Chapter

Economic, Social, and Environmental Dimensions of Development in Sudan

Elwasila Mohamed

Abstract

This chapter aims to investigate how social and environmental progress indicators lead economic indicators of development in Sudan. Economic indicators are represented by gross domestic product (GDP), investment, and unemployment. Social progress indicators are represented by life expectancy at birth standing for health and school enrollment for education. Environmental performance is indicated by access to safe drinking water and access to sanitation facilities. Trade as percentage of GDP is included to represent openness and outward of the economy. The study provides analytical links between these development dimensions and found empirical verification that social and environmental performance indicators cause economic growth rather than the other way around through dynamic econometric methods utilizing time series data over the period 1970–2017. Accordingly, the study provided recommendations and projections on enhancing social progress indicators toward 2030 Sustainable Development Goal (SDG) targets.

Keywords: economic growth, social progress, environmental performance, health, education, Sudan

1. Introduction

Development, however defined and measured, is something that has not been realized in low-income countries. From its narrow measurement through gross domestic product (GDP) to human development index (HDI) to a more comprehensive index of sustainable development, now development can be seen in low-income countries. Low-income levels have been associated with low achievements in all aspects of social and environmental progress in these countries. Even some levels of economic growth in terms of income per capita and social, political, and environmental indicators of progress are all lacking behind. That is, economic growth alone is not sufficient to advance societies and improve the quality of life of citizens. True success, and growth that is inclusive, requires achieving both economic and social progress (SPI, 2018) [3]. In short, economic progress should be accompanied with social and environmental progress. The measurement of economic development in terms of gross domestic product (GDP) was well established in the economic literature pioneered firstly by Simon Kuznets and developed into systems of national accounts adopted by the United Nation agencies since the 1960s. However, major criticisms have been raised against using GDP as a measure of economic and social welfare, particularly among scholars in the field on environmental economics. This literature has been arguing for modification of GDP to include resource depletion and environmental degradation associated with economic growth in a context of sustainable development. The World Bank has adopted and started measuring the so-called genuine savings indicator developed by Pearce and Atkinson [1] and the genuine progress indicator (GPI), as measures of sustainable development. Yet, a massive body of literature had been developing arguing that economic growth is the only way to protect the environment, in the context of the so-called environmental Kuznets curve. Since the early 1990s, the UN Development Programme has adopted and started measuring the human development index pioneered by Sen and Haq. The HDI encompasses measures of economic, health, and education and ranks countries in a scale of 100 points according to their achievements in these dimensions. All these measures have been developed in lines of calls sustainable development following the World Commission on Environment and Development Report in 1987 and the Agenda 21 adopted in Rio 1991. In 2000, the world nations adopted the Millennium Development Goals (MDGs). The agreed MDGs had to be achieved by 2015. Many low-income countries failed to achieve the targets, while the world nations went forward to adopt the Sustainable Development Goals (SDGs) to be achieved by 2030. In the light of their progress to achieve the MDGs, low-income countries are unlikely to move forward to make progress in achieving the SDGs in a matter of 10 years. However, SDGs remain a guide to economic, social, and environmental policies in all countries but particularly in low-income countries. Detailed discussions on these measures of development in the context of MDGs and SDGs can be found in Chapter 5 of the United Nation Global Sustainable Development Report [2].

2. Economic growth or social progress

The Social Progress Imperative has recently formed. This initiative defines social progress as the "capacity of a society to meet the basic human needs of its citizens, establish the building blocks that allow citizens and communities to enhance and sustain the quality of their lives, and create the conditions for all individuals to reach their full potential" [3]. The main feature of the Social Progress Index (SPI) is that it focuses exclusively on the aggregation of social and environmental output oriented measures. The Social Progress Index sets out to do so by asking three fundamental questions about a society. First of all, does everyone have the basic needs of survival: food, water, shelter, and safety? Secondly, does everyone have the building blocks of a better life: education, information, health, and a sustainable natural environment? And does everyone have the opportunity to improve his or her life, through rights, freedom of choice, tolerance and freedom from discrimination and freedom of mobility, and access to the world's most advanced knowledge? It measures these aspects of inclusion directly using only social and environmental indicators. By excluding traditional economic indicators from the model, it allows to better interrogate the relationship between social progress, and each of its 12 components, and economic growth, and in so doing more richly unpacking their relationships and identifying the true drivers of progress of the society in question. The SPI launched a global index in 2014, analyzing 132 countries using 52 indicators of social and environmental performance. In 2018, the SPI captures outcomes related to 16 of the 17 SDGs in a simple but rigorous framework designed for aggregation, making it an invaluable proxy measure of SDG performance. To translate this definition into a concrete measurement tool, some researchers constructed the Social Progress Index (SPI) [4]. They constructed a SPI and used it together with basic human needs and opportunity indictors and find that these social performance indictors strongly affect subjective well-being. Nevertheless, economics, with its all school of thought, has been playing a central role on these advances of definitions, measurements, and determinants of development. For Seligman [5], "economics is both the creature and the creator. It is the creature of the past; it is the creator of the future. Correctly conceived, adequately outlined, fearlessly developed, it is the prop of ethical upbuilding, it is the basis of social progress" (1903, p. 70). The development that took place in the West and the United States in particular was described as a transformation to industrial society with all of its economic, social, and political facts and facets. On this type of development and how it has been achieved, Seligman made six points which differentiate modern industrial society from all its predecessors. In today's less developing countries, these points differentiate success from failure to achieve development. The points are the practical exhaustion of free land, the predominance of industrial capital, the application of scientific methods, the existence of a competitive regime based on the newer conception of liberty, the spread of education and the birth of a distinct public opinion, and a true democratic spirit and the growth of a new idealism. Unless these points take place in today's less developing countries, it is unlikely that they be able to move forward for real socioeconomic development.

Economic growth or more widely some development achieved in low-income countries cannot be attributed to conventional factors of production such as physical capital and formal employment. It is rather an outcome of private investment, social households, and individual behaviors with the use of assets from the natural environment. We give some examples in justification of this argument. Private spending health has always been far larger than government spending on health in low-income countries, including Sudan. Even on primary education, household spending exceeds government spending although primary education is supposed to be free and universal. This can be indicated by a large number of school dropouts, where school-age children go to work in informal jobs so as to help their often poor families. In the political arena, political and personal rights are lacking behind, and individuals are left to themselves to find ways to exercise and express their views and voices. Social media have been playing a major role in providing information to the public replacing the official government media channels. This has typically taken place in Sudan since December 2018. Communications and organization of activities through social media have contributed strongly to massive demonstrations which succeeded in ousting the regime that ruled the country for almost three decades. Thus defective social and political fabrics in less developed countries cannot be disentangled from all types of economic and political corruption which have been the chronic illness in these countries in postcolonial periods. In such cases, it is by no means to expect that economic policies and pure economic factors contribute economic growth and development and social equity. Instead, social and environmental progresses achieved however small have to be attributed to the private and household's behaviors and initiatives and thus are the main contributors to economic growth. Furthermore, economic growth achieved through these channels is always skewed toward the rich who are not necessarily contributing a fair share to its achievement. This can be reflected by a wide and even increasing income gap between the rich and the poor in low-income countries. Also, economic growth can be expected really to resolve and revert environmental degradation in terms of massive resource depletion and accumulation of pollution. Thus, arguably it is not more than luxury to seek a verification of environmental Kuznets curve in low-income countries. Furthermore, environmental policies in these countries are usually lax and lacking behind. This in turn has been pushing low-income countries to trade environment for development and become pollution havens. It is a fact that trade in its export side has been intensive in primary products and natural resources, both renewable and nonrenewable. Even this pattern has been a major dragger to economic growth in the sense of the so-called resource curse hypothesis. These facts and accounts are our rationale to model GDP growth against social and environmental performance indicators, rather than the other way around.

3. Analytical framework: from social and environmental performance to economic performance

Figure 1 shows a proposed analytical framework in which social and environmental indicators, together with investment and trade openness, are assumed to explain economic growth represented by the current gross domestic product (GDP). For a low-income country such as Sudan, social and environmental dimensions of development are more expected to lead economic dimension of development rather than economic leading to socio-environmental improvements. The framework also assumes that selected all economic, social, and environmental measures to affect economic development positively. In terms of causation, the analytical framework presumes that the causation runs from social and environmental performance to economic development as narrowly measured by GDP growth.

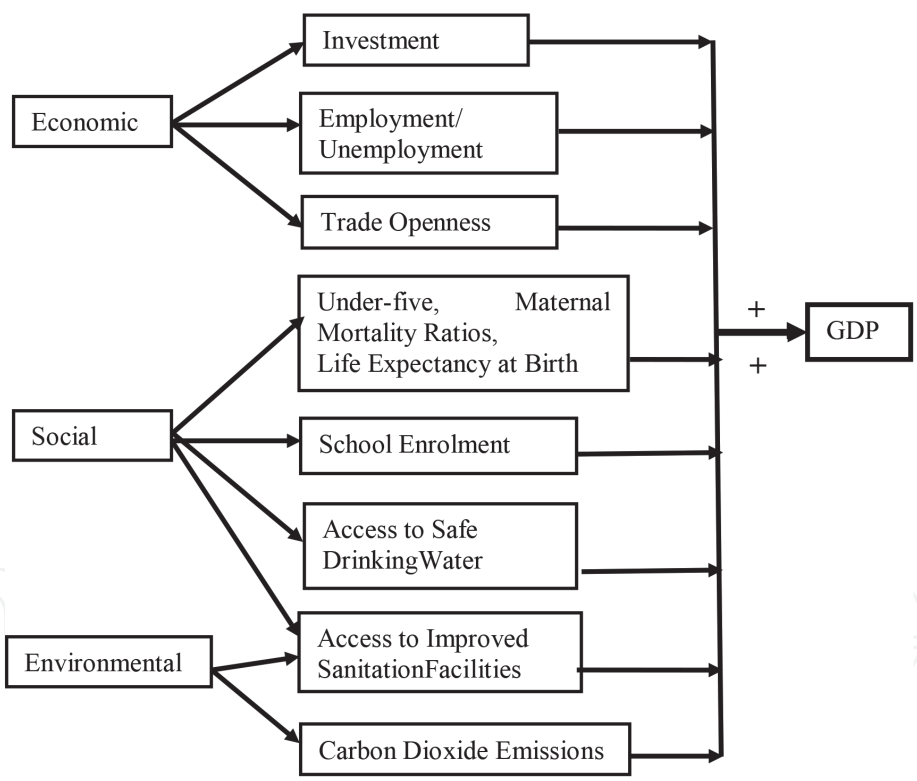

Figure 1.
Economic, social, and environmental dimensions of development.

4. Sudan: economic, social, and environmental dimensions of development

We used the framework set in **Figure 1** to explain how social and environmental indicators have affected development in its economic dimension as commonly measured by GDP. Variable selection is necessitated by availability of data, which is collected from the World Bank, World Development Indicators (WDI), and World

Bank 2018 [6] and complemented with other sources. The study variables are defined as follows:

Gross domestic product (GDP): GDP is the value of all goods and services produced in the economy expressed in current US dollars and stands for economic growth.

Domestic investment (INV): INV is measured by gross capital formation consisting of additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales and work in progress.

Unemployment is represented by the total youth unemployment as percentage of total labor force ages (15–24), and it refers to the share of the labor force ages 15–24 without work but available for and seeking employment.

Life expectancy at birth indicates the number of years a newborn would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Average school enrollment (EDU): EDU is measured by net enrollment rate which is the ratio of children of official school age who are enrolled in school to the population of the corresponding official school age. The World Bank acknowledges that primary education provides children with basic reading, writing, and mathematics skills. These are basics for any progression to secondary and tertiary education.

Access to drinking water (ASW): Access to safe drinking water is measured by people using at least basic drinking water services (% of population). It encompasses both people using basic water services and those using safely managed water services. Basic drinking water services are defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.

Access to sanitation facilities (ASF): It is represented by people using safely managed sanitation services (% of population) defined as the percentage of people using improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated off-site. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks, or pit latrines: ventilated improved pit latrines, compositing toilets, or pit latrines with slabs.

Access to electricity is measured by the average percentage of population with access to electricity.

Carbon dioxide emissions as defined by the World Bank are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. CO_2 emissions are measured in metric tons per capita (CO2P).

Trade openness is measured as the sum of exports and imports of goods and services as percentage of gross domestic product.

5. Empirical analysis

5.1 Descriptive statistical analysis

Table 1 presents the descriptive statistics of the study variables. From the Jarque-Bera (J-B) and associated prob. values, all variables look normally distributed expect education, access to drinking water, and access to electricity. The highest kurtosis is associated with GDP followed by access to drinking water and access to electricity. As for average rainfall, it has been reported that summer monthly precipitation over the Sahel is not normally distributed.

From the correlation matrix in **Table 2** noticeably, the GDP highly positively correlates with life expectancy at birth, education, access to drinking water, and access to electricity. Life expectancy and education both positively correlate with access to drinking water and access to electricity.

We conducted a graphical analysis of the study variables. **Figure 2** shows upward trend for current GDP, while **Figure 3** depicts erratic trend of investment. Also youth unemployment experiences high fluctuations as depicted in **Figure 4**. **Figure 5** indicates upward sloping life expectancy at birth over time. School enrolment shows upward trend with some small fluctuations as shown in **Figure 6**. Access to sanitation facilities runs through a period of upward trend and downward trend and more recently started to trend upward as depicted in **Figure 7**. Access to drinking water showed slow increase at the beginning of our time series but started to increase sharply after the year 2004 as shown in **Figure 8**. Access to electricity

	GDP	INV	YUN	LE	EDU	ASF	ASW	ELC	CO2P	TOP
Mean	2.60E+10	19.09	27.85	57.20	28.64	25.35	45.07	30.71	0.24	26.80
Median	1.24E+10	16.34	27.82	56.19	25.07	25.35	42.73	29.58	0.22	25.46
Maximum	1.17E+11	37.19	28.95	64.99	48.41	27.70	59.27	44.90	0.37	47.58
Minimum	2.44E+09	7.29	26.39	51.74	18.67	22.50	40.62	23.00	0.10	11.09
Std. dev.	2.91E+10	7.27	0.59	3.71	8.92	1.45	5.59	4.37	0.09	9.53
Skewness	1.60	0.67	0.03	0.51	0.93	−0.15	1.52	0.87	0.28	0.19
Kurtosis	4.43	2.49	2.51	2.12	2.48	1.82	3.93	3.93	1.54	2.31
J-B	24.52	4.14	0.50	3.67	7.44	2.97	20.32	7.81	4.91	1.25
Prob.	0.000	0.126	0.780	0.160	0.024	0.226	0.000	0.020	0.086	0.535
Obs.	48	48	48	48	48	48	48	48	48	48

Table 1.
Basic statistics.

	GDP	INV	YUN	LE	EDU	ASF	ASW	ELC	CO2P	TOP
GDP	1.00									
INV	−0.09	1.00								
YUN	−0.45	0.19	1.00							
LE	0.90	0.22	−0.29	1.00						
EDU	0.93	0.10	−0.35	0.97	1.00					
ASF	−0.44	−0.06	0.31	−0.48	−0.54	1.00				
ASW	0.98	−0.06	−0.39	0.91	0.95	−0.45	1.00			
ELC	0.83	0.23	−0.24	0.93	0.89	−0.32	0.87	1.00		
CO2P	0.63	−0.26	−0.54	0.44	0.60	−0.67	0.62	0.36	1.00	
TOP	0.04	0.22	−0.22	0.10	0.15	−0.65	0.03	−0.09	0.44	1.00

Table 2.
Correlation matrix.

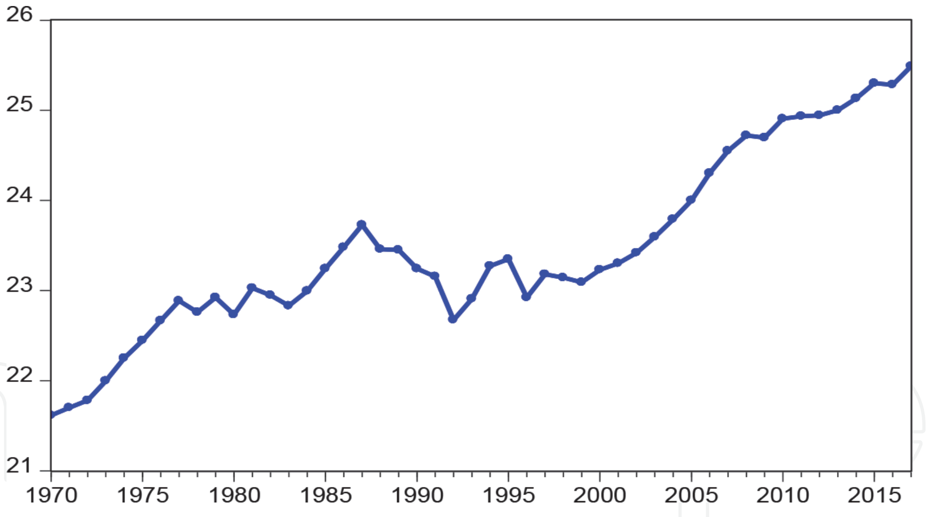

Figure 2.
Log of GDP.

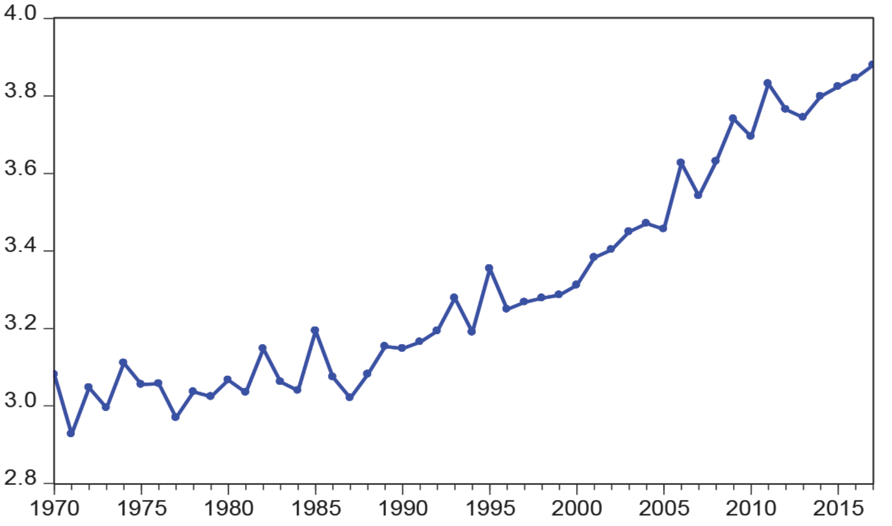

Figure 3.
Log of investment.

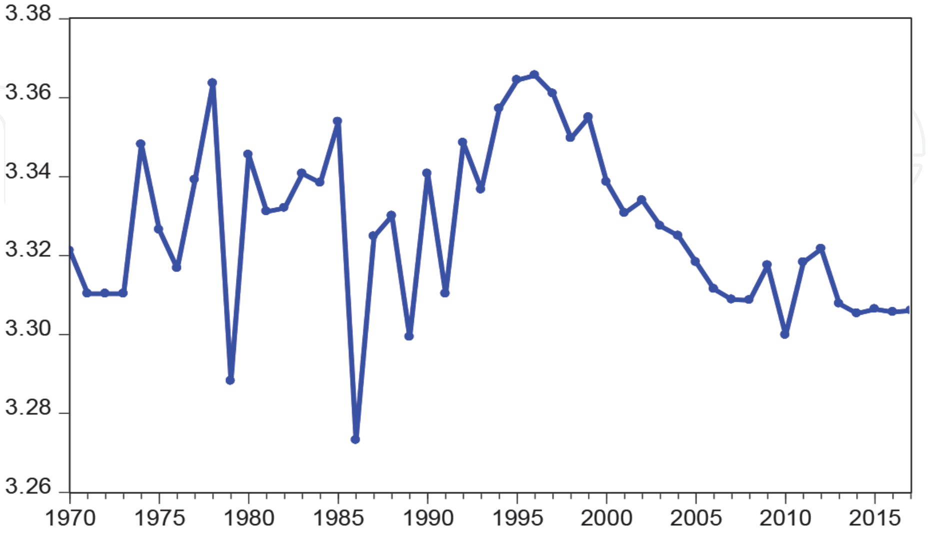

Figure 4.
Log of youth unemployment.

shows more erratic trend over time and only after 2002 started to show steady increase but with a drop in 2009 and a hike in 2014 as in **Figure 9**. Carbon dioxide emissions experienced a declining trend from 1974 until 1993 and then started to

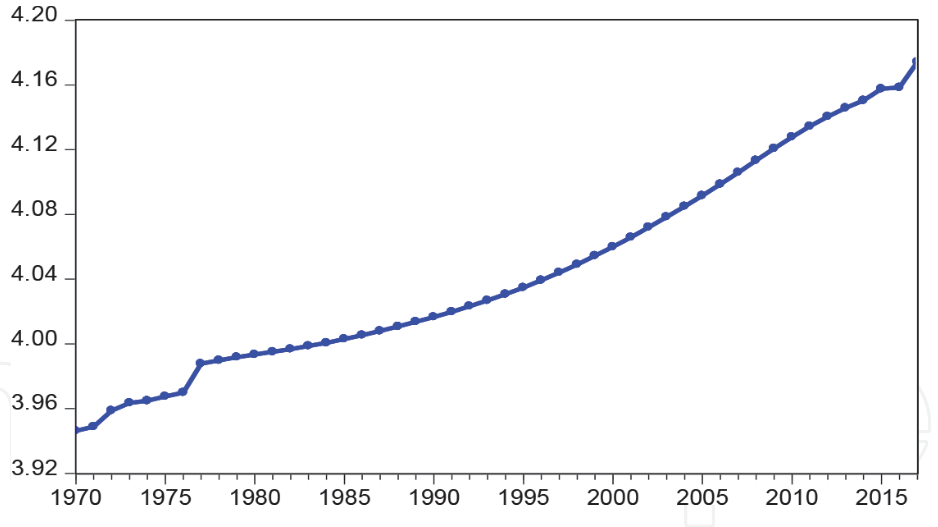

Figure 5.
Log of life expectancy at birth.

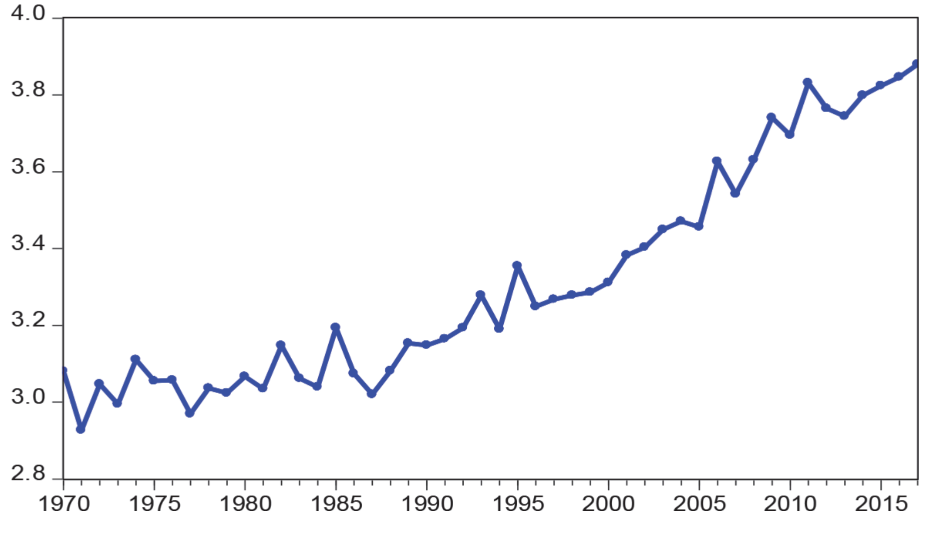

Figure 6.
Log of primary school enrolment.

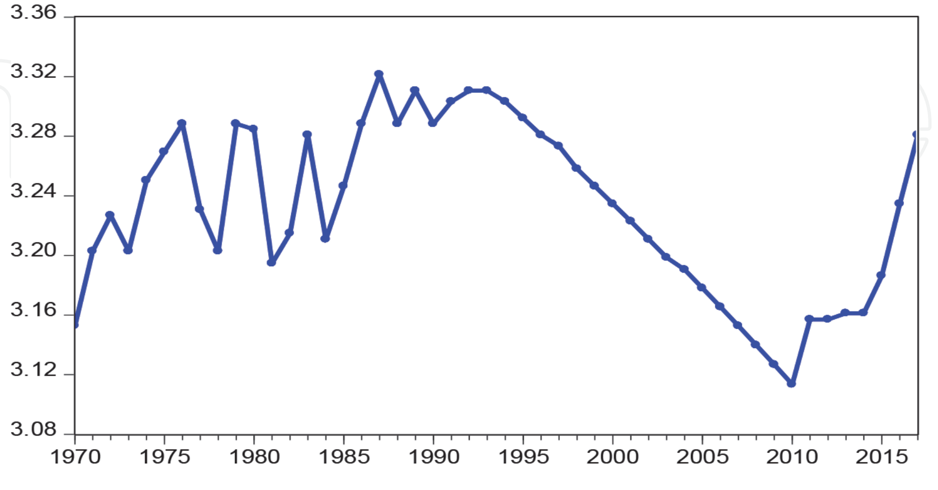

Figure 7.
Log of access to sanitation facilities.

increase over the rest of our time series frame as in **Figure 10**. Trade openness runs through relatively stable trend over the period 1970–1983, a massive decline from 1984 to 1993, an increase over the period 1994–2006, and then a decline over the rest of our time frameworks in **Figure 11**. These time trends of the economic, social, and environmental dimensions of development in Sudan reflect various episodes of war and environmental and climate change along generally failed macroeconomic policies to improve development with its multifacet and interacting dimensions.

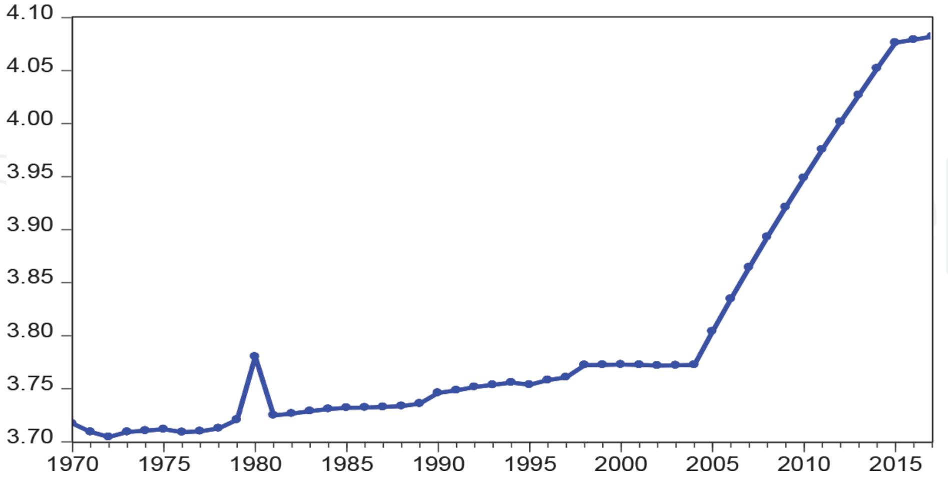

Figure 8.
Log of access to drinking water.

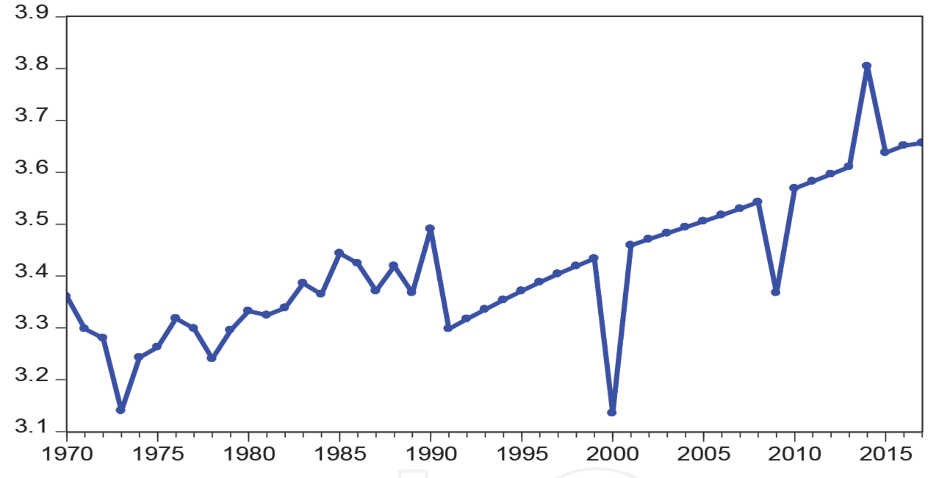

Figure 9.
Log of access to electricity.

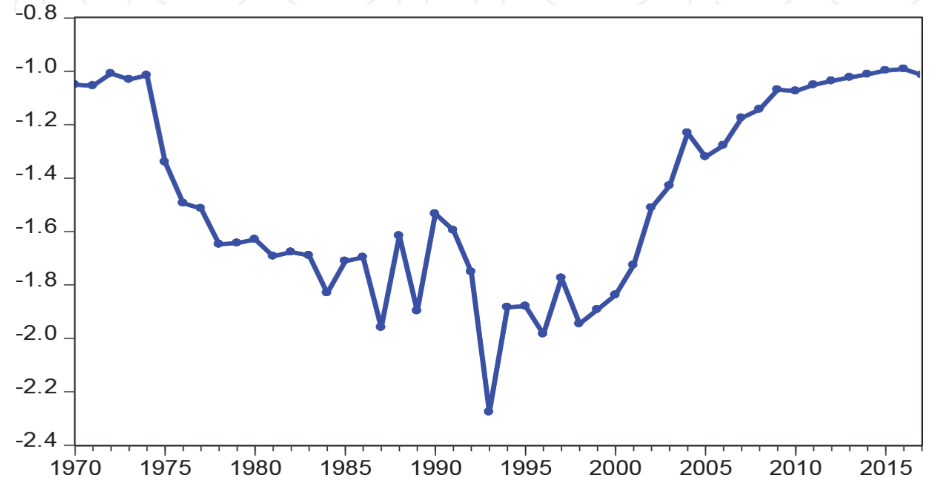

Figure 10.
Log of carbon dioxide emissions per capita.

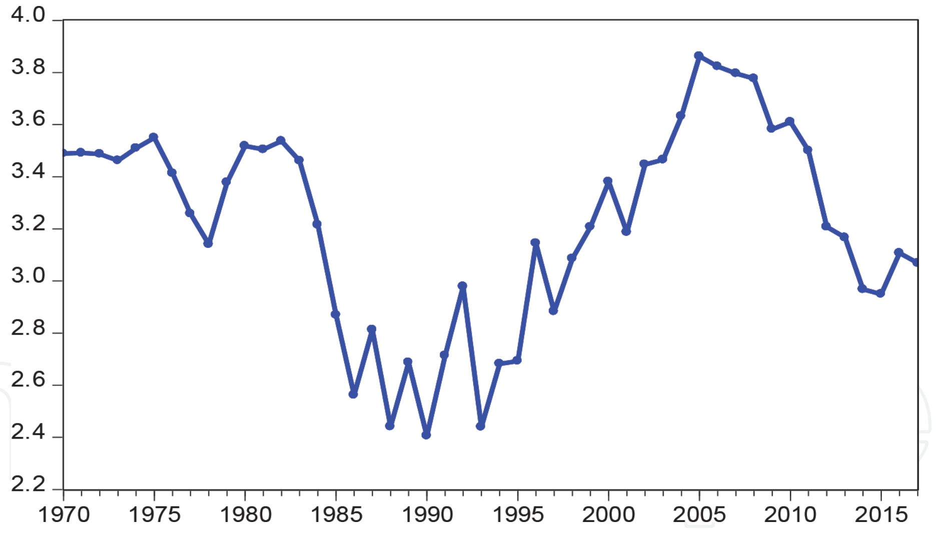

Figure 11.
Log of trade openness.

5.2 Empirical investigation

5.2.1 Econometric methods

This study is empirical and quantitative, using statistical and econometric methods. Sound empirical studies on economic, social, and environmental dimensions of development need to be based on clear theoretical framework, rigorous methodology, and reliable data. Empirical quantitative studies using dynamic econometric methods on these relationships are rare, although empirical-quantitative research programs in all socioeconomic and environmental issues are usually more rigorous [7]. The study is very selective on variables included, which is necessitated by data availability and possible theoretical links. The study presumes that economic growth is affected by social and environmental progress indicators rather than the other way around. The study covers the period 1970–2017 with annual time series data on all of its variables. Economic growth represented by current GDP is treated as the dependent variable, and social and environmental indicators are the independent variables. Trade openness is included as a control variable and represents the exposure of Sudan economy to international shocks. A general log linear model to capture the complexity of economic, social, and environmental dimensions of development in Sudan is written as:

$$L(GDP) = \alpha + \beta_1 L(INV) + \beta_2 L(UNE) + \beta_3 L(LE) + \beta_4 L(EDU) + \beta_5 L(ASF) + \beta_6 L(ASW) + \beta_7 L(ELC) + \beta_8 L(CO2P) + \beta_9 L(TOP) + \beta_{10} DUM + \mu \tag{1}$$

where DUM stands for dummy that is 0 in 1978, 1997, and 2011 and 1 otherwise. These years are judged to represent breaks in Sudan economy as years of the first ever devaluation of the national currency, imposition of sanction on Sudan by the United States, and secession of South Sudan, respectively.

5.2.2 Stationary and cointegration of variables

The first step is to use a preliminary statistic test to verify the stationarity for all variables. A time series is described as nonstationary if it has at least one of its moments (mean, variance, or covariance) as time independent.

However, a nonstationary series possessing a stochastic unit root can be differenced once to become stationary. Establishing stationarity of macroeconomic series is necessary for reliable econometric estimations and causality analysis tests and since most macroeconomic series are in fact not stationary. Stationary of time series included in this study is tested through the conventional augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, complimented by Kwiatkowski-Phillips-Schmidt-Shin (KPSS [8]). The ADF test takes into account only the presence of autocorrelation in the series, but the PP test considers also the hypothesis of the presence of a heteroskedasticity dimension in the time series and Kwiatkowski-Phillips-Schmidt-Shin (KPSS [8]). In literature, tests designed following the null hypothesis that a series is I(1) have low power to reject the null. Therefore, KPSS is sometimes used along the widely used ADF and PP tests to have robust results. The findings from the ADF, PP, and KPSS tests are reported in **Table 3**. Investment and unemployment are found to be stationary at level I(0) and first difference I(1) while the first differencing makes all variables stationary.

Combined results from these three tests indicate all series are integrated to the order i.e., I(1) but some of them are stationary at level I(0), i.e., all series are I(0)/I (1). As a result, we choose to use the autoregressive distributed lag (ARDL) bound test for cointegration because one of its main advantages is that it does not impose a

Variable	ADF		PP		KPSS	Order of integration
	Stat.	5% cri. value	Stat.	5% cri. value	Stat.	
L(GDP)	−0.380	−2.925	−0.400	−2.925	0.799	Nonstationary
ΔL(GDP)	*−6.349**	*−2.927*	*−6.349**	*−2.927*	*0.136**	*Stationary I(1)*
L(INV)	−3.048*	−2.925	−2.897	−2.925	0.450*	Stationary I(0)
ΔL(INV)	*−6.498**	*−2.928*	*−12.465**	*−2.927*	*0.500*	*Stationary I(1)*
L(YUN)	−2.555	−2.927	−5.338*	−2.925	0.201*	Stationary I(0)
ΔL(YUN)	*−8.931**	*−2.928*	*−16.341**	*−2.927*	*0.020**	*Stationary I(1)*
L(LE)	2.102	−2.931	2.679	−2.925	0.891	Nonstationary
ΔL(LE)	*−2.606*	*−2.929*	*−5.747**	*−2.927*	*0.632*	*Stationary I(1)*
L(EDU)	0.025	−2.928	−0.282	−2.925	0.788	Nonstationary
ΔL(EDU)	*−10.722**	*−2.928*	*−11.275**	*−2.927*	*0.239**	*Stationary I(1)*
L(ASF)	−1.941	−2.931	−2.131	−2.925	0.325*	Stationary I(0)
ΔL(ASF)	*−1.916*	*−2.931*	*−7.154**	*−2.927*	*0.131**	*Stationary I(1)*
L(ASW)	2.643	−2.925	2.487	−2.925	0.707	Stationary I(0)
ΔL(ASW)	*−3.243**	*−2.928*	*−5.924**	*−2.927*	*0.569*	*Stationary I(1)*
L(ELC)	0.050	−2.927	−0.259	−2.925	0.858	Nonstationary
ΔL(ELC)	*−6.829**	*−2.927*	*−13.650**	*−2.927*	*0.319**	*Stationary I(1)*
L(CO2P)	−1.097	−2.927	−1.391	−2.925	0.279*	Stationary I(0)
Δ(CO2P)	*−9.243**	*−2.927*	*−9.167**	*−2.927*	*0.254**	*Stationary I(1)*
L(TOP)	−1.920	−2.925	−1.888	−2.925	0.133*	Stationary I(0)
Δ L(TOP)	*−8.488**	*−2.927*	*−8.370**	*−2.927*	*0.084**	*Stationary I(1)*

Note: The ADF and PP unit root tests employ null hypothesis with the series that has a unit root against the alternative of stationary. The null hypothesis for the KPSS assumes that the variable is stationary. KPSS critical value is 0.463.
**indicates significance at 5% level.*

Table 3.
Unit root test results.

restrictive assumption that all variables should have the same integration order. Another advantage is that a dynamic error correction (EC) term can be derived from the ARDL through simple linear transformation. The error correction term shows the short-run dynamics with the long-run stable equilibrium without losing the long-run information.

5.2.3 ARDL model specification and estimation

An autoregressive distributed lag model bound test advanced by Pesaran and Smith [9], Pesaran and Shin [10] and with the bound test of Pesaran et al. [11] is used to investigate cointegration and the short-run dynamics and long-run equilibrium of GDP as the dependent variable and social and environmental indicators as explanatory variables. An unrestricted ARDL model on the basis of Eq. (1) is specified as follows:

$$\begin{aligned}\Delta L(GDP)_t = \alpha &+ \sum_{i=1}^{p} \beta_{1i} L(GDP)_{t-1} \\ &+ \sum_{i=0}^{p} \Delta\beta_{2i} L(INV)_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta L(UNE)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_{4i} \Delta L(LE)_{t-i} + \sum_{i=0}^{p} \beta_{5} \Delta L(EDU)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_{6} \Delta L(ASF)_{t-i} + \sum_{i=0}^{p} \beta_{7} \Delta L(ASW)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_{8} \Delta L(ELC)_{t-i} + \sum_{i=0}^{p} \beta_{9} \Delta L(CO2P)_{t-i} \\ &+ \sum_{i=0}^{p} \beta_{10} \Delta L(TOP)_{t-i} + \beta_{10} L(GDP)_{t-1} + \beta_{11} L(INV)_{t-1} \\ &+ \beta_{12} L(UNE)_{t-1} + \beta_{13} L(LE)_{t-1} + \beta_{14} L(EDU)_{t-1} \\ &+ \beta_{15} L(ASF)_{t-1} + \beta_{16} L(ASW)_{t-1} + \beta_{17} L(ELC)_{t-1} \\ &+ \beta_{18} L(CO2P)_{t-1} + \beta_{19} L(TOP)_{t-1} + \beta_{20} DUM_t + EC_t + \mu_t \end{aligned} \quad (2)$$

All variables and abbreviations are as defined above. The parameter p is the lag length, Δ is the difference operator, and EC is the ARDL error correction term. Eq. (2) can be estimated through the OLS to explore the long-run relationship of the model variables by performing an F-test statistics for the joint significance of the lagged-level variables. The null hypothesis of no cointegration (i.e., no long-run equilibrium relationship between the study variables) in Eq. (2) is: $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 + \beta_9 = \beta_{10} = 0$, against the alternative hypothesis of the existence of cointegration that: $H_1 : \beta_{11} \neq \beta_{12} \neq \beta_{13} \neq \beta_{14} \neq \beta_{15} \neq \beta_{16} \neq \beta_{17} \neq \beta_{18} \neq \beta_{19} \neq \beta_{20} \neq 0$.

The decision rule for the existence of cointegration in the bound testing approach according to Pesaran and Shin (1999) is two sets of critical values for the F-statistic: the lower bound where all variables are cointegrated of the order I(0) and the upper bound where all variables are cointegrated of the order I(1). If the F-statistic lies below the lower bound value, the conclusion is no cointegration, and if the F-statistic is found to be above the upper bound value, then cointegration exists, whereas if the F-statistic falls between the upper bound and the lower bound, then the test is inconclusive. The ARDL bound test is performed on Eq. (2), where each

F-bound test		Null hypothesis: no level relationship		
Test statistic	**Value**	**Significance**	**I(0)**	**I(1)**
F-statistic	7.47	10%	1.8	2.8
K	9	5%	2.04	2.08
		2.5%	2.24	3.35
		1%	2.5	3.68

Table 4.
Bound test cointegration: GDP dependent variable.

Lag	LL	LR	FPE	AIC	SC	HQ
0	467.371	NA	7.03e-22	−20.328	−19.926	−20.178
1	791.748	490.169	3.63e-26	−30.300	−25.884*	−28.654
2	945.800	*164.322*#*	6.50e-27	−32.702	−24.271	−29.560
3	1132.692	116.289	1.44e-27*	−36.564*	−24.118	−31.924*

**Indicates lag order selected by the criterion;*
 # at 5% level
LR, sequential modified LR test statistic (each test at 5% level); FPE, final prediction error; AIC, Akaike information criterion; SC, Schwarz information criterion; HQ, Hannan-Quinn information criterion.

Table 5.
VAR lag order selection criteria.

variable is treated as dependent while all other variables are independent. The results show that there at least eight cointegrated forms as summarized in **Table 7**. Thus, the results of the bound test cointegration confirm the existence of a long-run equilibrium relationship between economic growth measured by GDP in relation to the set of social and environmental indicators and other covariates included as reported in **Table 4**.

We then turn to investigate how economic growth and social and environmental indicators interact in the short run and the long run. For this purpose, an ARDL to be estimated is chosen out of 39,366 models (2, 2, 0, 2, 0, 2, 2, 1, 0, 2) on the basis of criteria reported in **Table 5**.

The main ARDL results are summarized in **Table 6**.

The ARDL short-run dynamics and long-run equilibrium results are summarized in **Table 7**.

ARDL short-run dynamics and error correction (EC) results are summarized in **Table 8**.

The ARDL model shows that in the short run, investment has positive effect on GDP but with 1-year time lag. Life expectancy at birth has a negative effect on GDP with the highest elasticity coefficient of −16.45. Access to sanitation facilities exerts negative effect on GDP, while access to drinking water exerts positive effect on GDP although at 1-year time lag. Trade openness also has a negative effect on GDP. In the long run, GDP growth is positively and highly significantly affected by life expectancy at birth, access to sanitation facilities, and trade openness, respectively, while GDP is found to be negatively affected by youth unemployment followed by access to drinking water and investment. These long-run effects indicate that investments in physical capital and drinking water services have either been insufficient or ineffective in promoting economic growth in Sudan. Carbon dioxide emissions have no significant effect on economic growth in both the short and long run, although their coefficients are positive in two time frames.
Youth unemployment is the most hurting to economic growth in Sudan. The

coefficient of the error correction term estimated at −0.53 is highly significant confirming cointegration of the study variables and average speed of adjustment to equilibrium in the long run in response to the short-run shocks of the model variables. Results of the diagnostic tests show that the estimated ARDL suffers none of the conventional econometric problems associated with time series data. Thus, the estimated model is stable and robust and significantly captures the behavior of the association between economic growth and social and environmental progress indicators.

Variable	Coefficient	Std. error	t-statistic	Prob.*
$L(GDP)_{t-1}$	0.69	0.123	5.620	0.000***
$L(GDP)_{t-2}$	−0.22	0.126	−1.737	0.096*
L(INV)	−0.41	0.090	−4.540	0.000***
$L(INV)_{t-1}$	0.30	0.096	3.126	0.005***
$L(INV)_{t-2}$	−0.44	0.092	−4.751	0.000***
L(YUN)	−3.05	1.292	−2.360	0.028**
L(LE)	0.61	6.138	0.099	0.922
$L(LE)_{t-1}$	−6.81	10.036	−0.679	0.504
$L(LE)_{t-2}$	16.45	9.763	1.685	0.106*
L(ASE)	0.28	0.430	0.650	0.523
L(ASF)	0.39	0.853	0.455	0.654
$L(ASF)_{t-1}$	0.52	1.051	0.493	0.627
$L(ASF)_{t-2}$	2.76	0.822	3.352	0.003***
L(ASW)	−3.18	1.529	−2.077	0.050**
$L(ASW)_{t-1}$	5.55	1.879	2.955	0.007***
$L(ASW)_{t-2}$	−3.91	1.461	−2.676	0.014**
L(ELC)	0.11	0.266	0.429	0.672
$L(ELC)_{t-1}$	0.49	0.246	1.987	0.060*
L(CO2P)	0.02	0.125	0.164	0.871
L(TOP)	−0.03	0.115	−0.269	0.791
$L(TOP)_{t-1}$	−0.04	0.135	−0.284	0.779
$L(TOP)_{t-2}$	0.49	0.128	3.832	0.001***
DUM3	0.01	0.095	0.104	0.919
C	−27.54	10.872	−2.533	0.019**
R-squared = 0.994; adjusted R-squared = 0.988; SER = 0.102; SSR = 0.229; LL = 56.70; F-statistic = 167.22, P(0.000); AIC = −1.422; SC = −0.468; HQ = −1.064; DW = 2.15.				
Diagnosis	Stat.	P. value	D.W.	
Normality	0.04	(0.979)	2.15	
Autocorrelation	0.59	(0.562)	2.05	
Heteroskedasticity	0.32	(0.996)	2.36	
Stability	0.12	(0.728)	2.23	

****, **, and * indicate significance at 1%, 5%, and 10% level, respectively.*

Table 6.
ARDL summary results.

Variable	Coefficient	Std. error	t-statistic	Prob.
L(INV)	−1.03	0.228	−4.537	0.000***
L(YUN)	−5.79	2.465	−2.347	0.028**
L(LE)	19.44	4.274	4.5480	0.000***
L(EDU)	0.53	0.842	0.629	0.536
L(ASF)	6.95	2.507	2.771	0.011**
L(ASW)	−2.91	1.471	−1.978	0.061*
L(ELC)	1.15	0.716	1.601	0.124
L(CO2P)	0.04	0.236	0.164	0.871
L(TOP)	0.80	0.257	3.114	0.005***
C	−52.28	19.266	−2.713	0.013***
EC = L(GDP) − (−1.03 L(INV) − 5.79 L(YUN) + 19.44 L(LE) + 0.53 L(EDU) + 6.95 L(ASF) − 2.91 L(ASW) + 1.15 L(ELC) + 0.04 L(CO2P) + 0.80*L(TOP) − 52.28)				

****, **, and * indicate significance at 1%, 5%, and 10% level, respectively.*

Table 7.
ARDL long-run form. Case 2: restricted constant and no trend.

Variable	Coefficient	Std. error	t-statistic	Prob.
$DL(GDP)_{t-1}$	0.22	0.077	2.816	0.010***
DL(INV)	−0.41	0.052	−7.776	0.000***
$DL(INV)_{t-1}$	0.44	0.056	7.756	0.000***
DL(LE)	0.61	4.044	0.150	0.882
$DL(LE)_{t-1}$	−16.45	4.658	−3.532	0.002***
DL(ASF)	0.39	0.437	0.888	0.384
$DL(ASF)_{t-1}$	−2.76	0.487	−5.661	0.000***
DL(ASW)	−3.18	0.940	−3.379	0.003***
$DL(ASW)_{t-1}$	3.91	0.909	4.302	0.000***
DL(ELC)	0.11	0.139	0.821	0.420
DL(TOP)	−0.03	0.068	−0.451	0.656
$DL(TOP)_{t-1}$	−0.49	0.072	−6.819	0.000***
DUM3	0.01	0.026	0.377	0.710
EC_{t-1}	−0.53	0.048	−10.931	0.000***
R-squared = 0.86; adjusted R-squared = 0.80; SER = 0.085; SSR = 0.229; LL = 56.70; AIC = −1.856; SC = −1.300; HQ = −1.648; DW = 2.15				

Note: Case 2—restricted constant and no trend;
**** at 1% level.*

Table 8.
ARDL short-run estimates.

As evident from **Figures 12** and **13**, all plots of cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) statistics of the recursive residuals are well within the critical bounds, implying that the coefficients in the error correction model of the ARDL are stable.

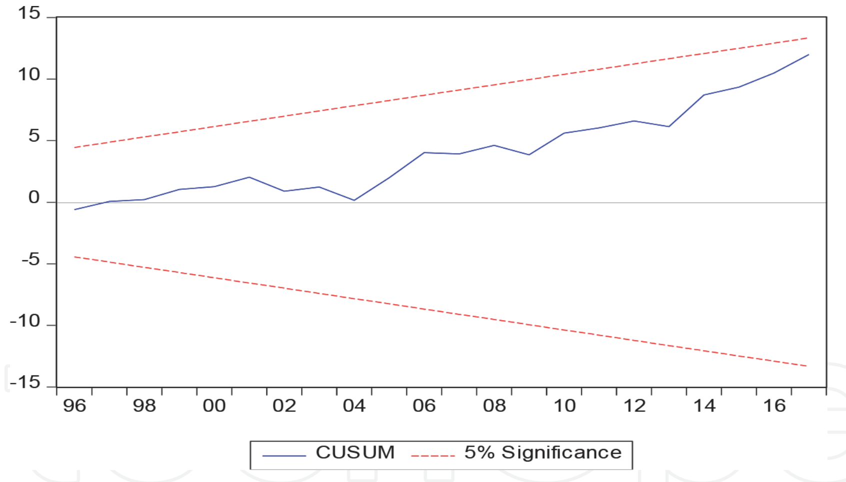

Figure 12.
CUSUM of the residuals.

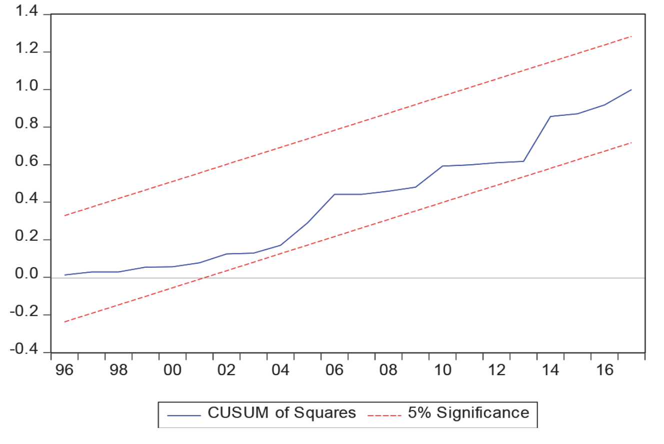

Figure 13.
CUSUM of squares of the residuals.

5.2.4 Johansen cointegration test

In addition to the ARDL bound test approach, Johansen cointegration method is also employed at lag length of 2. The Johansen's cointegration test determines the number of cointegrating vectors of equations. It is based on the statistics of two different likelihood ratios (LR): the trace statistic and the maximum eigenvalue statistic. With the assumption of intercept only, the test shows the existence of nine cointegrating equations with the trace statistic and seven cointegrating equations with maximum eigenvalue, while with the assumption of intercept and trend, the test shows the existence of ten cointegrating equations using the trace statistic and five cointegrating equations when using the maximum eigenvalue as shown in **Table 9**. Thus, the test results show that a long-run equilibrium relationship exists among the variables of the study and also justifies the use of the ARDL bound test method to cointegration.

Thus both the ARDL and Johansen cointegration tests confirm the existence of a long-run equilibrium relationship which indicates that the social and environmental indicators, together with investment and trade openness, are simultaneously playing an important role in determining the GDP growth in Sudan.

5.2.5 Granger causality analysis

Cointegration implies that causality exists between the series, but it does not indicate the direction of causality. Granger causality test enables to detect the

H_0	H_1	Intercept only				Intercept and trend			
		Trace stat.	0.05 cri. value	Max. eigenvalue stat.	0.05 cri. value	Trace stat.	0.05 cri. value	Max. eigenvalue stat.	0.05 cri. value
r = 0	r = 0	514.493*	239.235	134.344*	64.505	570.844*	273.189	134.384*	68.812
r ≤ 1	r = 1	380.149*	197.371	101.701*	58.434	436.460*	228.298	106.157*	62.752
r ≤ 2	r = 2	278.448*	159.530	82.403*	52.363	330.304*	187.470	96.049*	56.705
r ≤ 3	r = 3	196.046*	125.615	50.966*	46.231	234.254*	150.559	53.479*	50.600
r ≤ 4	r = 4	145.080*	95.754	42.747*	40.078	180.775*	117.708	50.569*	44.497
r ≤ 5	r = 5	102.333*	69.819	36.978*	33.877	130.206*	88.804	37.727	38.331
r ≤ 6	r = 6	65.355*	47.856	27.671	27.584	92.479*	63.876	30.562	32.118
r ≤ 7	r = 7	37.684*	29.797	20.444	21.132	61.917*	42.915	27.665*	25.823
r ≤ 8	r = 8	17.240*	15.495	14.8780*	14.265	34.252*	25.872	19.378	19.387
r ≤ 9	r = 9	2.362	3.841	2.362	3.841	14.874*	12.518	14.874*	12.518

Intercept only: Trace test indicates nine cointegrating equations; max. Eigenvalue test indicates seven cointegrating equations. Intercept and trend: Trace test indicates ten cointegrating equations; max. Eigenvalue test indicates five cointegrating equations;
** denotes rejection of the hypothesis at a 0.05 level.*

Table 9.
Johansen cointegration results.

direction of causality in which a series causes another series if the knowledge of the history of the first improves the prediction of the second. Therefore, consistent with the ARDL bound test and Johansen cointegration tests, the causal relationships among the economic, social, and environmental dimensions of development in Sudan is examined with lag length of 2. The Granger causality tests results are reported in **Table 10**. No causal relationship is found between investment and youth unemployment. Life expectancy at birth is found to cause GDP growth rather than the other way around. Also, education and access to sanitation facilities are found to cause GDP growth with no sign of feedback from these social and environmental indicators to GDP. A bidirectional relationship is found between access to drinking water and GDP growth. GDP is found to cause access to electricity rather than electricity causing GDP growth. GDP is also found to cause carbon dioxide emissions rather than the other way around. Trade openness is found to cause GDP growth with no sign of feedback from growth to trade openness as reported in **Table 10**. As for the causal relationships among the social and environmental indicators, we report the most notable and significant relationships. Education is found to cause investment. There exists a bidirectional relationship between access to sanitation facilities and investment. Both access to sanitation facilities and education are found to cause unemployment. Unemployment is found to cause access to drinking water. Both carbon dioxide emissions and trade openness are found to cause unemployment. Interestingly, a bidirectional causal relationship is found between life expectancy and education, which indicates the importance of investing simultaneously in both sectors. A unidirectional relationship is detected to run from life expectancy at birth to access to sanitation facilities, access to drinking water, access to electricity, and carbon dioxide emissions. Access to sanitation facilities is found to cause education, access to drinking water, and carbon dioxide emissions. Education is found to cause access to drinking water, access to electricity, and carbon dioxide emissions. A bidirectional relationship is detected between access to drinking water and access to sanitation facilities indicating the proximity

H_0	Obs.	F-statistic	Prob.	Decision	Direction of causality
H_0: L(INV) does not cause L(GDP)	46	0.050	0.951	Accept	None
H_0: L(GDP) does not cause L(INV)	46	0.097	0.908	Accept	None
H_0: L(YUN) does not cause L(GDP)	46	0.284	0.754	Accept	None
H_0: L(GDP) does not cause L(YUN)	46	1.579	0.219	Accept	None
H_0: L(LE) does not cause L(GDP)	46	3.557	0.038	Reject	LE to GDP
H_0: L(GDP) does not cause L(LE)	46	1.122	0.335	Accept	None
H_0: L(EDU) does not cause L(GDP)	46	4.927	0.012	Reject	EDU to GDP
H_0: L(GDP) does not cause L(EDU)	46	0.268	0.766	Accept	None
H_0: L(ASF) does not cause L(GDP)	46	2.633	0.084	Reject	ASF to GDP
H_0: L(GDP) does not cause L(ASF)	46	0.111	0.895	Accept	None
H_0: L(ASW) does not cause L(GDP)	46	3.575	0.037	Reject	ASW to GDP
H_0: L(GDP) does not cause L(ASW)	46	5.142	0.010	Reject	GDP to ASW
H_0: L(ELC) does not cause L(GDP)	46	1.094	0.344	Accept	None
H_0: L(GDP) does not cause L(ELC)	46	9.590	0.000	Reject	GDP to ELC
H_0: L(CO2P) does not cause L(GDP)	46	1.501	0.235	Accept	None
H_0: L(GDP) does not cause L(CO2P)	46	4.860	0.013	Reject	GDP to CO2P
H_0: L(TOP) does not cause L(GDP)	46	6.196	0.005	Reject	TOP to GDP
H_0: L(GDP) does not cause L(TOP)	46	0.531	0.592	Accept	None
H_0: Independent Variables	Obs.	F-Statistic	Prob.	Decision	Direction of causality
H_0: L(EDU) does not cause L(INV)	46	3.243	0.050	Reject	EDU to INV
H_0: L(ASF) does not cause L(INV)	46	3.967	0.027	Reject	ASF to INV
H_0: L(INV) does not cause L(ASF)	46	4.141	0.023	Reject	INV to ASF
H_0: L(EDU) does not cause L(YUN)	46	2.457	0.098	Accept	EDU to YUN
H_0: L(ASF) does not cause L(YUN)	46	6.133	0.005	Reject	ASF to YUN
H_0: L(YUN) does not cause L(ASW)	46	5.478	0.008	Reject	YUN to ASW
H_0: L(CO2P) does not cause L(YUN)	46	4.850	0.013	Reject	CO2P to YUN
H_0: L(TOP) does not cause L(YUN)	46	3.244	0.049	Reject	TOP to YUN
H_0: L(EDU) does not cause L(LE)	46	2.628	0.084	Reject	EDU to LE
H_0: L(LE) does not cause L(EDU)	46	4.134	0.023	Reject	LE to EDU
H_0: L(LE) does not cause L(ASF)	46	4.282	0.021	Reject	LE to ASF
H_0: L(LE) does not cause L(ASW)	46	3.619	0.036	Reject	LE to ASW
H_0: L(LE) does not cause L(ELC)	46	11.616	0.000	Reject	LE to ELC
H_0: L(LE) does not cause L(CO2P)	46	3.370	0.044	Reject	LE to CO2P
H_0: L(ASF) does not cause L(EDU)	46	5.793	0.006	Reject	ASF to EDU
H_0: L(EDU) does not cause L(ASW)	46	4.372	0.019	Reject	EDU to ASW
H_0: L(EDU) does not cause L(ELC)	46	7.313	0.002	Reject	EDU to ELC
H_0: L(EDU) does not cause L(CO2P)	46	2.952	0.063	Reject	EDU to CO2P
H_0: L(ASW) does not cause L(ASF)	46	3.745	0.032	Reject	ASW to ASF
H_0: L(ASF) does not cause L(ASW)	46	5.227	0.010	Reject	ASF to ASW

H_0	Obs.	F-statistic	Prob.	Decision	Direction of causality
H_0: L(ASF) does not cause L(CO2P)	46	6.213	0.004	Reject	ASF to CO2P
H_0: L(TOP) does not cause L(ASF)	46	5.610	0.007	Reject	TOP to ASF
H_0: L(ASW) does not cause L(ELC)	46	4.568	0.016	Reject	ASW to ELC

Table 10.
Granger causality test results.

Year	UNE required increase	UMR SDG	MMR SDG	ASE SDG	ASW SDG	ASF SDG	ELC SDG
2015	17.29	49.47	308.06	45.78	58.93	26.90	29.11
2016	17.27	48.09	231.05	46.81	59.09	26.60	29.61
2017	17.28	45.85	215.64	48.41	59.27	26.40	30.08
2018	17.15	43.62	200.24	52.40	60.33	28.95	32.86
2019	17.03	41.38	184.84	56.40	61.39	31.50	35.64
2020	16.91	39.14	169.43	60.39	62.45	34.05	38.42
2021	16.79	36.91	154.03	64.39	63.50	36.60	41.20
2022	16.67	34.67	138.63	68.38	64.56	39.15	43.98
2023	16.54	32.43	123.22	72.38	65.62	41.70	46.76
2024	16.42	30.20	107.82	76.37	66.67	44.25	49.54
2025	16.30	27.96	92.42	80.37	67.73	46.80	52.32
2026	16.18	25.72	77.02	84.36	68.79	49.35	55.10
2027	16.06	23.49	61.61	88.36	69.85	51.90	57.88
2028	15.93	21.25	46.21	92.35	70.90	54.45	60.66
2029	15.81	19.01	30.81	96.35	71.96	57.00	63.44
2030	15.69	16.78	15.40	100.34	73.02	59.55	66.22

Table 11.
Projection of key socioeconomic indicators toward SDGs.

of these variables to one another. Trade openness is found to cause access to sanitation facilities which might indicate the importance of imported goods to the improvement of sanitation facilities. Access to drinking water is found to cause access to electricity. Only significant causal relations between social and environmental dimensions of development are extracted and reported in **Table 10**.

In the light of our findings on the performance of Sudan on socioeconomic components of development, we make some projections for the period of 2015–2030. Projections are made according to the values of indicators in 2015 compared with that in 1990. We assume that the youth unemployment can be reduced to fluctuate around an average of 10%, and accordingly we projected the required job creation for youth in order to achieve this. Under five (UMR) and maternal mortality (MMR) ratios are projected according to the target of reduction by two third and 75%, respectively. Access to sanitation facilities, access to safe drinking water, and access to electricity are projected against full coverage of 100% of population. Projections are summarized in **Table 11**.

6. Conclusion

This study is a synthesis of arguments on economic, social, and environmental dimensions of development with empirical testing in the case of Sudan. The outcome of the study confirms that social and environmental indicators, together with investment, (un)employment, and trade openness, lead to economic growth measured by GDP and not the vice versa. That is, in whatsoever level of economic development achieved, the social progress indicators have been the main sources and not the factors of production as conventionally subtracted in physical capital and formal labor. This social factor-based economic development has also been backed with the use of natural environmental assets and amenities. Such findings have important policy implications for achieving development as an objective and on rethinking the real factor that has been leading to economic development in low-income countries such as Sudan, regardless of how small it has been. Although our findings are more on aggregate measures, they are in conformity with Hassan et al. [12], who found that social spending leads to an increase in GDP per capita and that an increase in primary education by 1% is associated with a growth by 0.8%, whereas health capital is found to have negative but insignificant effect. Accordingly we make the following general recommendations:

Spending on health and education has to be increased and be reverted in a social finance transition from a predominantly heavily burdened private and household sector to the government. Access to basic sanitation and drinking water facilities needs to be improved majorly, which contributes to health and education achievements. There is a need for planned gradual shifting of trade composition from export of environmental and primary products to high value added manufactured goods. On the other hand, there is an urgent need to regulate imports in favor of capital goods and equipments away from the imports of consumption goods particularly the luxurious ones. Efforts to adapt renewable energy sources should be enhanced, particularly in solar and wind energy which can be seen as the most possible investment for expansion access to modern energies in remote and rural areas of Sudan. These recommendations can be designed into operational polices and can be monitored in line with the guidelines provided by the OECD [13], in its *Policy Framework for Investment*.

Author details

Elwasila Mohamed
Department of Economics, Faculty of Economic and Social Studies, University of Khartoum, Khartoum, Sudan

*Address all correspondence to: elwasila.sem@gmail.com

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