



Fintech's role in addressing climate change: insights from the COP28 global stocktake

Ujunwa Angela Nwigwe¹ · Justice Gyimah¹ · Joshua Kojo Bonzo¹  · Jizu Li¹

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Abstract

Many recommendations were highlighted during the COP28 as ways of mitigating global warming. In this respect, this research aims to examine the impact of Fintech on carbon emissions in West Africa. The data for the study ranges from 2000 to 2021. The study used Driscoll and Kraay's Panel Corrected Standard Error estimation. Insights derived from the study point towards the fact that fintech significantly influences carbon emissions. The finding aligns well with the pollution haven hypothesis, given that globalization is seen to promote carbon emissions. In addition, urbanization deteriorates the quality of environmental conditions. However, economic and population growth does not affect carbon emissions. According to the results, it is recommended that firms and households are to be educated and motivated to use green technologies.

Keywords Globalization · Carbon emissions · Population growth · Urbanization · Economic growth

1 Introduction

The international community endeavor to mitigate the impacts of global warming has been leading the way in policy and innovation dialogues, especially as the world prepares for the consequences of the COP28 Stocktake. The urgent need to combat global warming has propelled nations globally to implement actions to reduce the effect associated with

✉ Ujunwa Angela Nwigwe
sophiaangel229@gmail.com

✉ Joshua Kojo Bonzo
bonzokojo@gmail.com

Justice Gyimah
gyimahjustice@gmail.com

Jizu Li
lijizu@tyut.edu.cn

¹ College of Economics and Management, Taiyuan University of Technology, Taiyuan 030024, China

climate change. The renowned United Nations Climate Change Conference, recognized for its significant role in shaping global climate policy, is critical for assessing how the specified how the Paris Agreement goals are being realized and subsequent accords. About combating climate change has been pursued during the number of Conferences of the Parties (COPs) under the United Nations Framework Convention on Climate Change (UNFCCC), with COP28 representing a pivotal moment to assess advancements and chart forthcoming paths. The first Global Stocktake, concluded in December 2023 by the UN Climate Change Conference (COP28), and has become significant with respect to the international climate change fight. This comprehensive assessment of collective progress toward achieving the Paris Agreement goals that have set the stage for accelerated climate action in the coming years. As countries and stakeholders work to implement the decisions of the Global Stocktake, the growing importance of financial technology (fintech) in supporting climate initiatives has gained increasing attention. The process of the Global Stocktake, mandated by Article 14 of the Paris Agreement, evaluated progress in three key areas: reduction, adaptation and mechanism for implementation. The findings were stark - while some progress has been made, it can be stated that the world is not ready to reduce global warming not to surpass 1.5 °C above pre-industrial levels (Roelfsema et al., 2020). The Stocktake emphasized the urgent need for significant, lasting, and widespread reduction in greenhouse gas emissions across all sectors.

As the world converges on this pressing need to combat global warming, various sectors are being scrutinized for their potential to contribute to this international endeavor. Amidst this pivotal landscape, which the financial technology sector, or Fintech, has grown to become (Puschmann et al., 2020; Udeagha & Ngepah, 2023). Climate change and fintech are two distinct but interconnected areas that have gained increasing to attention in recent years. Fintech is the shortened form of financial technology through which it can be described as the employment of technology for the purpose of providing financial service and products (Alt et al., 2018). In contrast, climate change pertains to the enduring changes in worldwide or local climate trends, primarily caused by human activities which are emission of greenhouse gases (du Plessis & du Plessis, 2019).

As the international community continually seeks innovative solutions to address this pressing issue, the function of financial technology (Fintech) in the fight against global warming has gained increasing attention. Fintech, with its transformative potential in financial markets and transactions, has emerged as a promising tool in achieving objectives related to sustainable development goals, including reducing atmospheric pollutants (Saqib et al., 2023). Fintech, a blend of finance and technology, has also shown tremendous potential in revolutionizing the financial sector (Gomber et al., 2018). Its impact is far-reaching, extending beyond traditional banking and financial services to include innovations in payment systems, investment, insurance, and resource allocation (Murinde et al., 2022). Within the context of climate control, Fintech offers promising avenues through green finance, sustainable investing, carbon credit trading, and enhanced efficiency in resource allocation (Puschmann et al., 2020; Tamasiga et al., 2022). One of financial technology's most notable contributions to combating climate change contributes to achieving the purpose of building a carbon-reduced economy (Tamasiga et al., 2022; Zeng et al., 2024). Green finance, which encompasses investment in energy efficiency, renewable energy and other environmental sustainability projects, has seen a surge in interest facilitated by fintech platforms. These platforms enable investors to direct capital toward climate-friendly initiatives, bypassing

traditional barriers like uneven access to information and transaction costs (Bin Amin et al., 2022). Blockchain technology, another critical component of many Fintech applications, presents novel opportunities for tracking carbon emissions and ensuring transparency in environmental projects.

Globalization, defined by the increasingly integrated movement of commodities, finances, and data across international boundaries, shapes patterns of production, consumption, and emissions on a global scale (Bu et al., 2017). While globalization has facilitated economic growth and technological advancement, it has also played part in hastening the release of greenhouse gas emissions through activities such as international trade, industrialization, and deforestation (Raihan et al., 2022). Globalization has implications for climate governance and cooperation as nations grapple with shared challenges and divergent interests in addressing climate change. Transnational agreements and mechanisms, such as the Paris Agreement and carbon pricing schemes, reflect efforts to foster collective action and equitable burden-sharing in reducing emissions. However, globalization also challenges climate governance, including sovereignty, equity, and accountability issues in implementing climate policies (Jang et al., 2016).

As the world prepares to assess progress and ramp up ambitions at COP28, recognizing the full capacity of real changes in the world of fintech is crucial in increasing shift to a reduced-carbon, climate-smart economy. However, realizing this potential requires concerted efforts from policymakers, regulators, financial institutions, technology developers, and civil society stakeholders to create favorable conditions for the development of fintech that, at the same time, would align with sustainable development objectives (Arner et al., 2022). This paper explores an innovative intersection of Fintech and climate action, evaluating how Fintech initiatives contribute to the overarching goals of COP28, particularly in mitigating global warming through globalization, population, and economic growth. This research paper adds to the increasing evidence base regarding the impact of fintech on mitigating global warming, providing insights and recommendations for policymakers and practitioners alike to harness fintech's potential for climate action. By analyzing data from various Fintech applications and their effect on the sustainability of the environment, this research enhances a comprehensive appreciation of how digital finance can help speed up a shift to the low-carbon economy. The study explores the nexus of fintech, globalization, climate control, population, and economic growth, addressing two fundamental research questions: Can fintech help in climate control? And how relevant globalization is in climate control. This will provide an understanding of how Fintech can facilitate the shift to a carbon-neutral economy, thus contributing to climate control efforts.

The study employed Driscoll and Kraay's approach to calculating the Panel Corrected Standard Error. Due to the vulnerability of panel data to cross-section dependency, slope homogeneity, and multicollinearity, there is a need for a model with the potential and capabilities to check these not to affect the outcome of the analysis. The model employed can address this issue and present unbiased results. The Hausman test came out significant, indicating the use of the outcome from the Fixed Effect estimation for the analysis.

2 Literature Review

2.1 Fintech and global warming (CO₂ emissions)

Fintech's growing and flourishing field has been identified as a potential catalyst for reducing global carbon emissions, primarily by promoting green finance and sustainable investment practices (Saqib et al., 2023). The connection between financial technology (Fintech) and environmental sustainability, particularly in global warming and carbon emissions, has become a burgeoning field of interest among researchers, policymakers, and industry practitioners. Green finance, facilitated by Fintech, plays a critical role in sourcing resources for sustainable development projects, including those aimed at reducing carbon emissions (Saqib et al., 2023; Yang et al., 2021). Fintech's potential to contribute to reducing global carbon emissions has sparked a diverse range of studies exploring its effectiveness, challenges, and opportunities. The Studies by Muhammad et al. (2022) highlight fintech functions in facilitating investments in projects involving renewable energy and energy-efficient technologies, thus contributing towards reducing carbon footprints across industries. Liu et al. (2022) also posit that Fintech innovations, such as crowdfunding platforms and green bonds, have significantly increased allocating funds towards renewable energy projects and energy-saving technologies. Similarly, Vikas et al. (2022) discuss how Fintech enables smaller investors to participate in green finance, democratizing access to sustainable investment opportunities. These studies raise the question of the transformative power of Fintech as a gateway of closing the funding gap for climate mitigation and adaptation projects, thereby contributing to reducing carbon emissions.

Blockchain technology, a cornerstone of many Fintech applications, offers transformative potential for enhancing carbon trading mechanisms. Blockchain technology has also been lauded for its ability to improve transparency and accountability in carbon credit transactions, which can encourage more entities to participate in carbon trading markets (Tillemann et al., 2019). Furthermore, digital payment systems and online banking have been indicated they decrease the use of infrastructure and transportation resulting to minimal carbon emissions (Cruz & Sarmiento, 2020; Kwilinski et al., 2023). The nature of decentralizing blockchain also facilitates tracking of carbon emissions and verifying carbon offset projects. While Fintech is lauded for its role in promoting sustainability, the energy requirements of data centres, blockchain networks, and digital transactions have prompted scrutiny. The energy consumption associated with some digital financial technologies, especially cryptocurrencies, poses a significant challenge to their environmental sustainability (Corbet & Yarovaya, 2020). Xiao et al. (2023) explain in detail, the carbon footprint of the Bitcoin mining process, revealing significant environmental impacts. Conversely, Nath et al. (2014) argue that digital payment systems and online banking can reduce the carbon footprint compared to traditional banking by diminishing the need for physical infrastructure and transportation. This dichotomy illustrates the complex relationship between Fintech and global warming perspective, and the reliance of the digital technologies in Fintech on sustainable energy sources.

2.2 Globalization and global warming (CO₂ emissions)

The nexus between globalization and global warming represents a critical inquiry within environmental economics and international policy. Globalization is characterized by the growing interdependence among nations facilitated by trade, investment, and technology transfer and it has the determining influence on carbon emission and also indirect impact as well (Eweade et al., 2023). The relationship between globalization and global warming presents a multifaceted dynamic. While globalization has facilitated the rapid diffusion of green technologies and environmental best practices, contributing to more efficient use of resources and reduced carbon emissions (Gallagher, 2014), it also demonstrates how connected our planet is and that the effect of greenhouse gas emissions extends beyond regions that heavily emit them (Adnan et al., 2024a). One of the pivotal arguments favouring globalization is its ability to facilitate the transfer and diffusion of green technology. Numerous studies assert that economic integration allows for the rapid spread of energy-efficient and low-emission technologies across borders. A notable contribution by Popp (2011) postulates that increased trade leads to environmental improvements through the adoption of cleaner technologies, a phenomenon often referred to as the “technological effect.” This perspective is supported by Ahmed et al. (2022), who assert that globalization, mainly through trade agreements, can include environmental provisions promoting the adoption of green technologies. Alternatively, the rise in international trade and investment flows has resulted in higher production levels and greater energy consumption (Qamruzzaman & Jianguo, 2020). Globalization is associated with the intensification of production and energy use primarily due to the scaling effect, leading to increased carbon emissions. Rafindadi et al. (2023) describe how the economic growth spurred by globalization which frequently results in increased industrial and, therefore, the rise in energy consumption resources, particularly in less developed countries with less rigorous environmental regulations. This shift in manufacturing to developing countries, where environmental laws may be less stringent, can also be a concern. According to Rasli et al. (2018), who highlight that globalization leads to a “race to the bottom” within environmental regulations, exacerbating carbon emissions.

However, some scholars argue that globalization, through economic integration and cooperation, provides a unique opportunity to address climate change globally (Hettne & Söderbaum, 2006; Nahm, 2021; Ruggie, 2003). The role of global environmental agreements and regulatory frameworks in reducing the negative impacts of globalization on CO₂ emissions is thus critical in addressing global climate issues. The study by Harris (2007) has also underscored the significance of collaborating internationally and legally binding agreements to address the collective action problems presented by global warming. The Kyoto Protocol and the Paris Agreement are noted as a prime example of attempts to globalize the response to climate change, albeit with mixed success and participation levels. Consequently, research grounded on data collected based on the link between globalization and CO₂ emissions thus provide a mixed result. A seminal paper by Xia et al. (2022) also examines the link between globalization and CO₂ emissions across different countries, revealing a complex interaction that can differ greatly depending on the given stage of the country's development and its economic structure. Recent studies by (Asongu et al., 2020; Wang et al., 2022), employ econometric analyses to demonstrate that there is conditional relationship between globalization and CO₂ emissions meaning that globalization has the

potential to affect carbon emissions, while certain forms of integration are capable of influencing such emissions.

2.3 Economic growth and global warming (CO₂ emissions)

The correlation between economic growth and global warming, with a particular focus on carbon emissions, has been extensively explored within environmental economics. As concerns about climate change have grown, economists and policymakers have sought to understand how economic development impacts greenhouse gas emissions and global temperatures, as well as how climate change may affect future economic growth. The primary question of debate concerns whether development pushes up the emissions of carbon and, by extension, global warming. The reverse of this has been confirmed in many studies where natural desasters due to global warming have caused damages to economics in different part of the world (Adnan et al., 2024b; Cappelli et al., 2021). Traditionally, economic growth was seen as antithetical to environmental sustainability, based on the assumption that higher income levels would invariably lead to increased consumption and production, thereby elevating carbon emissions. This perspective is rooted in the early work of classical economists, who posited that industrial activity was the primary driver of economic development (Opoku & Yan, 2019; Rocha, 2018). The traditional economic growth model, heavily reliant on fossil fuel consumption, is a significant driver of global warming. Many studies have pointed out the direct relationship between GDP growth and increased carbon emissions, suggesting that without substantial changes in energy production and consumption patterns, economic growth will continue to exacerbate global warming (Acaravci & Ozturk, 2010; Choudhury et al., 2023; Narayan et al., 2016). An analysis of 27 EU member states from 2000 to 2017 found that on average, for every 1% increase in GDP, approximately 0.072% increase in CO₂ emissions was emitted (Onofrei et al., 2022). However, the concept of “decoupling” economy expansion through carbon emissions has gained traction, with evidence of some economies maintaining growth while controlling emissions through technological innovation and policy measures (Azam et al., 2022; Dauda et al., 2019). The shift to a reduced-carbon economy is important for sustainable economic growth, with direct investments towards renewable energy and improving energy efficiency at the forefront (Fankhauser & Jotzo, 2018; Foxon, 2011). Recent research has highlighted the long-lasting economic effect changes in climate with evidence of climate impacts on economic growth persisting for up to 8–10 years for temperature effects and up to 4 years for precipitation effects (Adnan et al., 2024b; Kotz et al., 2024).

Empirical research has also provided mixed results about this relationship of economic growth and emissions. The literature has introduced the concept the Environmental Kuznets Curve (EKC) hypothesis, which posits that pollution levels increase as an economy develops but later decrease when it reaches a certain point (Leal & Marques, 2022; Özokcu & Özdemir, 2017), suggesting that at low levels of GDP, emissions rise, but they decline once a certain level of income is achieved in the process. The EKC hypothesis has been central to economic expansion and carbon emissions discourse. Bibi and Jamil (2021) provide a comprehensive review of the EKC, examining the conditions under which it holds. The findings indicate that while some countries show evidence supporting the EKC, others do not, implying that economic growth can lead to reduced emissions only under specific circumstances, such as solid environmental regulations and technological advancements.

The identification of technological innovation as a crucial element has been acknowledged as a factor that can decouple economic growth driven by carbon emissions. A stream of literature emphasizes the significance of green technologies and energy efficiency in reducing the carbon intensity of economic growth (Jiao et al., 2020; Rehman Khan et al., 2023). In this manner, Zhou et al. (2020) argue for directed technological change toward cleaner technologies for a more sustainable economic growth. Leal et al. (2019) investigate this relationship in the context of Australia and find that decoupling economic growth from carbon emissions is achievable with targeted policy interventions. In contrast, a study focusing on China by Zhang et al. (2014) suggests that emissions to a large extent, can be directly linked to economic development, highlighting rapidly industrializing economies' challenges. The correlation between economic growth and global warming is complex and contingent upon many factors, including technological innovation, policy frameworks, and country-specific circumstances. While the EKC offers a hopeful perspective that economic development can eventually lead to environmental improvement, it is not a guaranteed outcome. Sustainable economic growth requires deliberate policy choices and investment in green technologies to ensure that increases in GDP do not come at the cost of increased carbon emissions and global warming.

2.4 Population growth and global warming (Carbon Emissions)

The interconnection between population growth and global warming is another subject that has garnered considerable attention within the environmental sciences and policy-making arenas. The central question revolves around how and to what extent population growth contributes to global warming, primarily through the lens of carbon emissions. The most direct connection with climate change will be population growth exacerbating global warming through increased energy demand, greater land use or land use changes that alter the hydrological system (Adnan et al., 2024b; Zeren Cetin et al., 2023), and higher waste generation, leading to elevated carbon emissions. The studies by Malthus (1986) initially posited the negative environmental impacts of unchecked population growth. This theory has evolved to emphasize the role of consumption patterns and technology in mediating these effects. Recent research underscores a rising trend in carbon emissions resulting from population growth especially in the developing nations mainly because of rapid urbanization, and rising rate in energy and transportation (Anser et al., 2020; Sarkodie et al., 2020; Sikder et al., 2022). Indeed, GHG CO₂ stem from the demand for products and services, some of which are not apportioned fairly across nations, persons, regions or other localized geographical areas within nations. Population growth is still high in many countries, especially those in Africa and the latter accounts for a significantly lower percentage of global GHG emissions as well (Lamb et al., 2021). The largest population increases occur in developing countries, which often have lower per capita emissions but are experiencing rapid economic growth. However, strategies such as improving energy efficiency, advocating for sustainable consumption, and allocating resources towards renewable energy could help reduce the effects of the growth of population on the environment. Without a doubt, human has a substantial effect on the environment; this is reflected in the connection between human population, resource consumption, and the impact on ecosystems, which treats environmental impact as equal to the production of population, affluence and technology ($\text{Impact} = \text{Population} \times \text{Affluence} \times \text{Technology}$) (Liddle, 2013; Pham et al., 2020).

Empirical research has endeavored to the effects of increase in population on the emission of carbon. Ghanem (2018) offers a comprehensive analysis, demonstrating that population growth yields a multiplicative effect on emissions due to increased energy usage and resource use. Madlener and Sunak (2011) also illustrate that as populations grow, so does the energy demand, particularly in developing countries undergoing rapid industrialization and urbanization. This increased energy demand typically relies on carbon-intensive fossil fuels, thus exacerbating global warming. Conversely, Zhou and Liu (2016) suggest that the effect of population on CO₂ emissions diminishes when controlling the level of urbanization and per capita income is taken into account, indicating that other socio-economic factors may mediate this relationship. Urbanization, often a byproduct of population growth, has significant implications for carbon emissions. Settlement patterns, transportation, and the rapid increase of economic activities in urban areas are essential determinants of a region's carbon footprint. Ponce de Leon Barido and Marshall (2014) explore how urbanization can lead to both increased and decreased emissions, depending on factors such as infrastructure, density, and public policy. On the other hand, even though population increase is known to lead to enhanced emission of greenhouse gases, such a relationship is not direct or proportional. Factors such as consumption patterns, technological advancements, and economic development play significant roles. The literature suggests that addressing climate change requires a multifaceted approach focusing on sustainable development, energy efficiency, and empowerment of women and girls, rather than solely on population control measures (Chancel, 2022).

2.5 Integration of fintech in recent COPs

The use of financial technology (fintech) to address climate change has been an emerging topic at recent United Nations Climate Change Conferences (COPs). While not always a central focus, fintech has been increasingly recognized as a potential tool to mobilize climate finance and support mitigation and adaptation efforts (Mhlanga, 2022). Prior to COP26 in 2021, discussions of fintech at COPs were limited. The topic was occasionally mentioned in side events or informal discussions but did not feature prominently in official negotiations or outcomes. COP26 in Glasgow marked a turning point, with fintech receiving more attention as a potential climate solution. The conference saw the launch of the Glasgow Financial Alliance for Net Zero (GFANZ), which seeks to drive change in the transition to a net-zero economy (Jennifer et al., 2021; Sintang, 2024). While not exclusively focused on fintech, GFANZ highlighted the role of financial innovation contributed to the climate change issue. The COP26 decision text called for “making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development” (Jennifer et al., 2021). This broad language opened the door for increased consideration of fintech solutions. At COP27 in 2022, fintech played a more visible role. The conference featured discussions on using blockchain and cryptocurrencies to enhance climate finance transparency and efficiency (Tiwari et al., 2024; UN Environmental Programme, 2022). There was also increased focus on fintech's potential to enhance climate finance means for developing countries. The COP27 cover decision emphasized the need to “significantly enhance support for developing countries to build resilience to the impacts of climate change” (UN Environmental Program, 2022). While not explicitly mentioning fintech, this language supported the exploration of innovative financial tools.

COP28 in 2023 saw fintech firmly established as a key tool in climate finance. The conference featured multiple sessions and initiatives focused on leveraging fintech for climate action (UN Climate Change, 2023a). The launch of the Net-Zero Export Credit Agencies Alliance at COP28 highlighted the growing role of fintech in aligning financial flows with climate goals (Karazhanova et al., 2024; UN Environmental Programme, 2023). This alliance aims to use innovative financial instruments to facilitate the shift in energy system towards the low carbon economy. The COP28 decision text called for “accelerating the mobilization and deployment of climate finance from all sources” (UN Climate Change, 2023a). This language explicitly supports the use of fintech and other innovative financial tools to address climate change. COP28 Finance Day in 2023 also saw several announcements related to innovative financial mechanisms including the Introduction of climate-resilient debt clauses (CRDCs) in financing from the world’s largest development banks and economies, the Commitments to increase the usage of the CRDCs by 2025 from 73 nations, (Franczak, 2024; UN Climate Change, 2023b). The UAE pledged \$200m towards assisting the low-income, vulnerable countries through the IMF Resilience and Sustainability Trust (RST) to tackle climate change. The treatment of fintech at UN Climate Change Conferences has evolved significantly over time. From limited mentions in earlier COPs, fintech has emerged as a recognized tool for mobilizing climate finance and supporting mitigation and adaptation efforts. Recent COPs have seen increased focus on concrete fintech initiatives and their potential to enhance climate finance accessibility and effectiveness. With global climate consciousness rising and the accompanying drive for change heightening, COP discussions and resultant developments will see a greater inclusion of the fintech sector’s influence. The integration of financial innovation with climate policy represents a promising avenue for accelerating the transformation to a low-carbon, climate-resilient future.

3 Methodology

The literature has explored the relationship between CO₂ and various variables as a means of finding solutions to global warming. In this regard, this study aims at extending prior research by analyzing the implications of Fintech on carbon emissions in West Africa. The research applied Driscoll and Kraay method of computation of the Panel Corrected Standard Error for the estimation. Since panel data is vulnerable to cross-section dependency, slope homogeneity, and multicollinearity, a model that can check these effects is recommended to avoid biased results. The panel-corrected standard error estimation can overcome and address these problems. This puts our results in a position to reflect the actual outcome without external or internal influence. In addition, the model is capable of dealing with cross sectional heteroskedasticity that helps to provide an accurate standard error in a large panel.

Considering the econometric estimation of previous studies, the econometric equation (Eq. 1) below is used for the analysis.

$$\ln c_{it} = \chi_0 + \chi_1 \ln f_{it} + \chi_2 \ln e_{it} + \chi_3 \ln g_{it} + \chi_4 \ln p_{it} + \chi_5 \ln u_{it} + \varepsilon_{it} \quad (1)$$

As presented in the Eq. 1, $\ln c$ represents carbon emissions, $\ln f$ represents Fintech, $\ln e$ represents economic growth, $\ln g$ represents globalization, $\ln p$ represents population growth,

$\ln u$ represents urbanization, and ε represents error term. The coefficients are represented in the equation as χ_0 – χ_5 , and it represent time.

3.1 Data description

The study data were derived from the World Development Indicators. As a result of data availability, the data spans from 2000 to 2021. This data covers 16 countries in West African. The study aims to investigate how fintech impacts carbon emissions in West Africa. Carbon emission is the dependent variable, and this is measured in kilotons. The independent variable is globalization, measured with two proxies emulating Gyimah and Yao's study. The proxies are trade openness measured in total exports and imports and the measurement of foreign direct investment in the total percentage of GDP net inflows. Economic growth is measured in (GDP) per capita. Population growth is expressed as a proportion of the total population. Urbanization is quantified in terms of the overall share of the people living in urban regions. Lastly, Fintech is measured with three proxies. The first proxy is the mobile cellular subscription, measured as “subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes (and is split into) the number of postpaid subscriptions and active prepaid accounts (i.e., used during the last three months). The indicator applies to all mobile cellular subscriptions that offer voice communications. It excludes subscriptions via data cards or USB modems, subscriptions to public mobile data services, private trunked mobile radio, telepoint, radio paging and telemetry services.” The second proxy refers to the fixed broadband subscription measured as “fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s. This includes cable modem, DSL, fibre-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband. This total is measured irrespective of the method of payment. It excludes subscriptions that have access to data communications (including the Internet) via mobile-cellular networks. It should include fixed WiMAX and any other fixed wireless technologies. It includes both residential subscriptions and subscriptions for organizations.” The third proxy is the internet users, measured as follows: “Internet users are individuals who have used the Internet (from any location) in the last three months. The Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc.” The Fintech proxies are the emulation of Xu et al. (2023) work.

The details of the source and explanation of the variables are as shown in Table 1. The descriptive statistics are highlighted in Table 2, as described below. They include the mean, median, maximum value, minimum value and standard deviation. The results demonstrate that carbon emissions have an average of 7.6953 and a maximum of 11.691, while fintech has an average of 14.258 and a maximum of 19.220. Each of the variables is estimated

Table 1 Source of variables description

Variables		Measure	Source
Carbon emissions	$\ln c$	Kilotons	WDI
Fintech	$\ln f$	Proxies	WDI
Globalization	$\ln g$	Proxies	WDI
Economic growth	$\ln e$	GDP per capita	WDI
Population growth	$\ln p$	% of the total population	WDI
Urbanization	$\ln u$	% of the total urban population	WDI

Table 2 Descriptive statistics

	$\ln c$	$\ln f$	$\ln g$	$\ln e$	$\ln p$	$\ln u$
Mean	7.6953	14.258	3.9339	0.8619	0.9387	3.6970
Median	7.5756	14.820	4.0758	1.0364	0.9679	3.7623
Max	11.691	19.220	4.9070	2.9734	1.7553	4.1230
Mini	4.9904	-1.5945	-1.1972	-3.4204	-0.2235	2.7841
Std. Dev	1.4783	3.1757	0.7957	0.8948	0.2791	0.3249

Table 3 Correlation

	$\ln c$	$\ln f$	$\ln g$	$\ln e$	$\ln p$	$\ln u$
$\ln c$	1					
$\ln f$	0.5756	1				
$\ln g$	0.0365	0.1422	1			
$\ln e$	0.0546	0.1122	0.1975	1		
$\ln p$	0.1085	0.1443	-0.3192	-0.0644	1	
$\ln u$	0.0707	0.0925	0.1938	0.0701	-0.4762	1

Table 4 Unit root test

	Im, Pesaran and Shin		Im, Pesaran and Shin		ADF - Fisher Chi-square	
	Levels	1st difference	Levels	1st difference	Levels	1st difference
$\ln c$	-1.3741	-8.4692*	2.3841	-9.1909*	16.389	142.859*
$\ln f$	-11.398*	-5.5281*	-10.152*	-5.4679*	164.378*	96.8974*
$\ln g$	-0.5645	-5.0968*	0.0903	-7.6856*	26.713	125.097*
$\ln e$	1.9348	-4.5296*	0.1745	-4.0912*	33.9154	64.3389*
$\ln p$	-1.9594	-6.0186*	-2.0157	-7.5656*	72.5576*	131.526*
$\ln u$	-3.5771	-5.2822*	1.5951	-8.6277*	85.8231*	423.957*

* denotes 1%

in its lag form. The results of correlation estimation are shown in Table 3. The analysis findings show that all of the coefficients are positive except globalization with population growth, economic growth with population growth and urbanization, with coefficients being -0.3192 , -0.0644 , and -0.4762 , respectively.

4 Results and discussion

4.1 Unit root test estimation

Table 4 shows the results of the Unit Root Test estimation. The results are presented in levels as well as in the first difference. The outcome suggests that all variables in the model are stationary.

Table 5 Panel corrected standard error model

	POLS	Random effect	Fixed effect
$\ln f$	0.2732* (10.091)	0.0269* (4.1722)	0.0195* (2.9643)
$\ln g$	0.0529 (0.3863)	0.944* (2.7171)	0.0961* (2.7580)
$\ln e$	-0.0155 (-0.1734)	0.0080 (0.5061)	0.0105 (0.6641)
$\ln p$	0.7752* (2.8123)	0.0276 (0.2946)	0.0195 (0.2071)
$\ln u$	0.7938* (4.8287)	2.9308* (14.355)	3.2526* (15.220)
Hausman Test	55.495*		

* denotes 1%

4.2 The panel corrected standard error model estimation

Table 5 depicts the findings obtained from the Panel Corrected Standard Error Model Estimation. The results are presented in three sections. The first is the POLS, which is the baseline for the analysis. Since the POLS is the baseline for the central estimation, its estimation outcome cannot be accepted. The second and the third are the random and fixed effects, respectively. The Hausman test is used to choose suitable results for the two models. The rule indicates that we are to accept random effect if the Hausman test is insignificant above 5%. However, since the Hausman test is 1% significant, we take the fixed effect results for the study.

The findings show that Fintech has a positive and significant influences on carbon emissions in West Africa (0.0195*). Similar to the findings of our research, Teng and Shen (2023) study also exposed that fintech has the potential to enhance carbon efficiency dramatically. However, the research done by Cheng et al. (2023) revealed that fintech might help minimize carbon emissions. Kai et al. (2024) further revealed that fintech helps alleviate CO₂ emissions. Accepting green technology into African society must be completed, as many factors do not support the transition.

In addition, the results further reveal that globalization has a positive and significant cause of CO₂ emissions (0.0961*). This shows that the movement of people and goods from country to country, region to region, and continent to continent deteriorates the environmental quality. In support of our study, Sultana et al. (2023) unveiled that globalization increases CO₂ emissions in N-11 countries. On the contrary, the study by Nan et al. (2022) mentioned that globalization reduces carbon emissions in neighbouring countries. Still, it does not notably impact carbon emissions in local countries. FDI and trade openness serve as the variables used as the indicators of globalization. The effect of globalization (FDI and trade openness) has been explained in the literature using two hypotheses (Justice et al., 2021). In the view of Gyimah et al. (2023), FDI has been one of the critical factors for economic development in developing countries. However, measures should be implemented to check its effect on the environment. The pollution haven hypothesis confirms what has been pointed out in our study.

However, the findings show no significant relationship between economic growth and CO₂ emissions. Nonetheless, when the Environmental Kuznets Curve hypothesis was used to unravel the impact of economic development on the environment, this study showed no effect of economic growth on CO₂ emissions in West Africa. Contrary to our findings,

Gershon et al. (2024) study uncovered that economic development plays a vital role in mitigating the negative impact of energy consumption on the environment. In addition, the study of Phadkantha and Tansuchat (2023) showed that economic growth has a U-shaped relationship with carbon emissions.

Again, the study reveals no relationship between population growth and carbon emissions. Nevertheless, the literature has indicated that the population growth rate influences the energy demand level and carbon emissions from that direction. The work of Rehman and Rehman (2022) revealed that population growth is a driving force for carbon emissions in India.

The effect of urbanization on carbon emissions has been shown to be significant and positive. Urbanization is the movement of people from rural areas to the urban areas where there is formulation of more and larger cities and towns as a result of the following factor (Gyimah et al., 2024). However, when these people move to urban areas, their presence influences the energy demand. The study of Xu et al. (2024) revealed that the new urbanization policy imposes substantial constraints on carbon emissions in pilot cities. Furthermore, the policy influences urban carbon dynamics through its impact on economic growth and population urbanization. Wu et al. (2024) study revealed that new-type urbanization and total carbon emissions have a significantly positive bidirectional relationship.

5 Discussion

Fintech holds significant potential to generate positive impacts on carbon emissions and the environment through the support of green technologies alone. Studies have found that fintech can impact corporate green innovation, which is desirable for attaining environmental sustainability. For instance, Wen and Liu (2023) state that fintech has the potential to result in cooperative effort in mitigating pollution and CO₂ emissions by encouraging regional innovativeness and green ventures. Additionally, implementing blockchain in carbon accounting can improve the transparency and flow of emissions trading, which is important for regulating carbon emissions (Mandaroux et al., 2021; Pan, 2023). Moreover, global studies demonstrate that fintech's presence is linked to reduced CO₂ emissions. For instance, a study on China's fintech investment found that for every fixed point increase in fintech adoption, there was a 0.18% decrease in CO₂ levels (Zhang, 2024). This correlation underscores the vast potential of fintech to promote environmentally friendly investment among businesses and consumers. However, our findings indicated that fintech causes carbon emissions. Similarly, Destek and Manga (2021) revealed that the relationship between fintech and carbon emission is partially linear. To the extent that financialization can be seen as fueled by the progress of fintech, the former also harms the quality of the environment. Findings also show that after financialization rises by 1%, carbon emissions are estimated to have increased by 0.203–0.222%. This duality has shown that there is a possibility of implementing and regulating fintech in a way that will cause more harm than good or missing the technology's opportunity to be at the forefront of championing sustainable practices.

The world has experienced a change in carbon emissions in the course of globalization due to the facilitation of industrialization, urbanization and hence energy use, especially in the developing world such as China (Chen et al., 2020). As countries integrate into global supply chains, their reliance on carbon-intensive industries increases, leading to higher

emissions and environmental degradation (Zhang et al., 2021). Weaker environmental regulations in some regions increase this issue, allowing emissions to rise further (Wang et al., 2016). However, globalization also provides opportunities for transferring green technologies, which, if paired with effective policies, can help mitigate emissions (Bekun et al., 2019). International agreements like the Paris Agreement aim to leverage globalization to reduce emissions, but progress remains limited without strong enforcement.

Lack of adequate energy infrastructure and increased carbon dioxide emissions are generally associated with economic development, particularly in developing nations where the process of industrialization and urbanization is in advance stage. For instance, studies indicate that there is a very negative impact arising from the exposure to economic growth in relation to the environmental impact index of a country, wherein a 1% increase in the economic growth rate elevates the environmental footprint by 0.721% (Khalid et al., 2023). This is in line with other studies that embarked on an investigation of the relationship between CO₂ emissions and GDP growth, which confirmed that the Environmental Kuznets Curve (EKC) Hypothesis holds the opinion that at the initial stage, emission is proportional and even causal of economic growth before reaching a stage of decline at higher income levels (Jalil & Mahmud, 2009; Mardani et al., 2019). However, the relationship is not universally linear. Some works describe specific cases when decoupling was observed, that is, economic growth has occurred with decreased carbon emissions. For instance, Pei et al. (2021) pointed out the relationship between economic development and carbon emissions in urban clusters and admitted that some patterns of the economy could encourage reduced emissions. In the same way, while stating that sustainable economic factors have direct and inverse effects on carbon emissions, the work of Ali et al. (2022), further added that both effects vary according to the context of the economic factors that are in question as well as to the character of the economic activities. Technological advancement intervenes between growth in economic activities and carbon emissions. Some scholars have commented that technologically developed approaches could contribute to emission consequences from using more power, while others have opined that environmentally sustainable technologies can restrain these impacts (Khalid et al., 2023; Xiang et al., 20212). For example, Khalid and other researchers affirmed that technological advancement may bring positive impacts and remove environmental degradation if technological developments and the nature of their applications are well aligned (Khalid et al., 2023).

The expansion of urban areas, especially in developing countries, has been cited as a major cause of rising greenhouse gas emissions because of high energy per capita, land use changes, and transportation. For instance, Chen (2015) emphasizes that urban infrastructure choices, especially in rapidly urbanizing nations like China, are crucial in determining greenhouse gas emissions, highlighting the importance of integrating green infrastructure to mitigate these effects. This is mentioned by Elliott and Clement (2024), who discussed the dual nature of urbanization's impact, where advancements in urban planning and green technologies can potentially reduce emissions. However, the trend often increases carbon outputs. The empirical evidence suggests that urbanization correlates positively with carbon emissions, particularly in regions experiencing significant industrial growth. For example, Ayitehgiza (2020) study on Ethiopia indicates that urbanization and economic growth are directly linked to rising CO₂ emissions, with a notable increase in emissions corresponding to urban population growth. Similarly, Tarasawatpipat and Mekhum (2020) highlight that urbanization, industrialization, and population growth in ASEAN countries have collec-

tively driven up energy demand and greenhouse gas emissions. This trend is not isolated to Southeast Asia; research by Wang et al. (2015) indicate that urbanization's contribution to carbon emissions is also observable in OECD countries, albeit with varying magnitudes depending on local contexts. Conversely, some studies suggest that urbanization can have a mitigating effect on emissions under certain conditions. Šatrović (2019) provided evidence to support the hypothesis that there is an inverse relationship between urbanization and CO₂ emissions, which means that urbanization is inversely proportional to CO₂ emissions and can result in better utilization of energy and lower per capita emissions in specific contexts. This perspective is supported by findings from Gnangoin et al. (2022), argue that human capital plays a crucial role in moderating the urbanization-CO₂ emissions nexus, suggesting that better-educated populations may adopt more sustainable practices that reduce emissions.

Population growth significantly impacts carbon emissions, an extensively studied relationship across various contexts and regions. Current studies confirm that with population growth, carbon emissions are also inevitable because of higher energy demands and growth in urbanization. For example, Martínez-Zarzoso et al. (2007) identified a strong, directly positive relationship between the population count of a given European country and the CO₂ emission count of the same country, indicating that larger populations contribute to higher per capita emissions due to increased demand for energy and resources. Similarly, Jorgenson and Clark (2013) assessment of national-level emissions from 1960 to 2005 highlighted that population size is a critical factor influencing carbon emissions. However, they noted that regional and temporal variations complicate this relationship. Moreover, the global perspective on population growth reveals alarming projections, with estimates suggesting that the world population could rise from approximately 6.8 billion to 9.2 billion by 2050. This growth will exacerbate greenhouse gas emissions unless significant measures, such as family planning and sustainable resource management, are implemented (Bryant et al., 2009). Chaurasia (2020), analysis further supports this by demonstrating that population growth has significantly contributed to increased energy use and CO₂ emissions globally from 1990 to 2019, although the impact varies across different countries. The interplay between population growth and economic factors is also crucial. Clayton et al. (2017) argue that while population growth contributes to environmental stress, changes in affluence and consumption patterns often affect emissions more pronounced. Edwards (2020) states this assertion, integrating population dynamics into the Environmental Kuznets Curve, suggesting that while population growth can lead to increased CO₂ emissions, the adoption of alternative energy sources can mitigate this impact after a certain threshold.

6 Conclusion and policy implication

Many countries and organizations desire to combat global warming to ensure environmental sustainability. Green technology is recommended for businesses and households to promote the agenda. Therefore, this study seeks to investigate how fintech impacts carbon emissions in West Africa. The study employed Driscoll and Kraay's approach of calculating the Panel Corrected Standard Error for estimation. The outcome of the Hausman test was significant indicating that Fixed Effect is suitable for the study. The study's data spans from 2000 to 2021. The study findings demonstrated that fintech, globalization, and urbanization posi-

tively and significantly influence carbon emissions. The findings imply that these variables produce carbon emission and this information will be useful for policy-making, planning and decision-making processes that affect growth and development. As much as some of the country's understudies have made efforts to check carbon emissions, more still has to be accomplished. Nevertheless, the performance indices for economic and population scales do not influence carbon emissions. From the above analysis, no variable understudy had a negative or significant correlation with carbon emissions.

Based on the findings, these recommendations are formulated to address carbon emissions mitigation. Firstly, the results indicate that fintech contributes to carbon emissions. This implies that households and firms are poorly educated and motivated to use green technologies. In this regard, education should be included in the campaign against global warming to create more awareness in rural and urban areas. Firms should be provided with financial assistance to encourage them to use green technologies in their production. Secondly, the findings show that both globalization forcing and globalization pull lead to carbon emission, supporting the study's pollution haven hypothesis. Government institutions responsible for emissions control have to implement measures to ensure that foreign investors do not engage local industries in using high-emission technologies.

Despite the comprehensive nature of our study, there are still shortcomings that future studies should address to expand the scope. Future studies can incorporate additional variables to enhance the quantity, as not all factors influencing carbon emissions have been examined. Again, future studies can increase the number of countries or analyze all African regions. Due to data availability, our data for the study is from 2000 to 2021, but future studies can increase the number of years to become more updated.

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Declarations

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