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Urbanisation, climate change and structural transformation in Accra, Ghana

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Abstract

This study examines the effect of climate on citywide labour productivity in the Accra city region. We use data from Ghana's Integrated Business and Establishment Survey dataset, climate data at the sub-city level from Ghana Meteorological Agency, and satellite and reanalysis data, as well as key informant interviews with representatives of enterprises and city authorities and officials of the National Disaster Mobilisation Agency, for this exercise. The findings show that rainfall, which contributes substantially to vulnerability and risk in the city, significantly reduces labour productivity, while the effect of temperature is not significant. This is an indication of the detrimental effect of rainstorms and floods on firm productivity and the growth of high-productivity sectors in the city. The findings are essential for discussions on the new urban agenda as African cities seek to understand the impact of climate change and how to integrate climate change considerations into urban planning strategies and policies. There is an urgent need for investment in adaptation to mitigate the impacts of climate shocks, in order to create a more liveable and sustainable city to facilitate economies of scale, specialisation and thriving high-productivity sectors.

Keywords: Urbanisation, structural transformation, climate, Accra

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1. Introduction

Urbanisation is taking place at an extraordinarily fast rate in Africa. More than two-thirds of the world's fastest-growing cities are in Africa (United Nations, 2022). It is estimated that Africa will see urban growth of 3.2% by 2050, the fastest urban growth rate in the world, with the urban population projected to double from 600 million to 1.2 billion (Adesina, 2023; OECD and SWAC, 2020). However, urban poverty is rising due to the lack of inclusive growth and of the creation of productive jobs in African cities. In many African cities, the transformation of the economy to create high productivity in sectors such as manufacturing or services seems difficult to realise. In many cities, we see a shift from low-productivity agricultural activities to low-productivity, informal and unorganised economic activities in manufacturing and non-tradeable services (Danquah et al., 2024). This lack of structural transformation at the city level indicates the inability of African cities to function effectively as engines of growth, to run as hubs for inclusive and resilient growth and economic transformation for the massive urban population.

African cities face many challenges that inhibit them in facilitating economic transformation. Investment in key urban infrastructure and services such as improved connectivity, affordable public transport systems, water and waste management, and housing has not kept pace with rapid urbanisation in many cases. As a result, many cities face urbanisation-linked challenges such as growing slums, congestion, pollution and high operating costs that dampen growth. One of the new challenges which is top of the list in relation to economic transformation in African cities is climate change (Ordu, 2023). Africa loses US$7-15 billion per year due to climate change (IPCC, 2022). The Intergovernmental Panel on Climate Change (IPCC) sixth assessment report on impacts, adaptation and vulnerability in Africa indicates that this is expected to rise to $50 billion by 2040 (IPCC, 2022). Climate change and climate-related shocks have significant effects on the performance of economic activities. The greater frequency of floods, droughts and heatwaves can trigger human losses, damages to public and private assets and disruption of economic activities (World Bank, 2022a). Sea level rises pose severe challenges to coastal cities. For instance, Lagos, on the Atlantic Ocean, is for the most part barely two metres above sea level. The constant challenge of rising sea levels complicates the potential for flash flooding and makes the city vulnerable to climate change. Ultimately, climate change may make some cities unliveable or intensify risks that would lower the cities' attractiveness for investment. Climate change and climate-related shocks may therefore hamper the gathering of firms and workers in cities and urban centres to create the potential for unlocking the "miracle of productivity" and enhance living standards via economies of scale and specialisation (Collier, 2016).

While there are studies that look at the effect of climate change, broadly speaking, they have generally focused on the adverse impacts of climate on urbanisation, agriculture, peace and security, and migration, and so on (see, for example, Barrios et al., 2006; Blanc and Schlenker, 2017; Collier et al., 2008; Colmer, 2021; Dell et al., 2014; Gollin et al., 2014; Henderson et al., 2017). Most of these empirical studies are based on country or cross-country data. There is also a growing literature on the effects of climate change on financial outcomes (Aguilar-Gomez et al., 2023; Awaworyi-Churchill et al., 2023; Brown et al., 2021; Collier et al., 2020).

With regard to work on cities, studies have focused largely on understanding productivity disparities between cities within a country from the points of view of agglomeration economies and human capital externalities (see Ahlfeldt and Pietrostefani, 2019; Bosquet and Overman, 2019; Dauth and Haller, 2019; Dingel et al., 2021; Duranton, 2015; Duranton and Puga, 2004; Moretti, 2004; Rodríguez Mora et al., 2023). Empirical studies that examine the relationship between climate and labour productivity or structural transformation at the city level are lacking in Africa. This paper, therefore, aims to address the critical question of whether climate-related shocks affect labour productivity. Understanding this relationship has direct implications for the growth of high-productivity sectors and structural transformation in cities.

The study focuses on the Accra city region in Ghana. Initial studies conducted by ACRC (2023) focusing on structural transformation in six African cities show that the pattern in structural transformation at the city level in Accra is no different from that of other African cities, but there are variations in patterns at the sub-city level (Danquah et al., 2024). In Ghana, the labour productivity[1] of business establishments at city level, specifically in Accra, is generally low, but it is not homogeneous at the sub-city level. With respect to climate change, the growth and prosperity of major cities in Ghana is vulnerable to climate. The World Bank's country risk profile for Ghana shows that in the last five decades, the average annual temperature has increased by around one degree Celsius, while the average number of "hot" days and nights has also increased significantly over the years (World Bank, 2021). Rainfall has also become more erratic, while coastal erosion has increased due to rising sea levels and changing hydrodynamics along the West Africa coast (World Bank, 2021). In the Accra city region, the global surface temperature is rising over time, despite natural variability, while rainfall patterns are irregular. The negative effects of climate-related events such as floods, rising heat and frequent poor weather significantly impact economic activities in cities. Such impacts – both direct in the form of, for example, loss of assets, lives and livelihoods, and indirect as a result of greater heat and increased rainfall – may have a differential negative effect on labour productivity and structural transformation at the city level (World Bank, 2022a).

Thus, given the heterogeneity in patterns of labour productivity/structural transformation and differential weather conditions and effects within Accra, an understanding of the relationship between climate and structural transformation in this setting will provide insight into possible adaptation and mitigation processes. This could be significant in developing strategies to "climate-proof" the city to enhance resilience, productivity and prosperity. Moreover, with weather conditions expected to change

[1] Labour productivity is used a proxy for structural transformation in the ACRC city study for Accra, due to the lack of city-level panel data.

substantially over the coming years, understanding this relationship is increasingly important to, at the least, assess the damage function (how future changes in climate will affect economic activity) that is central to estimating the potential economic implications of future climate change (see Dell et al., 2014). This has policy implications in terms of deepening our understanding of what investments are needed to support cities and business establishments to harness the benefits of urbanisation for economic transformation and resilient and inclusive growth.

To address these critical issues, this study combines Ghana's Integrated Business and Establishment Survey (IBES, I and II) dataset sourced from the Ghana Statistical Service (GSS, 2015), and climate data at the sub-city level from Ghana Meteorological Agency with satellite data from the European Center for Medium-Range Weather Forecasts (ECMWF, 2018). We complement the quantitative analysis with a qualitative element using interviews with key informants representing enterprises and city authorities and officials of the National Disaster Mobilisation Agency (NADMO, various years). The findings suggest that rainfall, which contributes substantially to vulnerability and risk in the city, significantly reduces labour productivity, while the effect of temperature is not significant in statistical terms. This is an indication of the detrimental effect on firms of rainstorms and floods, which will in turn constrain the growth of high-productivity sectors and structural transformation in the city.

The rest of this paper is organised as follows. Section 2 offers a brief overview of the related literature. In Section 3, we provide some context on urbanisation, structural transformation, labour productivity and weather/climate patterns in Accra. Section 4 describes the data and the methodology. The results and a discussion of them are presented in Section 5. Section 6 concludes the paper.

2. Related literature

Climate, broadly defined, could affect labour productivity in several ways. For instance, high temperatures could lead to a reduction in labour supply and working hours and an increase in inefficiencies (Dasgupta et al., 2021) Rainfall, on the other hand, could have an adverse effect on labour productivity by triggering severe floods, which impact on infrastructure and on firms' ability to operate their business. Yet the empirical literature on climate and labour productivity is rather scant. In the field of social sciences, a very limited number of studies have explored this link. For example, Liu et al. (2023), using six decades of the Indian census, report quantitative evidence that rising temperature induces a decline in labour productivity in the agricultural sector. Somanathan et al. (2021) also confirm the detrimental effect of hotter temperature on labour productivity. Using micro-data for India, the authors show that an increase in temperature reduces worker productivity and increases absenteeism.

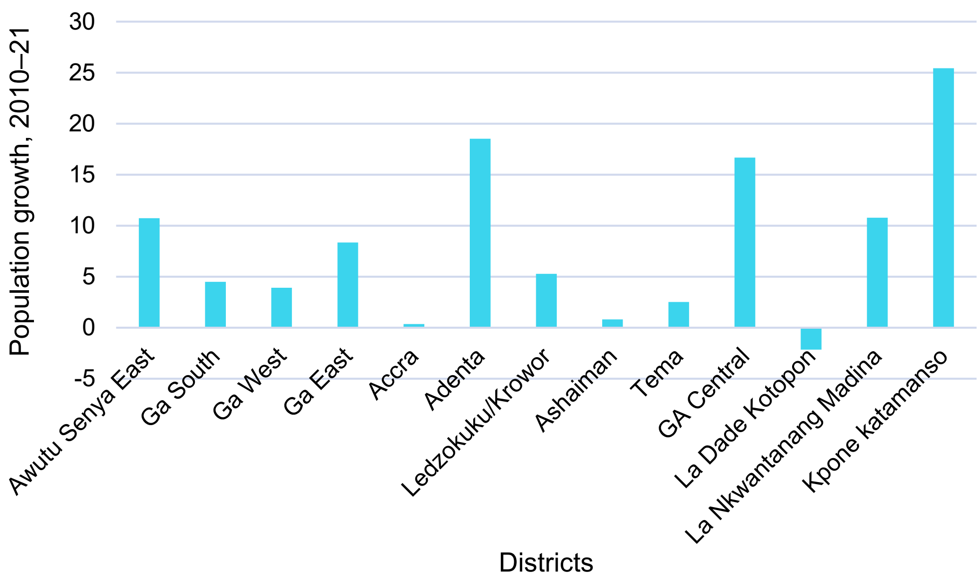
Outside the social sciences, other literatures have also investigated the effect of climate on labour productivity. Literature on physiology and engineering has shown that high temperatures tend to be associated with a fall in labour productivity. Along these lines, based on a field experiment, Mackworth's (1946) findings suggest that high temperatures may lead to inefficiency and thus low productivity of labour as workers make more mistakes. Meta-analyses by Hsiang (2010) and Hancock et al. (2007) indicate that high temperatures are associated with a decrease in labour productivity. This effect of high temperatures on labour productivity is also confirmed by other studies, such as Adhvaryu et al. (2020), Graff Zivin and Neidell (2014), Niemelä et al. (2002), and Seppanen et al. (2006). This paper contributes to the scant literature on climate and labour productivity by examining this relationship at the city level in Africa.

3. The context

3.1. Urbanisation and structural transformation in Accra city region

Ghana has experienced rapid urbanisation over the years. The share of the country's urban population increased from 23.1% in 1960 to 58.6% in 2022 (GSS, 2021; United Nations, 2022). Albeit the Accra city region has the smallest share (1.36%) of Ghana's total land area compared with other regions, the urban population grew by 8.1% on average between 2010 and 2021(GSS, 2021; ISSER, 2023). Accra has the largest urban population in Ghana, with the Greater Accra region accounting for 39% of the country's urban population overall (Cloete et al., 2019). This is attributable largely to interregional and international migration into the region. With the exception of La Dade Kotopon, all districts saw rapid growth in urban population from 2010 to 2021, with districts such as Adenta and Kpone Katamanso having rates as high as 18% and 25%, respectively (Figure 1).

Figure 1: Population growth in Accra city region, 2010-21



Source: Authors' illustration, based on data from GSS (2021).

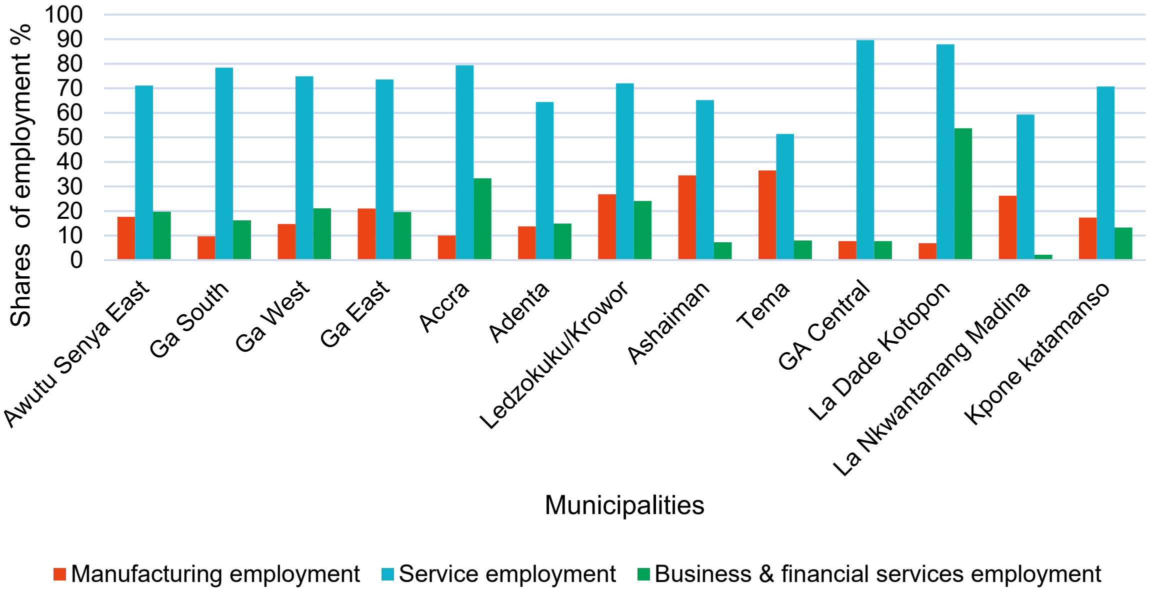
The rapid growth of urban population has been largely uncontrolled, as physical development in the fringe zone has not had the benefits of consistent and coordinated planning. As a result, the growth in the Accra city region is fragmented, with an amorphous and inefficient urban form (see Owusu and Yankson, 2017).

With respect to urbanisation and economic growth, Ghana seems to have better managed to gain from urbanisation than most African countries (Owusu and Yankson, 2017; World Bank, 2015). This runs counter to the general trend in many sub-Saharan African (SSA) countries, as they generally appear to urbanise without any significant economic growth (Onjala and K'Akumu, 2016). Ghana is one of the few countries in Africa that has been generally effective in harnessing the benefits generated by urbanisation early in this process, although it lags behind international trends (World Bank, 2015). In the Accra city region, urbanisation has produced some agglomeration effects and economies of scale that have enhanced productivity in densely populated urban areas (see Cloete et al., 2019). It has enabled secondary schooling in the city at scale and improved households' access to electricity and other amenities, thereby improving the stock of human capital and the quality of life in the city. However, Ghana, including the Accra city region, has a lower level of development than is expected, given its level of urbanisation, and the manufacturing sector and potentially high-productivity sectors, capable of supporting economic diversification, reducing poverty, and creating employment are much smaller (Gollin et al., 2016; Page et al., 2016; see Figure 2).

Despite its natural wealth, Ghana has not been able to invest sufficiently in infrastructure or human and institutional capital (World Bank, 2022b). As a result, investment in urban infrastructure has not kept up with rapid urbanisation, and Accra therefore faces several urbanisation-linked challenges that stifle the efficient operation of business establishments. Given the high rate of urbanisation, the overreliance on resource exports (oil and gas, gold, and so on), and the associated urban employment in informal manufacturing and non-tradeable services such as transportation, commerce, or personal and government services, Accra may be qualified as a consumption city (Cloete et al., 2019).

In general, the high urbanisation rates in Ghana have been associated with a reduction in the size of the manufacturing sector (World Bank, 2015). Within Accra city region, the rapid urban population growth has rather led to an increase in non-tradeable services, while high-productivity sectors such as manufacturing and business and financial services have significantly contracted (Figure 2). This shows that the city is not dense in capital, with low rates of capital investment by the private sector, especially in high-productivity sectors.

Figure 2: Employment distribution in manufacturing, business/financial services, and services in Accra city region

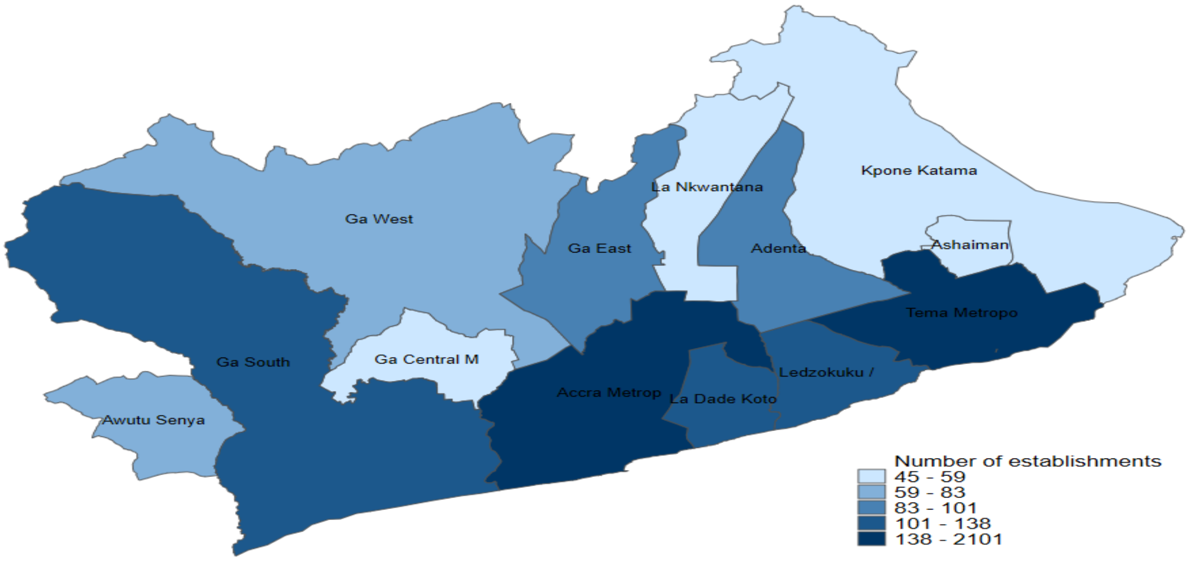


Source: Authors' illustration, based on data from GSS (2015).

About 28% of business establishments in Ghana are found in the Accra city region; however, the unemployment level in Accra is almost double the national average. The high number of services sector workers are employed mainly in low-productivity informal enterprises, often through self-employment (see Danquah et al., 2021). Many of these informal enterprises are found in wholesale and retail trade (Figure 3).

Spatial variation in business establishments matters in Accra (see Figure 3). The services sector dominates in all districts with higher shares of establishments and employment. More than 70% of economic activities in Accra city region are in services; the rest are in industrial, while urban agriculture is negligible. The share of manufacturing employment is around 18%. The number of new establishments has not been significant over the years in manufacturing and in potentially high-productivity sectors such as business and financial services (see Figure 2). The concentration of manufacturing and services employment varies across the city (Iddrisu et al., 2023). Labour productivity defined simply as output per worker at the sub-city level is used to gauge the levels of structural transformation across the city. With respect to patterns of structural change, the movements from agriculture are into lower- and moderate-productivity activities in (non-tradeable) services and manufacturing.

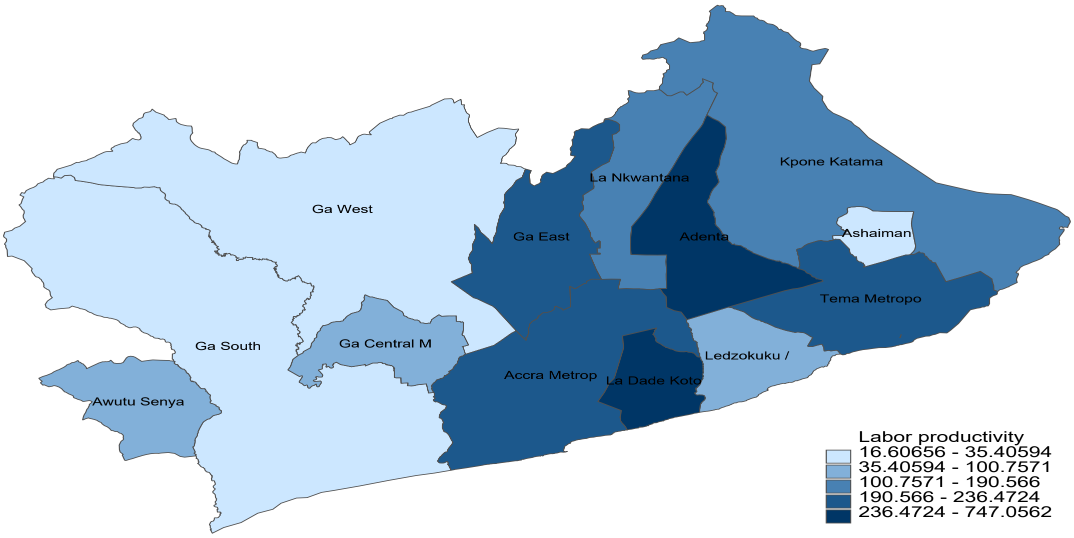
Figure 3: Spatial distribution of number of business establishments per district in Accra city region



Source: Authors' illustration, based on data from GSS (2015).

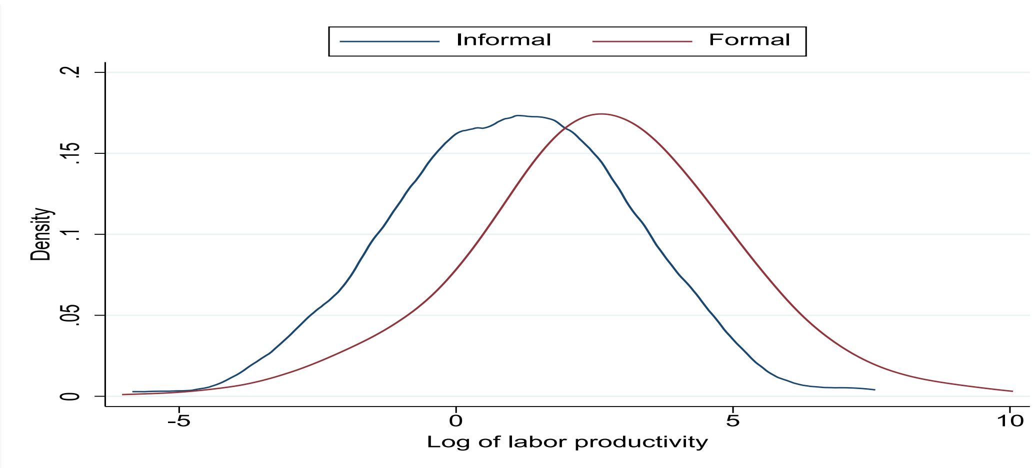
There is also heterogeneity in the labour productivity of business establishments across Accra city region (see Figure 4). Districts such as Adenta and La Dade Kotopon host the most productive enterprises, while Ga South, Ga West, Ashaiman and Ga Central host the least productive enterprises on average. Adenta has a high concentration of employment in construction, therefore the labour productivity in Adenta is driven by economic activities in construction. However, Ga West, which also has a high concentration of employment in construction, has very low labour productivity. La Dade Kotopon, which has a high concentration of employment in the finance and insurance subsectors, has high labour productivity, but Ga South and Awutu Senya, which have similar levels of concentration, have very low labour productivity. Albeit Ashaiman and Tema Metro have high levels of employment in manufacturing, but Ashaiman has very poor labour productivity compared with Tema Metro. The variation in labour productivity given the density of sector employment indicates the importance of different underlying factors, such as quality of infrastructure, congestion and subnational institutional performance, across the city and their connection to agglomeration economies. The productivity differences between formal and informal enterprises across districts show that formal enterprises are significantly more productive than informal ones in all districts in the city (see Figure 5).

Figure 4: Spatial distribution of labour productivity per district in Accra city region



Source: Authors' illustration, based on data from GSS (2015).

Figure 5: Kernel density plot of labour productivity by formality status



Source: Authors' illustration, based on data from GSS (2015).

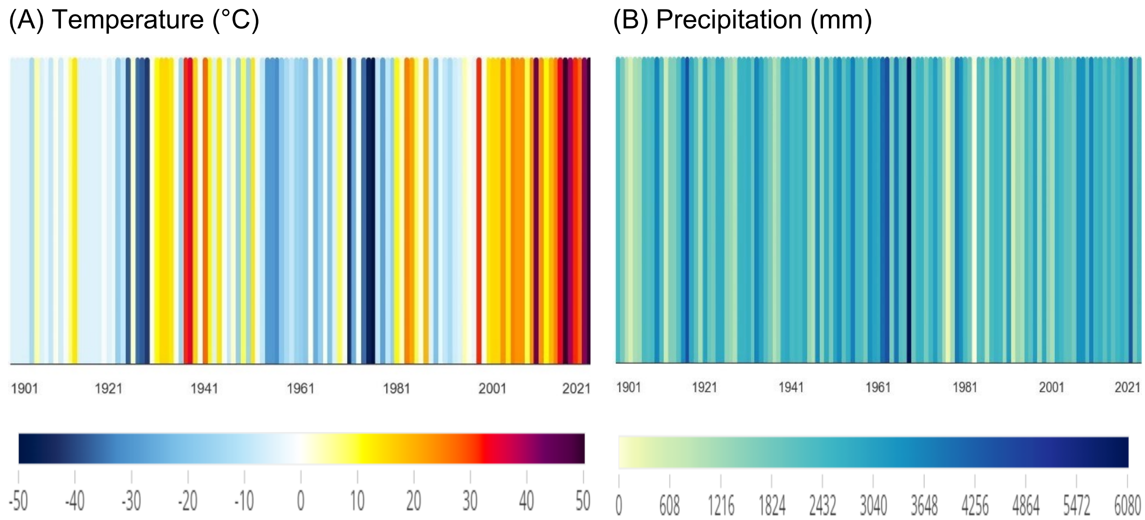
These patterns of labour productivity and its intersection with urbanisation in Accra can be attributed to poor urban planning and weak and dysfunctional urban land markets (see Owusu and Yankson, 2017). Due to rapid population growth and urbanisation and inadequate investments in Accra city region, as Owusu and Yankson (2017) indicate, urban infrastructure and services have proven to be very weak, with issues of service delivery and infrastructure particularly in terms of transport, water, and waste management. There is, however, some variation in severity at sub-city level. The journey to work in Accra city region has become longer and more stressful. The spatial expansion of the city has resulted in limited connectivity within the urban centres and between them and the peri-urban areas (Owusu and Yankson, 2017). Accra city region has by far the worst traffic congestion of all the regions in Ghana (GSS, 2021). This has presented significant challenges to enhancing productivity, as mobility is constrained by heightened transportation costs, longer commuting times and, as shown earlier, a decreased agglomeration effect. The negative externalities linked to congestion may erode the gains from agglomeration economies and cause them to disappear, as seen in some districts, if it becomes too expensive for economic actors to interact. This may lead to diseconomies of scale.

3.2. Temperature, rainfall shocks and vulnerability in Accra city region

One of the challenges connected to urbanisation is climate change. Cities are on the frontline of climate change impacts (Ordu, 2023). Climate change influences both human wellbeing and the economy, thereby posing significant risks to the livelihoods and assets of people living in cities (World Bank, 2011).

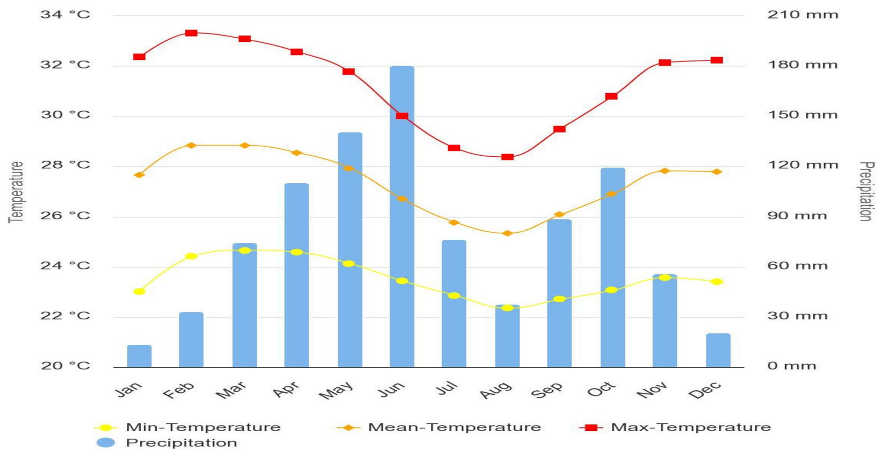
Since 1960, Ghana's average temperature has increased by around 1°C per year (World Bank, 2022a). The evolution of the historical record for Accra city region shows that the global surface temperature has risen continually while rainfall has become more erratic, despite natural variability (see Figure 6). In the Accra city region, surface temperature can reach a maximum of 33°C in February and March and is as low as 23°C in August. Rainfall is high in June (about 180 mm) and very low in December and January (below 30 mm) (see Figure 7).

Figure 6: Evolution of the historical record for temperature and rainfall, Accra city region



Source: Reproduced from the Climate Change Knowledge Portal (World Bank n.d.), under a Creative Commons Attribution 4.0 International License (CC BY 4.0) and as per the World Bank's terms of use for datasets.

Figure 7: Monthly average minimum, mean, and maximum temperature and rainfall, 1991-2020



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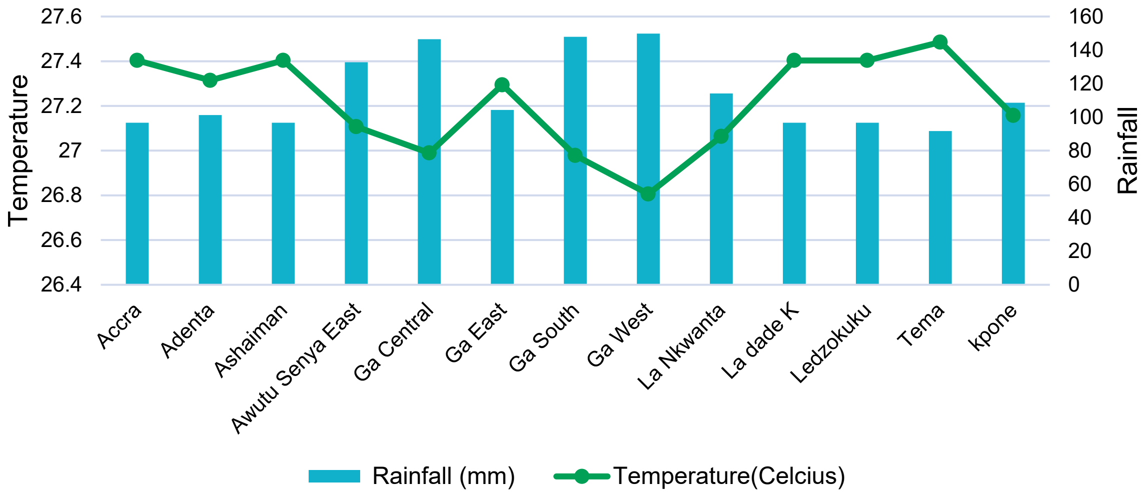
Within Accra city region, average temperature and precipitation varies at the sub-city level. For instance, the mean annual temperature and precipitation for 2014/15, the year the IBES was conducted, clearly shows this variation across municipalities (see Figure 8). Municipalities such as Tema and Accra Metros and Ashiaman have on average higher temperatures (around 27.5°C) compared with areas in Ga West and Ga South. With respect to rainfall, areas in Tema, Ledzokuku and Ashiaman record lower levels (below 100 mm) while areas in Ga West, Ga Central and Ga South have higher levels (above 140 mm) during the period.

Figure 8: Annual mean temperature and precipitation for municipalities in Accra city region, 2014/15



Source: Authors' construction based on data obtained privately from European Centre for Medium-Range Weather Forecasts.

The climatic conditions have resulted in an increase in the frequency and magnitude of weather and climate extremes, with floods, rainstorms and heatwaves in the Accra city region. Due to the city's location at the mouth of the Odaw River and the low-lying coastal landscape and poor infrastructure, the major environmental risk is flooding. This has become a perennial phenomenon, and seasonal flooding brings in its wake widespread destruction, disruption of economic activities and loss of life and property.

4. Methodology and data

We employ both qualitative and quantitative methods. With respect to the qualitative work, we interviewed representatives of key enterprises and city authorities and officials of the National Disaster Mobilisation Agency (NADMO) in each municipality to understand their experiences with climate change and economic activity. The qualitative work attempts to understand the frequency of extreme weather conditions – flash floods, windstorms, rainstorms, tidal waves – across the city, how they have impacted economic activities, how business establishments are dealing with them, and how city authorities are working with establishments to address the impacts on business performance. Based on this information and additional data from the agencies we interviewed, we develop a Vulnerability and Risk Matrix for Accra city region.

With respect to the quantitative work, we employ detailed descriptive and regression analysis. The patterns of structural transformation are examined using labour productivity across the city at the sub-city level. We regress labour productivity on climate-related variables.

Our baseline model is given by:

$$productivity_{im} = \beta_0 + \gamma'^{W_m} + \alpha'^{Z_m} + \beta'^{X_i} + \delta_r + \tau_j + e_i$$

where $productivity_{im}$ is the labour productivity of establishment i in municipality m. *Wm* denotes weather conditions in each sub-city/municipality. *Zm* and *Xi* capture sub-city and enterprise-level characteristics, respectively. The sub-city/municipality fixed effects are represented by δ_r and fixed effects for our sectors by τ_j. Labour productivity is measured as log of value added per permanent worker. We also use the log of sales per full-time worker for robustness. The analysis starts with the mean temperature and rainfall in levels. Several empirical studies (for example, Acevedo et al., 2020; Burke et al., 2015; Dell et al., 2012) have followed a similar approach. Then, following Kahn et al. (2021) and De Bandt et al. (2021), we compute new temperature and rainfall measures based on deviations from historical norms. To be more specific, temperature and rainfall deviations from the historical norms are calculated as:

$$\tilde{T}_t = T_t = \overline{T}_{historical\_norm}$$

$$\tilde{P}_t = P_t = \overline{P}_{historical\_norm}$$

where T_t and P_t represent, respectively, the quarterly levels of temperature and rainfall; and $\bar{T}_{historical\_norm}$ and $\bar{P}_{historical\_norm}$ are, respectively, the historical norms in temperature and precipitation. The idea is that deviations from these norms capture changes in climate events. Ideally, we would want to have weather data for districts going back to the pre-independence period of Ghana. However, this was not possible in the context of districts in Accra. In fact, the data for these districts could only be traced back to 1981. We therefore use the average for 1981-89 by district as the historical norms for temperature and rainfall. In addition, we compute an alternative measure for temperature ($temp\_dev\_historical2$) by using a temperature norm for the whole of Accra for the period 1931-60. Of course, we are making the assumption that this norm is the same for all districts. The deviations from historical norms allow us to control for cross-sub-city/municipality climate differences, while the average temperature and rainfall are captured by the municipality fixed effects (De Bandt et al., 2021). Sub-city characteristics (Zm) include log of population, while enterprise characteristics are formality status, type of ownership, size of the enterprise, nationality of owner, type of legal organisation, existence of accounts records and log age of the enterprise. Descriptive statistics can be found in Appendix Table A1.

Data on the labour productivity of business establishments, the share of sector employment, and enterprise characteristics are sourced from Ghana's IBES I and II conducted in 2014/15 by the Ghana Statistical Service. IBES I and II is conducted on the full set of economic units across the agriculture, industrial and services sectors of the Ghanaian economy. Data on population at the sub-city level are sourced from the Population and Housing Census (GSS 2021). Data on temperature and rainfall at the sub-city level are sourced from Ghana Meteorological Agency and satellite and reanalysis data. The temperature and precipitation data employed are derived from ERA5 satellite reanalysis provided by the ECMWF (2018). The ERA5 system amalgamates information from a variety of sources, including ground stations, weather balloons, and satellites, with a climate model. This provides hourly estimates of multiple climate-related variables, offering a global grid spacing of approximately 31 km, with data extending back to 1981. For the purposes of this study, we collect mean data and apply them to the sub-city level in Accra city region. This granular climate data allows us to draw more precise correlations between temperature and precipitation fluctuations and labour productivity, providing a more robust analysis of the impact of climatic shocks. As indicated, additional data on climate-related shocks (windstorms, rainstorms, tidal waves and floods) and magnitude of impact are collected from the National Disaster Mobilisation Agency (NADMO) and city authorities to construct the Vulnerability and Risk Matrix for Accra city region. District institutional performance data from Chachu et al. (2023) are used for further analysis.

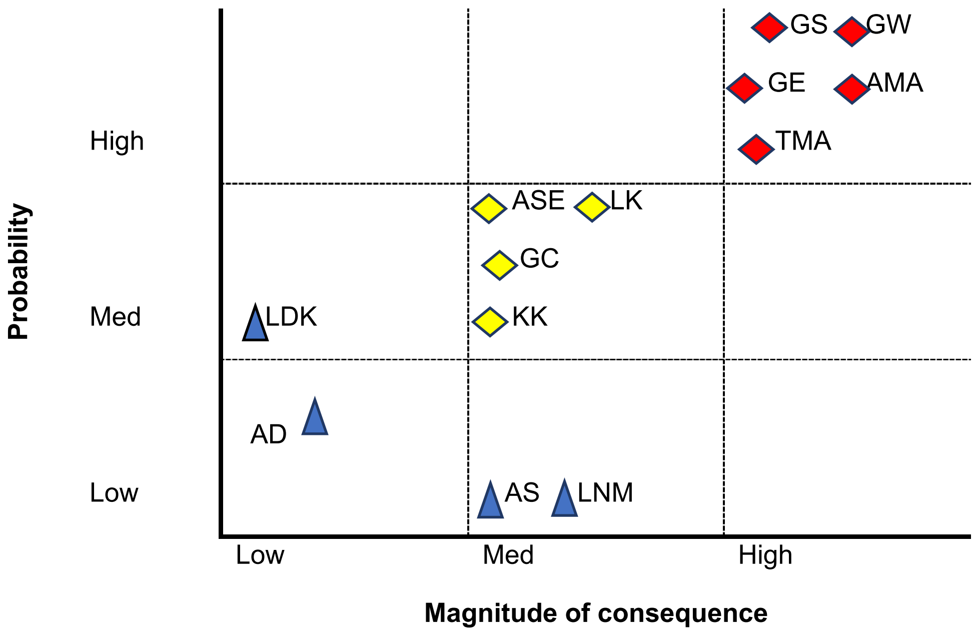
5. Analysis of results

In this section, we discuss the Vulnerability and Risk Matrix constructed for Accra. After that, we look at the effects of climate on labour productivity, then attempt to provide some explanations of the estimates using information from our key informant interviews.

Based on data from NADMO, Ghana Meteorological Agency and local government, we put together a Vulnerability and Risk Matrix for Accra city region using the frequency of weather and climate extremes at the municipality level and the magnitude of their subsequent impact. The main indicators of weather and climate extremes are windstorms, rainstorms, floods and heatwaves and their impacts in terms of disruption of economic activities and infrastructure in a municipality. The matrix (see Figure 9) shows that municipalities such as Ga East, Ga West and Accra Metro are the most vulnerable or high risk. In Ga East and Ga West, the risk is due to rainstorms and floods, respectively. Other municipalities, such as Awutu Senya East and Kpone Katamanso, are moderately at risk, while Adenta, the municipality with the highest labour productivity, has the lowest risk.

Risk aversion to floods, for instance, deters productive investments. The vulnerability of many at-risk municipalities and sectors will reduce if we understand how to increase productivity in a municipality given the prevailing climate condition. There are significant gains to be derived from adaptation and mitigation initiatives if we understand the productivity–climate nexus in a municipality.

Figure 9: Vulnerability and Risk Matrix for Accra city region



Note: Municipalities are Accra (AMA), Adenta (AD), Ashaiman (AS), Awutu Senya East (ASE), Ga Central (GC), Ga East (GE), Ga South (GS), Ga West (GW), Kpone Katamanso (KK), La Dade Kotopon (LDK), La Nkwantanang Madina (LNM), Ledzokuku/Krowor (LK) and Tema (TMA).

Source: Authors' illustration, based on data from Ghana Meteorological Agency and NADMO (2023).

In Tables 1 and 2, we show the results on the impact of temperature and rainfall on labour productivity. In Table 1 we use value added per permanent worker as a proxy for labour productivity, while in Table 2 we use total sales per full-time worker. We start with the means of temperature and rainfall in columns 1 and 2, followed by historical deviations in columns 3 and 4. We do not include districts and sector effects in columns 1 and 3; they are introduced in columns 2 and 4.

Table 1 shows that while the effect of temperature on labour productivity is mostly negative, it remains insignificant in statistical terms. This is the case irrespective of whether we use the mean temperature or deviations from historical means. In contrast, we find that rainfall consistently exerts a statistically significant negative effect on labour productivity. This is true for both mean rainfall and deviations from historical means. The negative effect of rainfall on labour productivity increases when we account for municipality and sector effects: see graphical illustration of regression estimates in Figure 10.

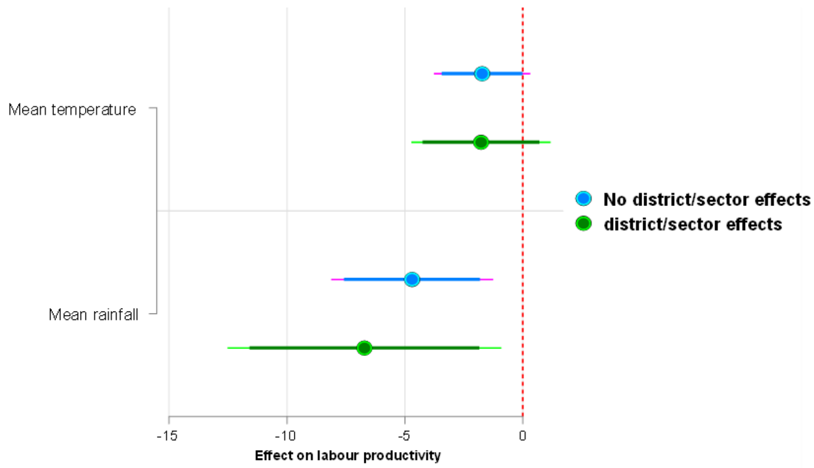
Table 1: Impact of climate on labour productivity (1)

Dependent variable: LP1 (log value added per permanent worker)	(1) Mean	(2) Mean	(3) Hist. dev.	(4) Hist. dev.
Temperature	−1.341 (0.992)	−1.623 (1.453)	−0.554 (0.448)	0.250 (0.605)
Rainfall	−0.0423** (0.017)	−0.071** (0.031)	−0.035*** (0.009)	−0.196*** (0.077)
Controls	Yes	Yes	Yes	Yes
District effects	No	Yes	No	Yes
Sector effects	No	Yes	No	Yes

Note: Robust standard errors in parentheses; control variables include log population of district, firm's formality status, ownership type, firm size, ownership nationality, type of legal organisation, existence of account records, and firm's age.

Source: Authors' calculations.

Figure 10: Graphical illustration of the increase in effect of rainfall when accounting for district and sector effects (1)



Note: Model controls for district- and enterprise-level characteristics.

Source: Authors' illustration, based on Table 1.

Next, we repeat the above exercise but this time our dependent variable is the log values of sales per full-time employee. The results are shown in Table 2 mirror those reported above.

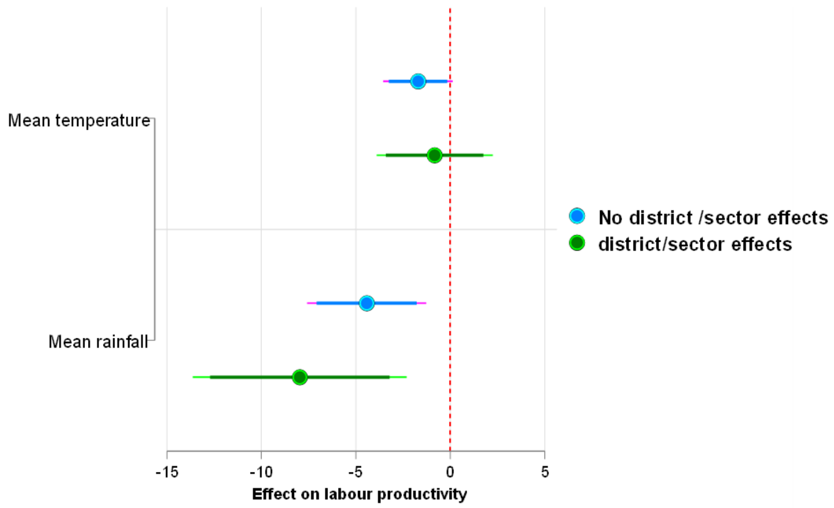
Table 2: Impact of climate on labour productivity (robustness)

Dependent variable: LP2 (log sales per full-time employee)	(1) Mean	(2) Mean	(3) Hist. dev.	(4) Hist. dev.
Temperature	−1.218 (0.892)	−0.645 (1.517)	−0.504 (0.398)	1.140 (0.654)
Rainfall	−0.037** (0.015)	−0.084*** (0.030)	−0.027*** (0.009)	−0.297*** (0.075)
Controls	Yes	Yes	Yes	Yes
District effects	No	Yes	No	Yes
Sector effects	No	Yes	No	Yes

Note: Robust standard errors in parentheses; control variables include log population of district, firm's formality status, ownership type, firm size, ownership nationality, type of legal organisation, existence of account records, and firm's age.

Source: Authors' calculations.

Figure 11: Graphical illustration of the increase in effect of rainfall when accounting for district and sector effects (2)



Note: Model controls for district- and enterprise-level characteristics.

Source: Authors' illustration, based on Table 2.

The negative and statistically significant effect of rainfall on labour productivity in Accra city region makes sense. This region experiences heavy rainfall, which generally culminates in severe floods. These floods affect existing infrastructure and firm's assets and increase the cost of production. Firms' premises may often be flooded and consequently their ability to operate is impeded until the recovery process is completed. These findings buttress the finding on the significant contribution of rainfall to vulnerability and risk in the city (see Figure 9).

The key informant interviews indicate that rainfall in particular has significant impacts on economic activities in the city. This takes place via the disruption of firms' supply chains, damage to infrastructure and property, decreased productivity and increased operational costs, and business and investment uncertainty. The damage to infrastructure and firms' property results in costly repairs and interruption to business operations. Small and medium-sized enterprises are particularly vulnerable and may not recover from such shocks due to their limited financial resources and insurance coverage. In the Accra city region, which is a popular tourist destination, the interviews indicate that excessive rainfall deters tourists from visiting the city, which in turn has a negative effect on the city's tourism and hospitality industry. Tourism is a tradeable service and it is seen as a potential high-productivity sector, and therefore this negative effect of climate change dampens structural transformation in the city. Many enterprises are also concerned about the unpredictability of the weather and its effects on long-term planning, investment decisions and business confidence in the city. Further, the local authorities that are generally responsible for building resilience in the districts are also affected by rainfall and thus their ability to function is limited. This is confirmed by Appendix Figure A1, which shows a high and negative correlation between rainfall and the institutional performance of municipalities. Local authorities indicate that heavy rainfall leads to infrastructure damage, disruption to the provision of utilities, displacement and housing challenges, and economic losses which hamper the municipality's ability to deliver services effectively. The inability of local governments to invest in resilience due to constraints in finance and technical expertise and institutional barriers, among other factors, can deepen the impact of rainfall on firms, as they can find it very difficult to bounce back after climate shocks. Some firms may reach a tipping point and exit. Firms need the relevant support as the continuation climate-change-impacted rainfall can negatively affect labour productivity and firms' ability to expand. This in turn will affect the municipality's ability to attract high-productivity firms.

Temperature, on the other hand, can affect labour productivity by affecting workers' ability to produce and by increasing cost of production. In Accra city region, albeit temperature has no effect on labour productivity, it has positive effect on the cost of electricity for firms. However, temperature levels as observed in Accra do not directly affect the existing infrastructure and may not impede firms' capacity to continue their operations.

The response derived from the interviews reiterates the need for adaptation to mitigate the impacts of climate shocks in the city. Participants indicate that the city should undertake a range of measures that focus on climate resilience, disaster risk reduction and sustainable and low-carbon development pathways. Accra needs a holistic and integrated approach that involves investment in climate-resilient infrastructure, early warning systems, sustainable water and sanitation management, investment in renewable energy, and close collaboration and partnerships with the private sector and development partners, among others, in order to create a more liveable and sustainable city for residents. The resultant reduction in the operating and adaptive cost for firms is essential for high-productivity sectors to thrive.

6. Conclusions

African cities are growing at a faster rate than cities elsewhere. Apart from the many urbanisation-linked challenges, cities in Africa are also at the forefront of climate change impacts. In this paper, we examine the role of climate in explaining citywide labour productivity in Accra city region. We employ both quantitative and qualitative methods for this exercise. The quantitative method – descriptive and regression analysis – uses enterprise-level data from Ghana's IBES I and II conducted in 2014/15, temperature and rainfall data from Ghana Meteorological Agency, and satellite and reanalysis data, as well as data from the Population and Housing Census (GSS, 2021). The qualitative method involves key informant interviews with representatives of enterprises, city authorities and NADMO. In addition, we analyse data from NADMO on climate-related shocks and impacts at sub-city level to ascertain the levels of vulnerability and risk at this level.

Our findings show that rainfall, which contributes substantially to vulnerability and risk in the city, significantly reduces labour productivity, while the effect of temperature is not significant. Clearly, the magnitude of the impact of rainstorms and floods in terms of disruption of firms' supply chains, damage to infrastructure and property, high operational costs and overall effect on business and investment hampers the productivity and growth of firms in the city. This dampens agglomeration effects and the emergence of high-productivity firms, which is crucial for workers and economic transformation in the city. There is an urgent need to adapt to and mitigate the impacts of climate shocks in the city. To create a more liveable and sustainable city which can facilitate economies of scale, specialisation and thriving high-productivity sectors, the city government needs support in building capacity and finance to develop and enforce urban planning policies and regulations that support climate resilience, strengthen data monitoring systems; it needs research to improve understanding of climate impacts; and it needs to start adopting green and low-carbon initiates.

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Appendix

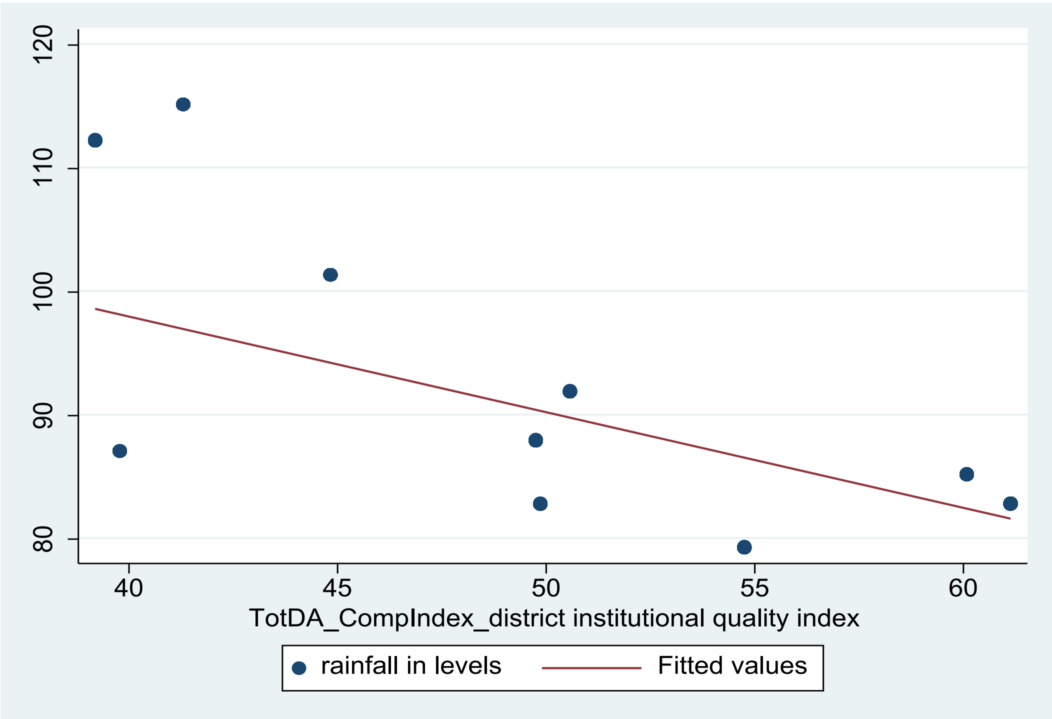
Table A1: Descriptive statistics

Variables	Mean	Std dev.	Min.	Max.
Log total sales per full-time worker	9.436312	2.399532	0.87707	16.96355
Log value added per permanent worker	9.594163	2.195651	2.867544	18.23006
Mean temperature (°C)	26.91227	0.150601	26.3458	27.0388
Mean rainfall (mm)	85.36762	8.667842	79.311	115.112
Temp. deviation from historical norm	0.329513	0.146736	−0.2542	0.449999
Rainfall deviation from historical norm	−4.66988	5.994609	−9.3609	26.4401
Log of population	13.43703	1.114382	11.40145	14.33472
Formality:				
Not formal	0.115417	0.319569	0	1
Formal	0.884583	0.319569	0	1
Type of ownership:				
State owned	0.002788	0.052734	0	1
Private owned	0.978255	0.145871	0	1
Public private partnership	0.018957	0.136393	0	1
Size of enterprise:				
Micro	0.096459	0.295261	0	1
Small	0.758851	0.42784	0	1
Medium	0.122665	0.328098	0	1
Large	0.022024	0.146782	0	1
Owner nationality type:				
Ghanaian	0.852596	0.354557	0	1
Non-Ghanaian	0.123674	0.329255	0	1
Ghanaian and non-Ghanaian	0.02373	0.152227	0	1
Type of legal organisation:				
Sole proprietorship	0.283399	0.450711	0	1
Partnership	0.0763	0.265514	0	1
Private limited company	0.578536	0.493863	0	1
Public limited company	0.010341	0.101178	0	1
Statutory body	0.003074	0.055369	0	1
Other government institution	0.004751	0.068775	0	1
Quasi-government	0.000839	0.028948	0	1
NGO	0.022079	0.146962	0	1
Cooperative	0.004751	0.068775	0	1

Association/group	0.015931	0.125225	0	1
Bank accounts:				
Yes	0.883152	0.321293	0	1
No	0.116848	0.321293	0	1
Log age of enterprise	2.537023	1.042829	0	4.75359

Source: Authors' construction based on GSS (2015) and ECMWF (2018).

Figure A1: Rainfall vs district institutional performance



Source: Authors' illustration based on ECMWF and Chachu et al. (2023).

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