مجلة بحوث الإدارة والاقتصاد

Management & **E**conomics **R**esearch **J**ournal
ISSN 2710-8856 (Online)
ISSN 2676-184X (Print)

Vol. 5 No. 1 (2023): March, pp. 15-44

https://doi.org/10.48100/merj.2023.258

Africa's Continental Free Trade and Sustainable Development: An Economic Assessment

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Received: 26-08-2022 *Accepted: 05-10-2022* *Published online: 08-10-2022*

How to Cite:
Quartey, J. D. (2023). Africa's Continental Free Trade and Sustainable Development: An Economic Assessment. *Management & Economics Research Journal*, *5*(1), 15-44. https://doi.org/10.48100/merj.2023.258

Abstract:

The quest for Africa's development breakthrough appears to be closely related to the African Continental Free Trade Area (AfCFTA). The Economic Commission of Africa believes the move could solve chronic poverty and joblessness prevailing on the continent. However, the benefit of hindsight reveals limits set by the laws of thermodynamics on the extent to which economic activities can be most beneficial to humanity. The motivation to expand trade thrives on energy for extraction, production, and consumption, yielding undesirable waste products. The need for sustainable development has responded to the limits imposed by excessive waste, stretching environmental carrying capacity to the breaking point. Thus, to avoid repeating past development errors, Africa's Continental Free Trade Area needs to ascertain the extent and cost of resultant environmental damage. Clearly, AfCFTA is yet to consider such effects. The COVID-19 pandemic, however, should be a reminder of how devastating a collision between economic activity and the natural environment can be. So far, studies

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on AfCFTA have been restricted to quantifying the effects of tariff reductions, non-tariff barriers, and trade facilitation. This study, however, assesses the outcomes of the efforts being made to achieve the goals of AfCFTA, from an environmental economics analytical framework, in line with tenets of sustainable development. It employs data from the World Bank and AfCFTA Secretariat to analyze the welfare effects of AfCFTA through resultant deforestation, solid waste management, and climate change adaptation. The study found the resulting environmental damage to be US$ 744.71 billion, far exceeding the projected AfCFTA benefits of US$450 billion to be realized by 2035. Thus, in its current form, AfCFTA will reduce the economic welfare of Africa by at least US$294.71 billion by 2035. While in the formative stages, AfCFTA will be better served if stakeholders can pay attention to the call for a fully operational plan to offset the impending environmental damage, which cannot be taken for granted if Africa wants sustainable development.
Keywords: Africa, African Continental Free Tade, Deforestation, Economic Welfare, Environmental Damage, Sustainable Development, Waste Management.
JEL Codes: F13, F18, O55, Q01, Q37, Q52, Q56.

1. Introduction

Africa's trade expansion goal seeks to increase trade among its economies from the present low of 16% to more than 60%. This effort rests on the African Continental Free Trade Area (AfCFTA) accord, made up of a human population of 1.3 billion in 55 countries with a total yearly output of US$3.4 trillion (World Bank, 2020a). Global trading prospects of a united African market are also expected to improve. The overall ambition of the African Economic Commission is to make AfCFTA the most effective tool against poverty through the resultant job opportunities to be created within the continent.

The success of AfCFTA could significantly close Africa's manufacturing gap. The current contribution of manufacturing to the continent's total GDP is an average of just 10%. Expanding Africa's manufacturing sector would enhance the capacity of Small and Medium Scale Enterprises (SMEs) in job creation to employ the youth who remain unemployed primarily to alleviate poverty since SMEs constitute about 80% of African firms (Akeyewale, 2018). However, existing evidence points to Africa's economic growth impacting its ecological resource base, which is the bedrock for future generations' development. In a joint study, the African Development Bank (AfDB) and WWF found that all African countries' ecological footprints from 1961 to 2008 had increased by 240% (AfDB &

WWF, 2015). In 2015, Africa attained (biocapacity deficit) status, where the adverse effects of the used resources exceeded the ability of Africa's ecosystems to generate useful biological materials and assimilate waste materials produced by its populations (AfDB & WWF, 2012). Even though Africa has diverse avenues for development, its extractive industry has been and will continue to be a major source of export revenue, contributing a substantial share to Gross Domestic Product (GDP) growth.

If the current African models of growth in consumption and production are continued and expanded as intended, the evidence shows that this will undermine Africa's ecological systems, leading to a limiting of the quality of economic growth. Thus, Africa will see the emergence of (ecological frontiers) or (hot spots) where the expanded extractive, industrial and economic activity will interfere with sensitive ecosystems. The resultant aggregate impact of natural resource degradation and increased conflicts over remaining stocks will become a common characteristic of these hot spots. The ultimate consequence of such impacts on such mostly fragile ecosystems and for the people, communities, and activities which depend on their sustained functioning will be severe (AfDB & WWF, 2015).

The efforts toward AfCFTA show that Africa is pursuing an expansion of its current extraction, production, and consumption models. The efforts were structured after the industrial revolution of the 20th century, which set the world economy on a collision course with the natural environment. With a closed earth system, and Africa's biocapacity deficit, the development paradigm adapted faces enormous resource challenges. Thus, a sustainable pathway is required, considering existing conditions and the requirement for passing on equal or better opportunities for the development of future generations. This paper, therefore, analyzes the economic implication of the development strategy of AfCFTA and explains why AfCFTA should be fully equipped to secure Africa's environment before execution, to avert imminent welfare loss for the continent through expanded trade.

The following section examines relevant theoretical concepts which govern the relationship between trade expansion and the natural environment, providing a framework within which AfCFTA will operate. A review of some empirical literature follows this. The next section examines the current state of Africa's trade and the prospects of AfCFTA. This is followed by a brief analytical procedure and presentation of the study's results. The major findings of the study are then discussed. The study concludes by presenting some lessons from the North American Free Trade Agreement (NAFTA) and making recommendations to guide AfCFTA policy toward sustainable

development.

2. Review of theoretical literature

2.1. Constraints from natural laws

The first and second laws of thermodynamics impose physical limits on the extent to which resources can be exploited to yield benefits for current and future generations. The first law holds that the exact mass of material extracted from the environment will not be destroyed but will return to it in other forms, mainly as some desirable material and waste. The only intervening delay between extraction and waste is recycling, which, though effective, cannot reverse the eventual waste outcome due to the second law of thermodynamics. Equations (1) and (2) depict thermodynamics' first and second laws, respectively.

$$M \equiv R^d \equiv R - R^r \equiv A^r + W \quad (1)$$

$$R - (R^r + A^r) = W > 0 \quad (2)$$

Where M is material extracted from the natural environment, R is residue generated through extraction from the natural environment, R^d is residue from extraction that is deposited within the natural environment, R^r is the residue from extraction recycled, and A^r is the assimilative capacity generated through recycling of residue. W is waste resulting from materials extracted from the natural environment at the extraction, production, and consumption stages of economic activity. These laws of nature imply that increasing extraction of environmental resources generates more waste both in the current and future periods. Sustainability involves staying within the natural environment's capacity to withstand the waste generated. If this is exceeded, the negative feedback effect will directly reduce human welfare by having direct and indirect adverse effects on human health, economic activity, and general welfare. The second group of negative feedback effects would render portions of the natural environment, which is useable, unfit because that part of the environment will have to serve as a dumping ground for the excess waste.

The question of whether the African continent has exceeded its environmental carrying capacity was answered long ago. Yes, the carrying capacity of the African continent had been long exceeded by 2006 (AfDB & WWF, 2015). The evidence, at first sight, is the numerous polluted portions of the continent and the severe effects of climate change on the continent. In

the case of climate change, a global problem, the world has been trying to find a solution by reduction of carbon emissions. However, pollutants accumulated locally would only affect the welfare of local residents and so must be addressed by local people. Thus, land and water pollution in Africa must be addressed by Africa since Africans are those directly affected.

Another problem with excessive extraction of resources from the earth is the faster-than-normal depletion of the resources, creating shortages not only for the current generation but also for future generations. Thus, the problems of deforestation, inadequate arable lands, and water scarcity are surface evidence of the excessive extraction of resources from the environment. These have been the causes of conflicts and chronic poverty in several African communities. The solution for excessive extraction is sustainable extraction. The sustainable development paradigms discussed in the next section have been proposed for development that protects human welfare.

2.2. Sustainable development paradigms

The Brundtland Report defined sustainable development as meeting present needs without compromising the ability of future generations to meet their own needs (WCED, 1987). Sustainability of resource use addresses the issues of intergenerational equity as well as intragenerational equity. This will necessarily mean that future generations' welfare is given the same or even better consideration in resource allocation than the current generation. Such consideration must be based on sufficient quantities of both natural capital stock and man-made capital. In the case of natural capital stock, Africa must not cross the red line of the critical natural capital stock, below which meaningful livelihood will be threatened in most communities. This underlines the strong sustainability paradigm.

The weak sustainability paradigm is the alternative to the strong one, which assumes perfect substitutability between natural and man-made capital. This means it does not matter if a country depletes its natural capital as long as it uses the proceeds from the depletion to acquire man-made capital. In applying the weak sustainability paradigm, Nauru converted its natural capital (phosphates) into man-made capital (high-interest-yielding foreign financial assets), hoping to secure the welfare of current and future generations. Intensive phosphate mining within the past 90 years has rendered about 90% of the country's centre a wasteland from mining. The primary phosphate resources were exhausted in 2006, leaving a heavy development burden and a difficult situation for future generations' development (SPREP, 2016).

While the investments yield dividends annually, Nauru has to import

water and food due to the loss of its rich soils, which were extracted and exported to acquire financial assets. The trade-off of natural capital for financial rewards has deprived future generations of the critical natural capital stock that will enhance their welfare. The question is: if every country had traded off its natural capital as Nauru did, where would Nauru have had water to import?

Africa does not need to make itself as vulnerable as Nauru made itself. However, if the right steps are not taken toward AfCFTA, that will ultimately be the outcome for Africa. Nauru was enticed by the benefits of trading their natural resources, just like in Africa. Since the earth is closed, Africa may deplete its natural resource stock to acquire man-made capital. However, this will mean future generations will inherit man-made capital and excessive waste and be deprived of the same opportunities the current generation had to develop. Such development is not unsustainable development.

AfCFTA needs a comprehensive plan underway to address current and future environmental and natural resource challenges, which will be scaled up with changing conditions. However, there is currently no effort to address environmental concerns of extraction, processing, and consumption of resources at the start of trade. The order of events is very critical here. The waste should only be generated and stored (where?) after it is cleaned up. The clean-up system must be ready before the first waste unit is discharged. Reversing the flow will aggravate the welfare conditions in Africa since it is already saddled with huge waste management challenges. Thus, given the gap in being unprepared to handle environmental and natural resource challenges, AfCFTA still needs to be on a sustainable path to development. As it stands, discussions and plans of AfCFTA have been structured after the industrial revolution of the 20th century, an unsustainable development path.

The question remains: How much more of Africa's resources will have to be extracted to meet the production targets for continental free trade? How much waste will be generated from extraction, processing, and consumption? Are these within the carrying capacity of the continent? What infrastructure has been installed to accommodate the waste? What indigenous technology has been developed and deployed to contain the increase in waste? The plan to increase inter-African trade from 16% to 60% within about five years will require more than double the quantity of extraction, processing, production, and consumption within the continent. The waste generation will, therefore, more than double without the readiness to contain it.

2.3. Expanded trade externalities and decision point

Apart from managing waste from expanded trade, there exists the

problem of trade externalities. These are external costs imposed on third parties through alterations in the natural environment, the economy, and human welfare due to expanded trade agreements. The following model is used to account for these externalities theoretically.

Let available technology be T, where U is the welfare function, K is capital stock, and L is labour. In the economy, technology, T combines capital and labour to produce a consumption good x and is available to all countries worldwide. A strictly quasi-concave production function, with constant returns to scale, satisfying the following conditions can be formulated as equation (3):

$$\lim_{K\to 0} \partial T/\partial K = \infty, \lim_{K\to\infty} \partial T/\partial K = 0 \quad \text{and for all } K > 0,$$

$$\partial T/\partial K > 0 \text{ and } \partial^2 T/\partial K^2 < 0$$

The welfare function (U) for every country is presented as follows:

$$U(x, T(K, L)) \tag{3}$$

The choice of a welfare function (4) should be positively related to the quantity of good x consumed and negatively related to the production level since increasing production increases related waste.

$$U(x, T(K, L)) = x - m(T(K, L)) \tag{4}$$

Where m is a strictly increasing and convex function.

The concept of a free trade space (FTS), defined as the situation where free trading of inputs and outputs exists between two countries or two sets of countries C_1 and C_2, can thus be employed to depict the effect of free trade on welfare. When equilibrium prices of capital and labour are substituted into the welfare function, where k(R) is the capital-labour ratio, the indirect welfare function (W_i) for the country becomes:

$$\begin{aligned} W_i(k(R), K_i) &= x_i - m(t(k(R))) \\ &= t(k(R) - t^1(k(R))(k(R) - K_i) - m(t(k(R))) \end{aligned} \tag{5}$$

Equation (5) depends only on the capital endowment of the country or group of countries Ki and its capital-labour ratio k(R).

Therefore, some countries or groups may be better off not participating in free trade expansion since an increase in their capital-labour ratio will positively impact their incomes and increase the extent of the

external cost they suffer through expanded trade. This result makes it imperative for countries seeking to embark on expanded free trade like AfCFTA to at least count the cost involved and decide whether it will be welfare-improving for its people.

2.4. Trade liberalization prospects for AfCFTA

AfCFTA intends to pursue, as a prime objective, increased foreign direct investment by lifting all impediments to attracting foreign capital; this could provide more options for capital acquisition by local investors, particularly if these investments are in the banking sector.

However, any agreement that grants freedom for trade expansion between developed and developing economies will facilitate negative externality transfers and the free movement of goods and production factors. The findings of Low and Yeats (1992) regarding the movement of capital between North (industrial) and South America (non-industrial) through foreign direct investment revealed that 4.5% of highly polluting industries relocated from the north to the south from 1965 to 1988.

Welfare levels are compared before and after a free trade policy to measure free trade effects on economic welfare. However, due to the adverse impact of expanded trade on some factors of production, Francois et al. (2011) argue that social and environmental adjustment costs must be added to the cost of the policy. While there is general agreement that free trade can cut trade costs and cause consumers' welfare to improve, the empirical evidence has been on the policy's long-term benefits without accounting for the negative dynamics within the transitional period (Liu, 2018).

Some transitional problems are derived from the degradation of the natural environment. This approach suggests that only the policies that ultimately generate some significant gains are documented. This needs to provide more information regarding what should be avoided to ensure successful outcomes. However, Francois et al. (2011) reported negative effects on output in the long run due to trade liberalization. The devastating effects of climate change on African economies and COVID-19 provide hard lessons as a warning against any system which will take the natural environment for granted.

AfCFTA literature has been confined to the effects of tariff reduction, assessments of trade facilitation, and non-tariff barriers (NTBs) (World Bank, 2020a). In its 2019 simulation of AfCFTA benefits, the African Development Bank (AfDB) used the Computable general equilibrium (CGE) model. Their results advocate for free trade among African countries and other developing countries to guarantee optimal trade benefits (AfDB, 2019).

Chauvin et al. (2016) used the MIRAGE-e CGE model, while Vanzetti et al. (2018) used the Global Trade Analysis Project model. The findings of these studies revealed that annual AfCFTA benefits where all tariffs are excluded would be up to US$3.6 billion. Chauvin et al. (2016) reported a loss of welfare for some countries due to expanded trade.

Using the Global Income Distribution Dynamics approach, the World Bank (2020a) found that AfCFTA could free about 30 million people from extreme poverty if the policy on free trade is well managed (World Bank, 2020a).

Official analysis has avoided issues related to the environmental effects of AfCFTA, even though over 70% of Africans obtain sustenance through the natural environment. Available evidence shows that there have yet to be any active efforts to officially account for the environmental cost of AfCFTA (World Bank, 2020a).

2.5. Policy relevance

At the individual country level, some attempts have been made to ensure that external costs from environmental damage are internalized. However, the international sphere is saddled with uncertainty regarding whom the external cost burden falls on. Also, since international institutions' authority usually does not include oversight of the environment, it becomes almost impossible for them to ensure that the external costs of actions they are associated with are internalized. This breeds irregular practices in the area of transnational trade externalities. Hence, most international trade agreements fail to capture the effects and consequences of environmental externalities (Harris & Roach, 2018).

The common African practice has been to ignore environmental policies that will ensure trade does not undo the benefits obtained through internalizing external costs. Thus, such policies generally do not exist; where they do, they are largely not implemented. This makes it too easy for substances that pollute the environment to be freely traded on the continent among its countries. The extension of this problem to the international community beyond Africa makes Africa the loser since it needs the necessary structures, expertise, and gadgets to verify the environmental damage of most imports. For instance, under the GATT Article XX, trade restrictions can be applied against some substances to protect some natural resources. However, due to ignorance and controversy, some trade partners get away with serious abuses of Africa's environment (Paarlberg, 2000).

The justification is that a polluting developmental pathway will be self-correcting because the Environmental Kuznets Curve (EKC) has been

faulty, particularly for Africa. The EKC approach calls for increased free trade, hoping it will quicken the process of economic growth, thereby leading to better environmental conditions. However, relevant tests to validate this position for Africa have not been successful.

The EKC has been applicable in only a few air and water pollutant cases. Its findings have not had support from research on all other pollutants of the environment, especially the greenhouse gases responsible for climate change. The EKC also failed to control municipal waste and soil and ecosystem degradation (Harris, 2004). This means the pollutants whose control is most relevant for Africa's trade and progress cannot be managed based on the EKC principle.

Findings of the World Bank indicate that as economies attain higher economic growth, their carbon dioxide emissions and municipal wastes increase. Meanwhile, income levels required as (turning points) on the EKC for pollutants that conformed ranged from US$2000 to US$12,000 for any significant response to be triggered in most developing countries. One EKC study estimated the global (turning point) period for sulfur dioxide as 2085 and that of nitrogen oxides as 2079, thus permitting more than 200% growth in emissions (Selden & Song, 1994). In addition, the results of EKC could not be reproduced with various indicators and the inclusion of more explanatory variables in different modelling trials. This shows the lack of scientific basis to accept that environmental pollution problems can be resolved by attaining economic growth (Rothman & De Bruyn, 1998).

Economic growth can improve the capacities of countries to preserve their natural resources. However, sustainable solutions to high levels of environmental abuse require well-thought-out lines of action to reverse the effects and guard against environmental degradation. The current AfCFTA set-up will need such policies to succeed.

2.6. Some empirical issues

Policymakers who seek answers to issues regarding environmental damage costs in Africa have often not had the privilege of making decisions guided by trade-related empirically significant analysis of environmental costs. Not all groups of people are equally affected by trade-related environmental costs; for some, the effect may be significant, while for others, it could be insignificant (World Bank, 2020a). Under such circumstances, it becomes necessary to identify those who suffer adversely through expanded trade for interventions and assistance.

However, there needs to be more empirical evidence on environmental damage costs in developing countries due to the need for more

documentation of the effects. Where some have been documented, these need to be done correctly. Birdsall and Wheeler (1993) found that factors militating against correct measurement, monitoring, and enforcement of environmental standards in most developing countries were the high cost involved, the inadequacy of personnel with the requisite training, and the lack of appropriate equipment.

This situation leaves policymakers with two options. First, to use values measured in developed countries, and second to assume that the costs do not exist since they have yet to be quantified. Currently, the most prevalent practice is the second option in Africa. If some of these values are required, measures from developed countries are adapted as best practices. This creates a distorted scene of the effect of trade expansion on the welfare of African countries. The most prevalent value for the environmental cost of trade expansion in Africa is zero.

Using developed country estimates in developing countries is not acceptable because there exists a significant difference between the two groups in economic, institutional, and social dynamics. This makes the nature and magnitude of environmental costs from expanded trade between developed and developing countries not substitutable (Francois et al., 2011). Developing countries have a substantial role in natural resources in trade, where several informal sector actors with little diversity in trade activities persist. This makes the extrapolation of developed country findings for developing countries scientifically unjustified (Rodrik, 2004; Francois et al., 2011).

The argument that environmental damage due to expanded trade is minimal and insignificant thrives on the fact that these have not been correctly measured in Africa. It is worth noting that in Britain, the banking and insurance industry considers climate risks a significant variable in decision-making. Climate and environmental analysis have become a requirement for business assessments of risk for the Bank of England, weighted as changes in interest rates (Bank of England, 2019). If these costs were insignificant, the Bank of England would not consider them a significant source of business risk.

Even for the SDGs, the African SDG report of 2019 shows substantial data gaps. Out of the 169 targets, only 50% have data available, and just 40% of the indicators show some level of data availability. There are even cases of incomplete data collection methods for some variables (SDG Center for Africa and Sustainable Development Solutions Network, 2019).

3. Free trade and Africa's environment

AfCFTA will need to generate more energy, use more pesticides, and use another throughput to expand exports. However, some of these activities have adversely affected the African ecology and contributed to deteriorating local and global ecological conditions.

Global trade dynamics ensure the movement of business capital to economies that guarantee low production costs based on regulating raw materials, labour and trade practices (Daly, 1993). Thus, economies whose corrupt governments can accept to sell resources cheaply to trading partners to secure arms and other needs will equip them to suppress civil society activities and permit lazed environmental conditions. This will make it easier to attract financial capital. Here, the quest for growth through expanded trade will only worsen pollution and environmental degradation and put the assimilative and regenerative capacities of the biosphere at very high risk. Thus, through state manipulation, technology and capital migrate to economies with low wages, low taxes and tax exemptions, and lax environmental controls. One of such ideal places for financial capital of late has been Africa.

The most appealing argument for free trade expansion has been that competition will emerge internationally through trade. Such international competition is expected to result in lower costs since the most efficient producers are likely to survive because they have a comparative advantage. However, free trade expansion in Africa has, in many cases, led to a (race to the bottom) and, consequently (pollution havens) as discussed in the following section. This worsens the plight of people for whom the trade was expected to cause growth and development.

3.1. Pollution havens and the race to the bottom in Africa

Externalizing costs under free trade is common among competitors who seek to maximize profits as and when they can escape responsibility (Daly, 1993). This means that any trading partner without a well-structured and planned trade agreement to deal with the environmental externalities of trade is likely to experience unexpected external costs due to expanded trade.

The failure of most developing countries to address the issues of pollution and externalities in international trade opens an avenue for environmental degradation in such countries, usually referred to as (pollution havens). This concept shows that producers from economies with strict environmental regulations to economies with weaker environmental regulations would relocate the dirtiest production systems. Otherwise, they

will become less profitable. Generally, the countries with more ineffective regulations are lower-income and developing countries, mainly in Africa. This provides a means through which residents in the economy with stricter environmental regulations can benefit from the cheaper commodities produced in the pollution havens.

When an economy relaxes requirements for sound environmental management to attract firms from abroad or keep such firms from moving elsewhere to prevent the loss of jobs, that economy engages in a race to the bottom. This means the economy chooses to be a pollution haven through a policy that attracts high-pollution firms due to its lax environmental standards (Harris & Roach, 2018).

Thus, from the incentives created for competition through expanded international trade, developing countries appear compelled to use loose environmental regulations to attract investors, who consider the lower production costs provided through loose environmental regulations and cheap labour as avenues for high profits. Where capital mobility exists in trade, the competitive advantage sources are firms' willingness to degrade the environment and cheap labour (Starkey, 2006).

Ayadi et al. (2019) found that the pollution haven hypothesis was a reality for Nigeria. Their study tested the pollution haven hypothesis using the autoregressive distributed lag model.

Chao and Yu (1997) and Oates and Schwab (1988) also found that some developing countries deliberately set inefficient and low environmental standards to attract capital from abroad to help raise tax revenue through capital taxation. Copeland and Taylor (2004) observed that the race-to-the-bottom attitude of developing countries was so strong that the effect it had on African countries exceeded all other motivations for trading in polluting goods.

3.2. Current state of African trade

The 55 countries in the AU are responsible for only 3% of the world's goods trade. Between 2013 and 2019, the AU's annual imports and exports declined from 2013 to 2016 and then increased afterwards, but imports exceeded exports each time. Thus, from 2013 to 2019, Africa had a negative trade balance with world trade (Figure 1). Also, the ratio of commodities exports to commodities imports fell from 92.5% in 2013 to 83.1% in 2019. In addition, extra African trade constitutes over 80% of the AU's total trade. The balance of extra-AU trade has also been negative, averaging 372 billion US dollars in exports and 495 billion US dollars in imports (AU, 2020).

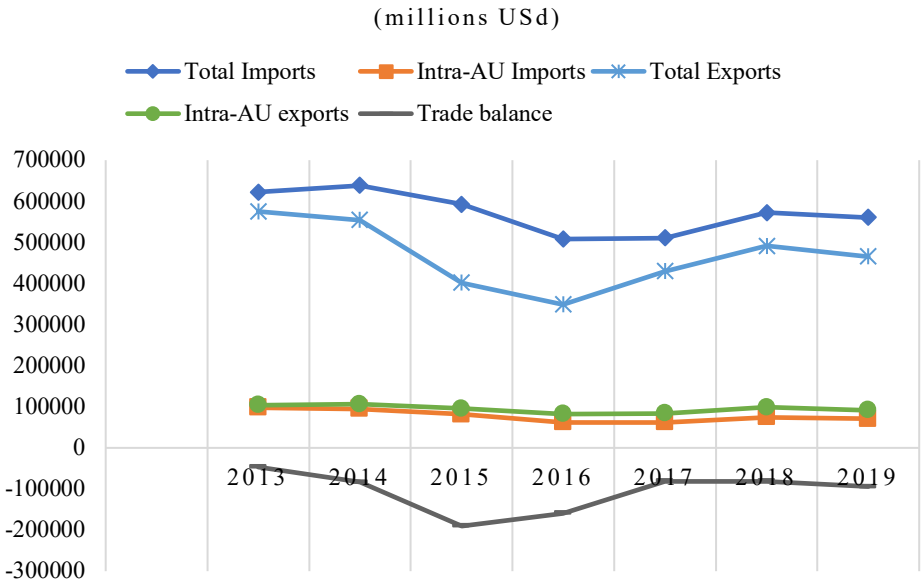

Figure 1. African Union trade from 2013 to 2019

Intra-AU trade must be improved to boost economic development and continent-wide integration. However, from 2013 to 2019, the share of Intra-AU trade was low, averaging 13% in intra-AU imports and 20% in intra-AU exports (Figure 2).

Africa's major imports have been mineral fuels and their related products, electrical machinery and equipment, and vehicles and their related products. These constitute about 52% of Africa's imports from the rest of the world (AU, 2020; AfCFTA, 2021). It is certain that by 2035, about 75% of AfCFTA imports will still be coming from outside Africa (World Bank, 2020a). This means all the imports with massive pollution and environmental damage potential are expected to persist within the next decade.

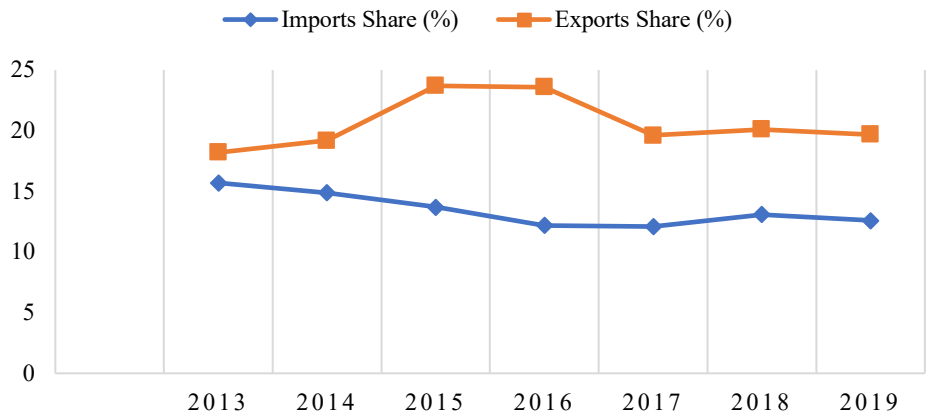

Figure 2. Share of intra-AU trade from 2013 to 2019
Source: Author's construct from AU statistics, 2020

4. Analytical framework

A multiple regression estimation of the relationship between trade and waste generation was carried out for 49 sub-Saharan African countries. Data for the analysis was obtained from the World Bank's World Development Indicators for 1970 to 2019, 50 years. The dependent variable was solid waste generation per annum in tonnes. Solid waste is substances or objects in the solid state that are disposed of, supposed to be disposed of, or required to be disposed of (Basel Convention, 1989; UNEP, 2005).

The independent variables were traded as a percentage of Gross National Income (GNI), mineral depletion as a percentage of GNI, deforestation as a percentage of GNI, and carbon dioxide (CO_2) damage as a percentage of GNI. The STATA 16 software was used to analyze the data.

Thus, the model estimated for Africa was:

$$\text{Waste} = f(\text{Mineral depletion, Deforestation, } CO_2 \text{ damage, Trade})$$

Two similar analytical procedures were carried out to determine the welfare effect of expanded trade based on data from the AfCFTA, World Bank, and the African Union to support the results for the estimated regression model. The first approach is a net benefit analysis, where the size of externalities may not be evident. The second approach, in contrast, uses a net welfare analysis to take externalities into account specifically.

4.1. Net benefit estimation

Economists generally agree that actions undertaken within the natural environment have benefits and opportunity costs. The benefits generally refer to the value derived from the action. On the other hand, the opportunity cost refers to the next best alternative as the forgone or actual cost of undertaking the action. A desirable action is one for which the benefits exceed the actual cost. Any action for which the benefits are lower than the actual cost is thus undesirable. This expression can be presented formally as the following.

Let B be the proposed policy's benefits and C be the actual cost. The decision rule becomes:

If $B > C$, the action is upheld. Otherwise, the action is opposed.

Given that B and C are positive values, $B > C$ implies $B - C > 0$, implying further that a positive net benefit will make an action desirable. Thus, the decision rule for AfCFTA to be acceptable is when the benefits of AfCFTA trade exceed its actual cost or when the net benefit of AfCFTA trade is positive. A negative net benefit means rejecting expanded trade is most desirable for optimality. Thus, a negative net benefit will not result in sustainable development.

4.2. Net welfare estimation

In the absence of externalities, the market's equilibrium is efficient because it ensures maximum net social benefit. However, in the presence of externalities, the market equilibrium no longer becomes economically efficient. In the case of the presence of externalities, the social equilibrium becomes the most efficient resource allocation position, providing maximum social welfare.

The net social welfare (NSW) is the sum of consumer surplus (CS) and producer surplus (PS) minus the damage costs from externalities (ED). This is stated as equation (6).

$$\text{Net Social Welfare (NSW)} = CS + PS - ED \quad (6)$$

Based on equation (6), the net social welfare effect of AfCFTA was computed. A positive result signifies welfare improvement, and a negative result signifies a deterioration of social welfare for Africa through expanded trade.

5. Results and discussion of findings

Descriptive statistics for the data are presented in Table 1 for 50 years, from 1970 to 2019. Within this period, the mean trade value as a percentage of Gross National Income (GNI) for Africa was 48.1. This means that, on average, 48.1% of African gross national incomes are derived through trade, the maximum percentage being 63.3%. Thus, trade constitutes a large source of income in Africa.

Table 1 also indicates that the mean amount of solid waste generated annually in Africa is 369519.5 tonnes. This allows policymakers to ascertain whether current measures and infrastructure can handle the quantity of solid waste being generated and its implication for the welfare of the people.

The data also shows that Africa's mineral resources are depleted at an average rate of 0.62% relative to gross national income. In comparison, the rate of forest loss is an average of 0.84% with respect to gross national incomes. The damage caused by carbon dioxide emissions in Africa is shown in Table 1 to be, on average, 1.84% of gross national income. Thus, from mineral depletion, deforestation, and carbon dioxide damage, Africa loses, on average, 3.30% of gross national income per annum.

Table 1. Descriptive statistics of variables from 1970 to 2019

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Mineral depletion (percentage of GNI)	50 years	0.622586	0.386918	0.140215	2.455286
Deforestation (percentage of GNI)	50 years	0.840712	0.382659	0.208090	1.594883
Carbon dioxide damage (percentage of GNI)	50 years	1.836349	0.572259	0.825797	3.159647
Trade (percentage of GNI)	50 years	48.148860	7.898674	34.812760	63.290340
Solid waste generated per annum (in tonnes)	50 years	369520	144144	174283	664116

Source: Author's computations from WDI data, 2022

5.1. Regression analysis

The study ensured that all the mean and variance of the time series data used did not change over time. Thus, the stationarity status of the variables was verified to avoid spurious regression analysis. This ensures that shocks are temporary within the data set to guarantee its ability to support the theory-based economic explanation of long-run relationships derived through the data. To this effect, the Augmented Dickey-Fuller test was applied. The results for the Augmented Dickey-Fuller test shown in Table 2 show that

mineral depletion was stationary at the level, while the remaining variables were stationary after the first differencing. Thus, the data can support the theory-based economic explanation of long-run relationships involving the variables for the study.

Table 2. Results of augmented Dickey-Fuller test for unit root

Variable	Level	First difference
Mineral depletion	-4.464 (0.0017)***	-
Deforestation	-2.540 (0.3082)	-6.727 (0.0000)***
Carbon dioxide damage	-1.245 (0.9010)	-4.555 (0.0012)***
Trade	-2.309 (0.4291)	-7.217 (0.0000)***
Waste	17.477 (1.0000)	-5.916 (0.0000)***

***indicates statistical significance at the 1% level.

Multiple regression analysis was then used to model the relationship between solid waste generated in Africa and trade, with mineral depletion, deforestation, and carbon dioxide damage as control variables. The results from the regression analysis are presented in Table 3.

Table 3. Results of regression analysis

Waste	Coefficient	Standard Error	t	P > l t l
Mineral depletion	9334.35	38203.27	0.24	0.808
Deforestation***	273572.90	44638.20	6.13	0.000
Carbon dioxide damage	-13934.87	31819.15	-0.44	0.664
Trade***	5244.84	1671.32	3.14	0.003
_cons	-93231.61	87508.79	-1.07	0.292
Number of observations	=	50		
F (4, 45)	=	23.55		
Prob > F	=	0.0000		
R-squared	=	0.6767		
Adj R-squared	=	0.6480		

***indicates statistical significance at the 1% level.

The regression results (Table 3) show that trade and deforestation were statistically significant and positive determinants of waste generation in Africa at the 1% significance level. Mineral depletion and carbon dioxide damage were not statistically significant determinants of African solid waste generation. From the results, one unit change in the trade as a percentage of GNI will result in an additional waste generation of 5244.84 tonnes per annum. Also, one unit change in deforestation as a percentage of GNI will result in additional 273572.9 tons of solid waste per annum in Africa.

The explanatory power of the model is very high, at 67.7%. In contrast, the overall ability of the model to represent the relationship between trade and solid waste generation (F-statistic) is statistically significant at the

1% significance level.

5.2. Discussion of the regression results

5.2.1. AfCFTA trade and waste generation

The regression results found a positive and highly significant relationship between trade and solid waste generation in Africa. This has several implications for AfCFTA and the welfare of Africa through expanded trade. The discussion examines one group of trade items that will manifest the regression results. This group constitutes the import of mineral fuels and their related products, electrical machinery and equipment, and vehicles and their related products, which currently accounts for about 52% of Africa's imports from the rest of the world (AU, 2020; McKenzie, 2021).

The World Bank (2020a) is sure that by 2035, about 75% of AfCFTA imports will still come from outside Africa. The implication is that all imports with huge pollution and environmental damage potential are expected to persist by 2035. These realities confirm the significance of the finding about the relationship between trade and waste generation in the regression analysis.

Expanding trade generally causes income growth among trading parties. However, this way of obtaining income growth also causes environmental damage, with almost all the damage in Africa currently not accounted for. Trade partners may benefit from trade by specializing in goods they produce with the greatest efficiency. However, the comparative advantage theory does not consider the environmental externalities that occur through goods extraction, processing, and consumption (Harris & Roach, 2018). Thus, as AfCFTA embarks on its expanded trade agenda, it will affect Africa's welfare from import trade in machinery, as depicted in Figure 3.

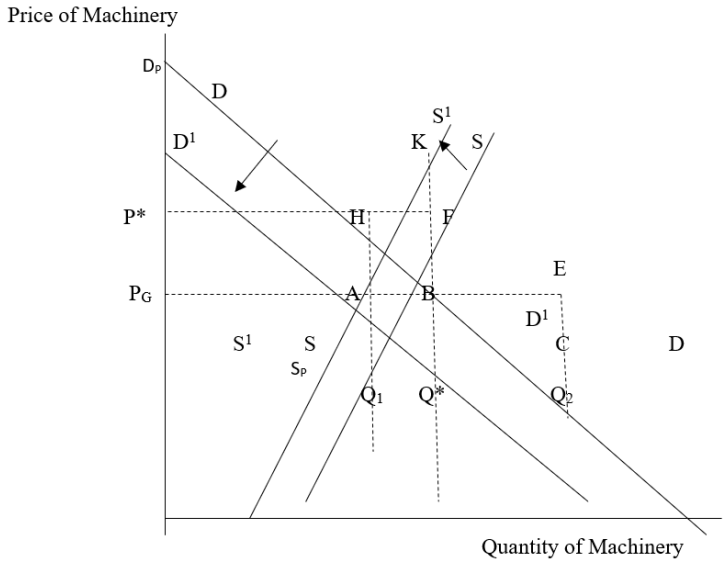

Figure 3. Effect of expanded trade in machinery on Africa

Figure 3 depicts the current equilibrium quantity and price for African machinery production and consumption before the commencement of AfCFTA trading as Q* and P*, respectively. Also, DD and SS represent the demand and supply of machinery, respectively.

AfCFTA trading will change the equilibrium through cheaper machinery exported to Africa from the developed world at price P_G. The perfect elasticity of machinery supply to Africa at price P_G will reduce demand for African machinery from Q* to Q_1. However, due to the cheaper machinery imports, Q_2 machinery will be bought. Table 4 shows the total surplus computation for the trade in the machinery due to AfCFTA, based on Figure 3.

Table 4. Total surplus estimation before and due to AfCFTA trade expansion

Trade activity	Consumer surplus (Area)	Producer surplus (Area)
Before AfCFTA	P^*FD_P	P^*FAS_P
Due to AfCFTA	P_GEFD_P	P_GAS_P
Total surplus gain/loss	+ P^*P_GEF	- P^*P_GAF

Source: Based on figure 3

The total surplus = Consumer surplus + Producer surplus
= Area P^*P_GEF - Area P^*P_G AF
= Area AEF

Thus, the total welfare effect of expanded trade with no consideration of the externalities of AfCFTA will be a positive area AEF. This is the gain reported by the World Bank and African Union computations so far about AfCFTA. However, that is not the real state of affairs due to expanded trade externalities. The only condition under which AEF will remain the total welfare is when externalities are equated to zero, the current assumption in most of Africa.

The damage caused by the deposits of unusable machinery and their parts, electrical parts and components, petroleum products used in the machinery and their residues, plastics, wood, cardboard used for packaging, and other consumables included with these products are some examples of externalities. All these are deposited within the African environment and affect land, water bodies, air quality, human health, and welfare.

To recognize the effect of externalities from trade expansion, it is worthy of note that the production externality will shift the supply curve to S^1, while the consumption externality shifts the demand curve to D^1. This makes the welfare effects of AfCFTA area AFKH for production and supply externality and area BCEF for demand and use of machinery externality. The decrease in African machinery output means area AFKH environmental externality will not be borne directly by AfCFTA. However, because Africa's external trade partners will bear this external cost, the cost will be charged to AfCFTA through imported machinery prices due to Africa's inelastic demand for such imports.

The cost of environmental damage to Africa for increased machinery purchases due to price P_G is area BCEF. Since current trade rules do not recognize environmental externalities, the real full cost of damage to the environment through machinery trade, area AFKH and area BCEF will be borne by Africa. This cost of environmental damage is far greater than the gain from trade, area AEF. Thus, the import trade in machinery, equipment, and vehicles group end in a net welfare loss in Africa for AfCFTA trade. Therefore, the trade in large manufactured goods under AfCFTA will not promote sustainable development for Africa in its current form.

5.2.2. Solid waste management

Africa's gross national income represents its total output over one year in monetary value. This output, worth US$3.4 trillion, covers all the productive activities of the 1.3 billion people in Africa. Of this value, an average of 48.1% comes from trade, as shown in the descriptive statistics of the data analyzed. By 2014, Africa's solid waste generation was 0.65kg per person per day, making 273.75kg per person per annum. Total solid waste

generation for Africa thus stands at 308.425 million tonnes per annum.

This means that for the 1.3 billion people in Africa, the total solid waste generation from trade comes to about 170.86 million tonnes per annum. According to the World Bank (2020b), solid waste management based on African treatment systems costs US$75 per tonne. This means the cost of treating solid waste generated through trade in Africa would be US$12.82 billion annually. If this cost remains the same between 2021 and 2035, the cost of solid waste management for expanded trade in Africa will be US$192.22 billion. Based on the World Bank's projection of 7% output growth by 2035, an additional US$13.46 billion would be required for solid waste management, giving a total of US$205.68 billion. This represents 45.7% of the projected AfCFTA benefits of US$450 billion by 2035.

5.2.3. Deforestation

The regression results show that deforestation is a statistically significant determinant of African waste generation. It indicates that one unit change in deforestation as a percentage of GNI will result in additional 273572.9 tons of solid waste per annum in Africa. The World Bank (2020) has projected that the highest export increase from AfCFTA by 2035 will be in natural resources, with timber being one of the most prominent. However, Africa's timber trade is characterized by high deforestation externalities. The associated effects on the natural environment are the degradation and loss of watershed resources, loss of soil fertility, waste, depletion of carbon sinks, loss of biodiversity and several ecological costs and their related adverse implications for current and future generations.

To account for the deforestation, the FAO (2012) estimated an additional cost of US$8.1- 16.2 billion per annum to prevent 75% of Africa's current deforestation. Therefore, if reducing deforestation to 25% is acceptable for Africa per annum, about US$182.25 billion on average would be needed from 2021 to 2035. Thus, the cost of required deforestation avoidance with respect to trade would be about US$87.66 billion. This constitutes about 19.5% of the projected gains from AfCFTA for 2021 to 2035. Since Africa does not yet recognize damage to its environment for harvesting its natural resources for export, this cost appears to have eluded considerations in computing the net gains from AfCFTA.

5.2.4. Cost of climate change adaptation

The fact that damage due to carbon dioxide emissions constitutes 1.84% of gross national incomes in Africa, as shown in the analysis, makes it

an issue for discussion since the cost of damage is substantial. The fact that the damage was not a significant determinant of solid waste generation does not make a discussion of it irrelevant since, from climate science, it is clear that the effect works more through gaseous emissions than solid waste generation. The scientific explanation is that carbon dioxide (gaseous) is responsible for 60% of climate change, while methane (derived from solid waste decomposition) contributes 30% to climate change. Thus, the cost of carbon dioxide damage becomes relevant to climate change from an adaptation science perspective.

Climate change is a global externality, and this analyzes climate change adaptation as a welfare issue. In its assessment, the Pan African Climate Justice Alliance (PACJA) found that addressing Africa's adaptation needs for climate change will cost the continent at least US$20 billion annually from 2030-2035 (PACJA, 2019).

From the WDI data analyzed, the mean annual climate change damage of 1.84% of GNI amounts to US$62.56 billion per annum. The trade component based on trade contributes 48.1% of GNI to US$30.1 billion per annum. Thus from 2021 to 2035, the carbon dioxide damage cost due to African trade is US$451.37 billion. It is worth noting that the cost of carbon dioxide damage to the African economy through trade exceeds the projected gains from AfCFTA from 2021 to 2035. Specifically, the Cost is US$1.37 billion more than the entire projected gains for the period. This means that with respect to only the cost of carbon dioxide damage, AfCFTA will generate a net loss of US$1.37 billion. The extent of climate change adaptation needed to offset the carbon dioxide damage of AfCFTA will have to be at least equal to the damage caused to achieve sustainability. This means AfCFTA will require at least US$451.37 billion for climate change adaptation to ensure that the welfare of Africans is not reduced through its activities.

5.2.5. Net benefits analysis

According to the World Bank (2020a), if full implementation of AfCFTA is achieved, gains to Africa will be US$450 billion by 2035. However, the World Bank (2020a) speculates that its estimates could be wrong.

This study finds that by 2035, the cost of solid waste management due to expanded trade through AfCFTA will be US$205.68 billion, while the cost of required deforestation avoidance due to expanded trade will be US$87.66 billion. In addition, the cost of climate change adaptation required would be US$451.37 billion. These costs add up to US$744.71 billion, which is US$294.71 billion more than the projected gains. This means AfCFTA will

impose a net welfare loss of US$294.71 billion on Africa by 2035 if implemented in its current form.

5.3. Can Africa learn from the North American Free Trade Agreement (NAFTA)?

AfCFTA has a lot to learn from the North American Free Trade Agreement (NAFTA), which has been operational since the 1990s. Trading doubled among the countries involved in NAFTA; consequently, Mexico replaced Japan as the next largest trading country with the USA after Canada. However, after the commencement of trade, the USA experienced an annual trade deficit of US$16 billion, a reversal of the USA's trade situation before NAFTA. The Economic Policy Institute reported a job loss of 394,000 in the USA manufacturing sector after NAFTA commenced, even though NAFTA was expected to boost jobs by 200,000 (Starkey, 2006).

While Mexico gained more than 500,000 jobs in manufacturing, opening up its farm industry to efficient and often subsidized producers from the USA led to the loss of more jobs on Mexico's farms than the gains it made in manufacturing. Mexico experienced growth in productivity from foreign investment, but this did not translate into better wages because of high growth in population, high unemployment, and labour union ineffectiveness. NAFTA resulted in some gains for both the USA and Mexican. However, these benefits were offset by what millions of citizens of both the USA and Mexico lost.

Due to most of the unexpected and undesirable outcomes of NAFTA, the USA recommended some amendments, resulting in a new agreement named U.S.-Mexico-Canada Agreement (USMCA). However, the renegotiated agreement needed more provisions for the natural environment.

The NAFTA agreement resulted in the movement of some firms with excessive pollutant emissions to Mexico and similar areas where environmental restrictions were weaker than what prevailed in the USA. After production, however, these firms exported their final products to the USA (Chernichiwan, 2017). One major failure of the USMCA was its need to recognize climate change, even though the WTO and United Nations Organization had sufficiently documented that trade expansion agreements have been responsible for higher global emissions of carbon dioxide (WTO-UNEP, 2009).

Even though NAFTA tolerated some mechanisms to safeguard controls on the environment domestically, these measures were not enough to prevent substantial damage to the environment. This means the integration hoped for between expanded trade and its environmental damage has yet to

materialize. Also, several breaches of the environment have been associated with NAFTA, whose adverse consequences have seriously undermined a safe environment within the region (Allen, 2018). Polaski et al. (2020) found that NAFTA's concessions could not deliver their expected checks against environmental damage.

Thus, the lessons from NAFTA are clear for Africa. The pollution of Africa's natural environment is sure to occur with the operation of AfCFTA. To find a way out, very well-structured systems to avert welfare reduction due to environmental externalities must be put in place and enabled to operate efficiently before, not after, the commencement of trading.

5.4. The Business-as-usual approach to net welfare loss

While the current value assigned to environmental damage in Africa is zero, environmental resource revenues are estimated to be US$ 125 trillion per annum globally (Grooten & Almond, 2018). This practice assumes that externalities do not exist, or if they do, they do not cause any damage in Africa. However, ignoring the effect of damage cannot make the damage nonexistent.

This leads to welfare loss for many African communities due to the damage caused by overlooked externalities, particularly where there is high dependence on the natural environment for sustenance. In the same way, ignoring the net welfare loss of US$294.71 due to AfCFTA will not wish away the loss, which will undoubtedly manifest itself in several undesirable forms in Africa to the detriment of the poor and vulnerable.

5.5. Africa's e-waste imports

The vacuum created by the absence of a comprehensive, well-structured, and functional environmental policy creates the avenue for an unprecedented flow of e-waste imports into the African continent due to expanded trade.

In addition to the net loss incurred from AfCFTA, the documented cases of movement of pollution from developed countries to developing ones pose a severe threat to expanded trade without functioning environmental regulations for trade in Africa.

Globally, e-waste pollution has increased (Kiddee, Naidu, & Wong, 2013). Even though exporting hazardous waste is prohibited by the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, some major e-waste-producing countries still need to ratify the agreement and therefore defy it. Some countries which have not

ratified the convention are Australia, Brazil, Canada, India, Japan, New Zealand, South Korea, Russia, and the United States of America (Ngounou, 2020).

Also, the Libreville Declaration, the Bamako Convention, and the Durban Declaration (Lundgren, 2012) have been saddled with some legal limitations to the extent that it becomes too easy for mislabeled exports to be accepted (Amoyaw-Osei et al., 2011; Daum et al., 2017). Table 5 provides substantial evidence of the extent to which e-waste imports into Africa have continued.

Table 5. Importation of pollution from developed countries by developing countries

Quantity of waste	Origin	Destination	Reference (Sources)
80% of e-waste outputs in developed countries	Developed countries	Developing countries	Lundgren (2012) (ILO)
2,500 tonnes of e-waste	Spain	Nigeria and seven other African countries	Ngounou (2020)
138 illegal shipments of hazardous waste between 2008 and 2019	Spain	Benin, Gambia, Ghana, Guinea Conakry, Nigeria, Senegal, Sierra Leone and Togo	Ngounou (2020)
Shipments of e-waste to avoid exceeding the waste quota in the EU	European Union (EU)	Ghana	Europol (2011)
16,900 tonnes of e-waste in 2015 and 2016, 77% of which was from the EU	European Union - Germany (20%), the UK (19.5%), Belgium (9.4%) and the Netherlands (8.2%)	Nigeria	EPA (USA) and Ngounou (2020)
171,000 metric tons of e-waste per annum	Developed countries	Ghana	Amnesty Int. (2011)

The implication is that with expanded trade, more of Africa's clean environments will get polluted with e-waste. The disposal of these imports of e-waste in Africa's environment causes extensive environmental pollution, depriving residents of these areas of decent and healthy living conditions (Frazzoli et al., 2011; Weber et al., 2013). Due to heavy tropical rains, sites contaminated by e-waste easily spread the contamination through rainwater flowing from these sites into nearby farmlands and water bodies.

The consequences of the pollution on the livelihoods of the many Africans who depend on land and water resources can be devastating. This ultimately results in limited development due to the scarcity of good land, air, and water resources for agriculture, housing, and general well-being. In sub-Saharan Africa, e-waste dump sites are occupied by several people who provide various services to workers in these sites. This makes the effects of e-waste exposure widespread, affecting large communities daily (Long et al.,

1995). In Ghana, about 1200 deaths occur yearly through exposure to lead alone, while about 7,200 die prematurely from air pollution complications yearly (World Bank, 2020b).

6. Conclusion and policy implications

African trade expansion through AfCFTA has prospects of success in reducing poverty and improving economic welfare. However, the absence of a well-structured and functioning regulatory environmental framework tends to deny Africa the benefits and even exacerbate deprivation on the continent. The challenges to a sound and functioning arrangement to make AfCFTA sustainable are enormous. They cut across institutional factors, technical capacity, data requirements as well as the adoption of the strong sustainability paradigm.

The study found that expanded trade would create environmental setbacks, requiring substantial resources to manage, resulting in a net welfare loss of US$294.71 billion to Africa by 2035. AfCFTA will need to implement appropriate and functioning environmental policies and measures before starting trade expansion to avert this loss. Actions like border regulations and denial of entry for products that compromise the environment can be applied to reduce environmental damage costs.

Even though existing international trade arrangements have inefficient structures for environmental damage mitigation, AfCFTA trade can set an excellent example for correcting this global anomaly. Getting trade rules to internalize environmental externalities of expanded trade will be the first needed assurance of welfare improvement under AfCFTA. The absence of such an arrangement will compromise the welfare of about 70% of Africa's inhabitants.

The extent of the influence of deforestation on Africa's environmental damage shows that AfCFTA should avoid any trade expansion activity that will increase deforestation in Africa since such activity will devastate the welfare of Africans.

Also, the adverse effect of carbon dioxide emissions damage on expanded African trade suggests that AfCFTA will have to ensure a speedy energy transition away from fossil fuels. Thus, AfCFTA must give priority and incentives to investments in renewable energy. Such a move will contribute positively to the requirements for reducing the costs of adaptation to climate change for human welfare improvement.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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