CHEMICAL ENGINEERING TRANSACTIONS

VOL. 107, 2023

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it

Guest Editors: Petar S. Varbanov, Bohong Wang, Petro Kapustenko

ISBN 979-12-81206-07-6; **ISSN** 2283-9216

DOI: 10.3303/CET23107023

Environmental Sustainability and the First Demographic Dividend. The Case of Four Eastern African Countries

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Sub-Saharan Africa faces immense challenges in spurring economic development and alleviating poverty, while these countries also should protect the environment amid population growth and industrial development. This study analyses the interrelationships between demographic change, economic growth, and pollution in four East African countries – Ethiopia, Kenya, Sudan, and Uganda – from 1990-2019. Using panel data and econometric analysis, the paper examines whether declining fertility rates and parallel diminishing of the youth dependency burdens are associated with accelerated growth and rising emissions. The results affirm that falling fertility has opened a window of opportunity through the 'first demographic dividend', which can catalyse growth by increased shares of working-age individuals. However, this growth has been accompanied by rising carbon dioxide emissions, underscoring potential trade-offs between environmental and economic objectives. The findings highlight the importance of complementary health, education, governance, and sustainable production investments for countries to leverage their demographic dividends for inclusive and green growth. Successfully doing so will be vital to achieve multiple Sustainable Development Goals simultaneously.

1. Introduction

Sub-Saharan African countries nowadays have to cope with the need to feed their growing populations, provide opportunities for economic development and address issues of environmental sustainability (Sadigov, 2022). The region remains the world's poorest. Over 40 % of people live on under $1.90 per day, with food insecurity and unemployment. Africa's population is projected to double by 2050, which will exacerbate strains on the environment and natural resources (Sadigov, 2022). At least within a given country, environmental sustainability is very often neglected (Cantarero, 2020). According to the United Nations Economic and Social Council (2016), seven of the seventeen United Nations Sustainable Development Goals (SDGs) directly address environmental sustainability, and four others link it to economic progress. However, inherent trade-offs exist between goals like ending poverty and protecting the environment (Chikezie Ekwueme et al., 2023). Poorer countries focused on short-term growth find it difficult to make progress on multiple SDGs simultaneously (Crespo Cuaresma et al., 2014).

The demographic transition underway in Africa provides opportunities through declining dependency ratios, but there are also risks if growth happens unsustainably. As fertility rates fall, the share of working-age adults rises, opening a so-called Demographic Window for accelerated economic growth known as the first demographic dividend (Bloom and Williamson, 1998). However, this dividend is not automatic. Optimally leveraging it requires complementary investments in health, education, infrastructure, governance, and job creation. At the same time, evidence on the relationship between economic growth and environmental impact in developing regions is mixed (Jahanger et al., 2022). Some studies find growth inevitably degrades the environment, while others support an environmental Kuznets curve hypothesis where damage eventually falls with rising income (Ansari, 2022). Recent evidence indicates that in sub-Saharan Africa, economic growth has increased deforestation and industrial air pollution (Li et al., 2020).

Few studies have concurrently modelled demographic, economic and environmental dynamics in developing countries (Hák et al., 2016). Evidence is especially limited on how demographic change impacts growth and

Paper Received: 27 May 2023; Revised: 23 June 2023; Accepted: 18 October 2023
Please cite this article as: Berde É., Mengesha S.T., 2023, Environmental Sustainability and the First Demographic Dividend. The Case of Four Eastern African Countries, Chemical Engineering Transactions, 107, 133-138 DOI:10.3303/CET23107023

ecology together to achieve sustainable development, particularly for poorer regions like sub-Saharan Africa. This study aims to help fill these knowledge gaps by investigating the synergies and trade-offs among demographic, economic, and pollution trends needed to make progress on multiple SDGs simultaneously in four East African countries – Ethiopia, Kenya, Sudan, and Uganda. Using panel data from 1990-2019 and econometric techniques, it examines whether declining youth dependency burdens are associated with economic growth and rising industrial emissions. The findings will aid policymakers in sustainably managing demographic shifts and growth for multiple SDGs.

2. Data

Data for this study were obtained from Global Economy (2023) in May 2023. The specific datasets and variables included in the analysis are stated in the subsequent sections.

2.1 Countries and variables included in the analysis

We aimed to analyse the situation in Ethiopia and nearby countries. Given the inconsistency and gaps in the time series data of this region, we could only include Ethiopia, Kenya, Sudan, and Uganda in our analysis. Three of the four – Kenya, Ethiopia and Uganda are in the Eastern region of Africa. Sudan, while in the northern region of Africa, borders Ethiopia and has a similar level of development to Ethiopia and Uganda. These countries' positions in the World Bank's poverty ranking done in April of 2023 are close to each other. Ethiopia obtains 32nd place, Kenya 51st, Sudan 36th, and Uganda 26th. In addition, all these four countries belong to the same country grouping, the so-called 'Intergovernmental Authority on Development' (IGAD). Table 1 below lists the variables and country abbreviations we included in the analysis.

Table 1: Variables used in the analysis and country codes

Name of the variable	Content of the variable
gdpcapita	GDP per capita, constant 2010 USD
lngdpcapita	Natural logarithm of the "gdpcapita"
greenemission	Greenhouse gas emissions, kt CO_2-eq
carbondioxidtonna	CO_2 emissions, kt
secondarysch	Secondary school enrolment, per cent of all eligible children
tertiarysch	Tertiary school enrolment, per cent of all eligible children
dependency	Dependent people (younger than 15 or older than 64) as a per cent of the working-age population
fertility	Total Fertility Rate (TFR), births per woman. It shows how many children a woman will give birth to in her lifetime if her habits remain the same as those of the average woman of different ages in the given year.
ETH, KEN, SDN, UGA, FRA, CHN	Ethiopia, Kenya, Sudan, Uganda, France, China

2.2 Basic analysis

Among the categories in Table 1, we highlight the 'fertility' variable because the driver of changes on the demographic side is clearly the decline in the TFR, and all other demographic changes – like the decrease in mortality rate and increase in life expectancy - are dwarfed comparing the massive fertility decline. The evolution of the TFR is presented in Figure 1a, where, in addition to the studied East African countries, a time series for France is shown to facilitate comparability. France is one of the countries in Europe with the highest TFR values, and those politicians who intend to save their population number count France as a 'model' country. Beginning in 2000 for 10 y, France had a TFR above or close to 2. However, there is a huge contrast between the fertility rates of the African countries studied and those of the European 'model' country.

Mason et al. (2016) show that a steady decline in fertility rates leads to an increase in the share of the working-age population. The ratio of the number of youth (0-14 y) and seniors (65 and above) to the working-age population (15-64 y) is called the dependency ratio. Mason et al. (2016) also prove that the decrease in the dependency ratio creates the potential for rapid economic growth.

The movement in the dependency ratio from 1990 to 2019 is shown in Figure 1b. For comparison, the time series of the French dependency ratio is also shown here, with the increasing trend being driven by the rise in the number of people aged 65 and over rather than by an increase in the number of young people.

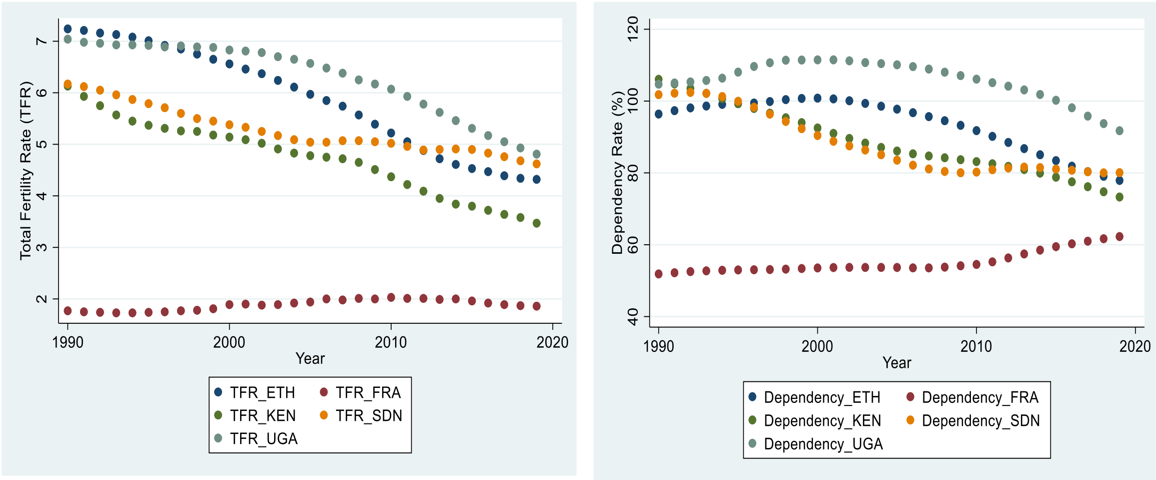

Figure 1: Time series of the four East African countries and France for the Total Fertility Rate (TFR) on the left (1a) and time series of the same countries for the dependency ratio on the right (1b). The source of the base data used is the Global Economy (2023)

Crespo Cuaresma et al. (2014) draw attention to the fact that in developing countries, a reduction in the share of young people and a decrease in the dependency rate is by no means sufficient to accelerate economic growth. However, the acceleration of economic growth also requires the education of the population, i.e. adequate investment in human capital. The increasing share of the working-age population will not improve living standards if the country's workforce is unskilled and job creation fails. In addition, a substantial improvement in the quality of medical care is also essential for economic growth.

We now look at the link between pollution and economic growth. Unfortunately, only two pollution variables, greenhouse gas emissions and carbon dioxide emissions, could be included in our analysis because we could not find time series data for other pollutants. The emission levels of these two pollutants are extremely low in all four African countries studied. For example, in the case of carbon dioxide emissions, none of the countries ever reached 0.3 % of the emission value of the largest carbon dioxide polluter, China. Here, we deliberately do not compare pollution per capita because we want to show the amount emitted and then the annual increase in the amount. If we look at the annual increases in pollution, a completely different picture emerges than in the case of the volume of pollution.

Figure 2 illustrates that the four African countries generally have higher annual growth in carbon dioxide emissions relative to the previous year than the largest global polluter, China. In other words, despite the low pollution levels, carbon dioxide emissions in these African countries are increasing at a remarkably fast rate. Even so, it will take a long time for them to 'catch up' with China counting per capita emissions (Zheng et al., 2018).

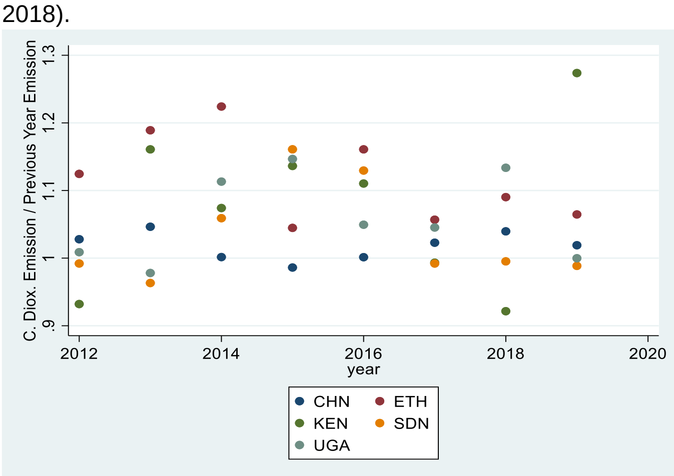

Figure 2: The ratio of carbon dioxide emission values compared to the previous year. The source of the base data used is the Global Economy (2023)

In the following paragraphs, we show that carbon emissions and greenhouse gas emissions look as if they promote economic growth. Even though this effect is spurious and is merely a 'by-product' of increased production, it is very difficult to maintain low levels of pollutant emissions. Indeed, the African countries under our review currently have such low levels of emissions that they appear to be able to increase this type of pollution and are not penalised for emissions. It is very difficult to achieve environmentally friendly production processes because they are usually significantly more expensive, and the primary objective of these countries is currently to increase GDP per capita. In Figure 2, China has three times the smallest annual carbon dioxide emissions growth of the five countries, and in no year does China have the largest growth rate.
Table 2 shows the results of the correlations between the variables. The correlation matrix expresses how GDP per capita and its logarithm increase or decrease as the value of each variable increases or decreases. It shows the direction and amount of correlation between other variables as well. When the correlation coefficient is positive, then the two variables move in the same direction. If negative, they move in the opposite direction. The closer the absolute value of the coefficient to 1, the higher the relationship between the two variables.

Table 2: Matrix of correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) lngdpcapita	1.000						
(2) greenemission	0.162	1.000					
(3) carbondioxidtonna	0.762	0.647	1.000				
(4) secondarysch	0.791	0.436	0.817	1.000			
(5) tertiarysch	0.810	0.585	0.905	0.681	1.000		
(6) dependency	-0.740	-0.673	-0.931	-0.840	-0.818	1.000	
(7) fertility	-0.741	-0.543	-0.813	-0.947	-0.692	0.836	1.000

Table 2 shows that the two pollution variables and GDP per capita are increasing simultaneously. The same is true for secondary education and tertiary education enrolment. The decline in the dependency rate - see the negative sign in Table 2 - has developed in parallel with the increase in GDP per capita. The relatively high absolute correlation coefficient of 0.74 between the ‘dependency’ and ‘lngdpcapita’ variables indicates that the decline in the combined share of children and old age over the working-age populations is very strongly correlated with the increase in GDP per capita. In the row of the ‘dependency’ variable, the high correlation value (looking at the absolute value) with greenhouse gas emission of 0.931 is striking. This is certainly a co-movement between the decrease in dependency ratio and the clear upward trend in greenhouse gas emission over the period under study. As the Total Fertility Rate has been steadily decreasing over the period under study, and the other variables except for ‘dependency’ have been increasing, the row of the ‘fertility’ variable in Table 2 shows a negative number with a large absolute value everywhere except for that particular variable and itself.

3. The Panel Model

The basic analysis has shown that GDP per capita and demographic changes, as well as GDP per capita and pollution, have moved in the same direction in the four countries over the past 30 y or so. However, simple correlation coefficients do not provide complete information on the co-movement of several variables. It was decided to build an econometric model from our data. Due to the brevity and incompleteness of the time series, the panel model, a joint analysis of the four countries, was the best method. Preliminary statistical tests to find an unbiased estimate showed that the generalised least squares random effect equations give the best results. The initial hypothesis was that both the increase in the first demographic dividend and the increase in pollution were associated with an increase in GDP per capita. However, we determined which variable best expresses this process by including step by step our categories from Table 1 in the model. We defined two groups of our variables, one for the demographic dividend and the other for pollution. In some cases, we used lagged forms of the education variables. Our aim was to build a model where at least one variable from both groups is in the model. The period of analysis lasted from 1990 to 2019, or when no observations were available for a variable in a given year, the observation period was shortened by that year. The calculations were performed using Stata 17. After several iterations, the variables 'carbondioxidtonna' (carbon dioxide emission) and 'secondlag2' (2 y lag of the secondary enrolment rate) were found to be the best explanatory variables for ‘lngdpcapita’ (logarithm of GDP/capita). The best set of variables for our calculations is shown in Table 3.

Table 3: Cross-sectional time-series FGLS regression (Stata 17 output)

lngdpcapita	Coef.	St.Err.	t-value	p-value	[95 % Conf	Interval]	Sig
carbondioxidtonna	.0000264	7.31e-06	3.607	0.000	.000	.000	***
secondlag2	.0118105	.0032793	3.602	0.000	.005	.018	***
Constant	6.634889	.1333851	49.742	0.000	6.373	6.896	***
Mean dependent var	6.672		SD dependent var		0.799		
Number of obs	68		Chi-square		43.161		
*** p<.01							

With the method used, the multiple correlation coefficient (R2) is not meaningful, and the program did not calculate this value. The 'dependency' variable was found to have the expected negative coefficient with the explained variable ('lngdpcapita'), but was insignificant. Because of the insignificance of the 'dependency' variable, we ran the model calculation without it, and Table 3 shows this result. Our panel model confirmed the first demographic dividend theory, as the 2 y lag of secondary education is positive and significant at a 1 % level. That is, the expansion of education contributes to the increase in GDP per capita. In terms of its sign, the variable 'dependency' also supported the first demographic dividend theory; the lower the dependency ratio, the more the economy grows, but the presence of 'dependency' also spoiled the significance of the other two independent variables.

In Table 3, the coefficient of carbon dioxide emission is positive and significant at a 1 % level. Although this correlation supports a theory mentioned earlier in this article, which is referred to in the literature as the "pollution dividend", the result is detrimental to social welfare. What is at stake is that, as pollution increases, GDP per capita increases in parallel with pollution, at least in the East African countries under study, which are still low-polluted countries. In fact, the correlation matrix in Table 2 has already indicated the direction of this relationship. Our model calculations also included a version with greenhouse gas emission instead of carbon dioxide emission, which was also statistically significant and with a positive coefficient, but in this case, the effect of secondary education was not significant with any lag. It is unfortunate that no data were available for other environmental pollutants, such as pesticide contamination.

We must be always very cautious when analysing the simultaneous growth of pollution and GDP per capita. In terms of causality, we cannot say that increased pollution causes increased economic output. Rather, it is that increased production, which also caused GDP/capita growth, went hand in hand with increased pollution (Al-Mulali et al., 2015)

4. Conclusions

The 17 Sustainable Development Goals of the United Nations include targets to improve living standards for all and environmental sustainability as well. The example of the East African countries we have studied shows that there are many difficulties in achieving both sets of goals in parallel. The results affirm that declining fertility rates and dependency burdens are significantly associated with rising GDP per capita. However, the analysis also reveals rising CO_2 and greenhouse gas emissions accompanying economic growth. This highlights potential trade-offs between economic prosperity and environmental objectives, consistent with past studies warning of mounting emissions and pollution with development in Africa absent sufficient policy efforts. The lack of any decreasing pollution while GDP is growing suggests that economic development may continue degrading environmental quality in these nations absent concerted policy efforts. The findings underscore the complex balancing act needed to simultaneously advance multiple Sustainable Development Goals. While fertility declines and shrinking youth burdens catalyse growth, environmental sustainability requires additional measures like clean energy, sustainable agriculture, conservation of natural resources, and enforcement of environmental regulations. The findings underscore the complex synergies and trade-offs involved in simultaneously pursuing the SDGs. While demographic change promotes prosperity, it also strains resources and the environment. Strong institutions and governance, human capital investments, cleaner production techniques, and enforcement of environmental regulations will be critical to leverage East African countries' fertility declines into a sustainable development path going forward.

This study makes a novel contribution by modelling demographic, economic, and environmental factors together in a developing country context in a panel framework. The analysis highlights the importance of integrated strategies to manage population dynamics, invest in human capital, spur inclusive growth, and mitigate environmental impact. Balancing these objectives will be critical for nations to capitalise on demographic change to achieve sustainable development. However, data limitations necessitate caution in making definitive conclusions. Further research can provide more nuanced country-specific insights to help policymakers sustainably leverage demographic dividends.

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