas emissions and climate change (see Opoku and Aluko, 2021; Pata 2018). Prioritizing industry expansion is a logical choice in the early phases of industrialization, but it adds to a significant increase in carbon emissions (Dong et al., 2021). Rehman et al. (2021) showed that industrialization has a positive impact on carbon dioxide emissions in Pakistan. Further, Aslam et al. (2021) showed that industrialization is one of the predictors of Chinese carbon dioxide emissions. The most significant contributors to increased environmental pollution are industrial activities such as cement, iron, and steel production (Akhostanci et al., 2011). In industrialization, carbon dioxide is emitted in the production processes such as burning of fossil fuel combustion. However, industries can reduce CO2 emission for adopting energy efficiency, fuel switching, and the use of renewable energy (i.e., solar and wind) and recycling of materials.

In many countries, economic policies and strategies are geared toward long-term economic growth. Economic growth, on the other hand, may have an impact on global warming and climate change (Salari et al., 2021). In turn, economists believe that policies that limit production potential may have a long-term negative and harmful impact on economic growth (Ricci 2007). However, Grossman and Krueger (1995) argued that for countries to attain high economic growth, they needed more inputs in order to expand their outputs, resulting in an increase in waste and emissions caused by economic activity. Our findings show that economic growth (GDP) increased carbon dioxide emissions from 1990 to 2020 in Tanzania. Tanzania is still in the early phases of economic development, and its environmental degradation levels tend to rise significantly as income rises. This implies that the government and its people care more about economic development than environmental protection.

The term urbanization refers to a sociological phenomenon in which people migrate from rural to urban areas. Tanzania’s urban population grew to 22.1 million people in 2020, accounting for 37% of the country’s overall population (Statista 2021). According to our findings, urbanization in Tanzania has resulted in a rise in carbon dioxide emissions. In addition, urbanization increases industrial and residential energy consumption, as well as the change from rural to industrial output among urban populations (Odugbesan and Rjoub, 2020). Likewise, increased energy consumption, which is recognized as a significant source of climate change, as well as greenhouse gas emissions like CO2, have originated from growth and urbanization (see Zhang et al., 2021; Bakirtas and Akpolat 2018; Wang et al. 2018; Behera and Dash 2017; Heidari et al. 2015; Martínez-Zarzoso and Maruotti 2011). In a similar vein, large cities with higher per capita income are also associated with a high level of the urban population (Jedwab and Vollrath, 2015).

On the other hand, trade openness is one of the fundamental driving forces behind China’s economic development (Sun et al. 2019). However, our study findings reveal that trade openness has positive and significant effects on the rise of carbon dioxide emission in Tanzania. This means that international trade is critical to the rapid rise in carbon dioxide emissions (Hakimi and Hamdi 2016; Zhou et al. 2013). A good example is China, where the volume of carbon dioxide emissions embodied in interregional trade grew significantly from 2002 to 2010 (Xu et al. 2020). From the literature review, it should be noted that trade openness can have positive or negative effects on the economy.

Some scholars claim that financial development improves environmental quality (i.e., Tamazian et al. 2009; Al-Mulali et al. 2015), while others claim that financial growth deteriorates environmental quality (See Javid and Sharif 2016; Zang 2011; Sadorsky 2011). An economy’s financial development can raise carbon dioxide emissions since it tends to attract FDI and trade to improve economic growth, which in turn increases carbon dioxide emissions (see Frankel and Romer 1999). Customers are also more likely to purchase cars and dwellings that release more carbon dioxide when they receive loans/credit (Sadorsky, 2010). However, our findings reveal that financial development (i.e., domestic credit to the private sector) reduces carbon dioxide emissions in the EKC framework model. Financial development (i.e., credits) can contribute to environmental protection by lowering carbon dioxide emissions through the use of solar energy.

Lastly, a lot of studies are in line with our findings that economic growth, urban population, trade, and industrialization affect environmental quality (i.e., carbon dioxide emissions). These studies are Mahmood et al. (2020), Sarkodie and Strezov (2019), Salahuddin et al. (2018), Akhostanci et al. (2011), Odugbesan and Rjoub (2020), Wang et al. (2018), Bakirtas and Akpolat (2018), and Halicioglu (2009).
Conclusion

Using time series data for Tanzania from 1990 to 2020, this study investigated the effects of economic growth, financial development (i.e., credit to the private sector), industrialization, trade, and urban population on environmental quality (i.e., carbon dioxide emissions). Our findings show that trade, industrialization, economic growth, and urban population have positive and significant effects on environmental quality in the short run. However, the findings revealed that only economic growth leads to increases in carbon dioxide emissions in the long run. Also, economic growth is harmful to the environment above a threshold value of 6.23%. In addition, the environmental Kuznets curve (EKC) hypothesis was confirmed for Tanzania. In turn, the short- and long-run relationship between carbon dioxide emissions and financial development (i.e., credit) exists and significance for EKC model. The negative coefficient of financial development (i.e., domestic credit to private sector) indicates that it contributes to environmental protection by lowering carbon dioxide emissions through the use of solar energy. Our findings suggest that carbon dioxide emissions should be monitored and managed to protect the environmental quality through the use of given threshold value. Further, a strong focus should be placed on formulating environmental policies (i.e., carbon tax policy) as industrialization, urban population, economic growth, and trade continue to grow in the future, restricting carbon dioxide emissions and safeguarding the environment. We recommend the government to promote renewable energy technologies and planning application of renewable energy projects in the country. This could be a major target of carbon dioxide reduction combined with a carbon tax policy.

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Author contribution Mwoya Byaro: conceptualization, methodology, software, writing (reviewing and editing), data curation, and writing (original draft preparation).

Hozen Mayaya: supervision, reviewing, and editing.

Gemma Mafwolo: writing—original draft preparation.

Data availability The data was extracted from public available database (World Bank Development Indicators, 2020, Database).

Declarations

Ethics approval and consent to participate The manuscript does not involve human participants. Not applicable.

Consent for publication The manuscript does not contain data from any individuals reported.

Conflict of interest The authors declare no competing interests.

References

Ahad M, Khan W (2016) Does globalization impede environmental quality in Bangladesh? The role of real economic activities and energy use. MPRA. 258–279

Akboystane E, Tunç GI, Türüt-Asyk S (2011) CO2 emissions of Turkish manufacturing industry: a decomposition analysis. Appl Energy 88(6):2273–2278

Albiman MM, Suleiman NN, Baka HO (2015) The relationship between energy consumption, CO2 emissions and economic growth in Tanzania. Int J Energy Sector Manage 9(3):361–378

Al-Mulali U, Tang CF, Ozturk I (2015) Does financial development reduce environmental degradation? Evidence from a panel study of 129 countries. Environ Sci Pollut Res 22(19):14891–14900

Amran A, Lee SP, Devi SS (2014) The influence of governance structure and strategic corporate social responsibility toward sustainability reporting quality. Bus Strateg Environ 23(4):217–235

Aslam B, Hu J, Shahab S, Ahmad A, Saleem M, Shah SSA, Hassan M (2021) The nexus of industrialization, GDP per capita and CO2 emission in China. Environ Technol Innov 23:101674

Asongu SA, Odhiambo NM (2020a) Governance, CO2 emissions and inclusive human development in sub-Saharan Africa. Energy Explor Exploit 38(1):18–36

Asongu SA, Odhiambo NM (2020) Economic development thresholds for a green economy in sub-Saharan Africa. Energy Explor Exploit 38(1):3–17

Baalouch F, Ayadi SD, Hussainey K (2019) A study of the determinants of environmental disclosure quality: evidence from French listed companies. J Manag Gov 23:939–971

Bakirtas T, Akpolat AG (2018) The relationship between energy consumption, urbanization, and economic growth in new emerging-market countries. Energy 147:110–121

Behera SR, Dash DP (2017) The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (South and Southeast Asian) region. Renew Sustain Energy Rev 70:96–106

Boutabba MA (2014) The impact of financial development, income, energy and trade on carbon emissions: evidence from the Indian economy. Econ Model 40:33–41

Braam GJ, de Weerd LU, Hauck M, Huijbregts MA (2016) Determinants of corporate environmental reporting: the importance of environmental performance and assurance. J Clean Prod 129:724–734

Byaro M, Kinyondo A (2020) Institutional quality explains the difference of natural gas revenues to contribute in the economy: empirical evidence from Tanzania. African J Econ Rev 8(3):84–97

Byaro M, Lennge D (2018) Does development assistant for health buy better results in maternal health in Tanzania? Evidence from autoregressive distributed lag model (ARDL). African J Econ Rev 6(2):61–73

Coan TG, Holman MR (2008) Voting green. Soc Sci Q 89(5):1121–1135

Dong H, Xue M, Xiao Y, Liu Y (2021) Do carbon emissions impact the health of residents? Considering China’s industrialization and urbanization. Sci Total Environ 758:143688

Du L, Wei C, Cai S (2012) Economic development and carbon dioxide emissions in China: provincial panel data analysis. China Econ Rev 23(2):371–384

Edmonds HK, Lovell JE, Lovell C (2020) A new composite climate change vulnerability index. Ecol Indic 117:106529

Eofibj U, Belmondo T, Orkoh E, Atata SN, Akinyemi O, Beecroft I (2019) Environmental pollution policy of small businesses in Nigeria and Ghana: extent and impact. Environ Sci Pollut Res 26(3):2882–2897

Frankel JA, Romer DH (1999) Does trade cause growth? American Econ Rev 89(3):379–399
Xiangyang D, Guiqiu Y (2011) China’s greenhouse gas emissions’ dynamic effects in the process of its urbanization: A perspective from shocks decomposition under long-term constraints. Energy Procedia 5:1660–1665
Xu H, Zhao G, Xie R, Zhu K (2020) A trade-related CO2 emissions and its composition: evidence from China. J Environ Manag 270:110893
Yameogo CE, Omojolaibi JA, Dauda RO (2021) Economic globalization, institutions and environmental quality in sub-Saharan Africa. Research in Globalization 3, 100035
Zafar A, Ullah S, Majeed MT, Yasmeen R (2020a) Environmental pollution in Asian economies: does the industrialisation matter? OPEC Energy Review 44(3):227–248
Zafar MW, Qin Q, Zaidi SAH (2020) Foreign direct investment and education as determinants of environmental quality: the importance of post Paris Agreement (COP21). J Environ Manag 270:110827
Zhang YJ (2011) The impact of financial development on carbon emissions: an empirical analysis in China. Energy Policy 39(4):2197–2203
Zhang N, Yu K, Chen Z (2017) How does urbanization affect carbon dioxide emissions? A cross-country panel data analysis. Energy Policy 107:678–687
Zhang T, Song Y, Yang J (2021) Relationships between urbanization and CO2 emissions in China: an empirical analysis of population migration. PloS one 16(8):e0256335
Zhou H, Cao J, Sheng J (2013) The effects of China-EU trade on CO2 Emissions. Low Carbon Economy 4(04):14
Zhou A, Li J (2020) The nonlinear impact of industrial restructuring on economic growth and carbon dioxide emissions: a panel threshold regression approach. Environ Sci Pollut Res 27(12):14108–14123

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