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Beyond the concrete jungle: urban growth and natural disasters resilience in Africa

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Abstract

The aim of this paper is to empirically analyze the effect of rapid urbanization in Africa on the magnitude of natural disasters. In particular, we study two dimensions of disasters, namely droughts and floods, and capture their magnitude through two variables: total number of people affected and the total number of death. To test this hypothesis, we collected data on 40 African countries over the period 1980-2020 and estimated two models using OLS, Fixed-Effects Poisson estimator and quantile regression. The results suggest that urbanization strongly increases the number of people affected by natural disasters and thus increases their mortality in the African context. Also, the results also indicate the role of economic growth and corruption to tackle the negative impact of natural disasters in Africa. These results underline the urgent need to rethink urbanization policies in Africa to take better account of the risk of natural disasters.

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1. Introduction

Natural disasters include climatic disasters (droughts, floods), earthquakes, landslides or pandemics. These disasters have serious consequences in terms of health, poverty, food security, access to basic infrastructures and public finances and disrupt the normal functioning of states and economies (Djoumessi and Eyike, 2022). In the general context of developing countries, characterized by the low availability of public infrastructures and resources, the negative consequences of natural disasters are even more pronounced. According the Africa Disaster Risk Financing initiative, floods are responsible for losses of 77% in material goods, 23.5% on average in household income, and 4% in health expenditure (Africa Disaster Risk Financing initiative, 2019). The same report estimates the total cost of natural disasters in Lesotho between 2003 and 2018 at around $18million. In Yaoundé, according to the government, a landslide recently claimed dozens of lives and caused major economic losses. According to the World Bank (2016), developing countries suffer disproportionately from natural hazards and benefit least.

One reason for this high exposure to natural disasters is Africa's rapid and uncontrolled urbanization. Africa has experienced strong urban growth since independence. According to forecasts by the Economic Commission for Africa, more than half of Africa's population will live in urban areas by 2035 (ECA, 2022), and more than 90% of the world's urban population growth will occur in Africa. This sharp rise in the pace of urbanization is associated with renewed growth, reviving hopes of an association between urbanization and economic expansion (Rodrik, McMillan and Verduzco-Gallo, 2014). The continent's rapid urbanization is driven by strong demographic growth, on the one hand, and poverty, on the other, driving people to migrate to cities in search of a better socio-economic situation.This strong urban growth, and the form it is taking (high urban sprawl), is leading to a rapid increase in built-up areas. As a result, people are increasingly settling in areas at risk of natural disasters: slopes, foothills, flood valleys, swamps, intra mountain basins or corridors, gullies, etc. The occupation of these areas, unsuitable for housing, exposes people to the risk of natural disasters. What's more, the poor quality of construction and inadequacy of roads aggravate the consequences of these natural disasters. In this respect, a study conducted by researchers at the Royal Museum for Central Africa and published in Nature Geoscience has shown that urbanization accelerates the landslide process in the DRC, based on satellite images (Dille et al., 2022). This study analyzes the impact of urbanization on the probability of occurrence of natural disasters and the magnitude of their consequences in the African context.

A number of studies have analyzed the impact of urbanization on disaster risk. Generally speaking, these studies take two main directions. The first orientation, ex-post, proposes an analysis of the consequences of anarchic urbanization on the consequences of natural disasters in terms of economic losses (Bibbee et al., 2000; Zoleta-Nantes, 2003) and physical damage (Chen and Yang et al., 2014; Shi and Cui, 2012). As for the second orientation, it analyzes ex-ante the risks posed by anarchic urbanization on the scale of natural disasters (Cerdá et al., 2013; Cheng et al., 2013; Chinnarasri and Porkaew, 2015).

This study empirically analyzes the impact of urbanization on the extent of the consequences of these natural disasters. Anarchic urbanization is characterized by poor quality construction and inadequate roads, which aggravate the consequences of these natural disasters.

2. Literature review

The urban environment, comprising built elements, social structures, territory and ecology, is becoming increasingly fragile as a result of unplanned urbanization. As a result, urban populations are facing increasing risks linked to economic, social and environmental crises (Cui & Shi, 2012; Cheng et al., 2023). This problem is particularly pronounced in Africa, where urban migration and population growth are outstripping the capacity of local governments to meet basic needs, plan and finance growth, and cope with growing vulnerabilities within cities (UN Habitat, 2010). The high rate of migration from rural to urban areas, growing population trends and fragile economic conditions are fuelling rapid urbanization in Africa. The literature on the relationship between urbanization and natural disasters takes two main directions.

Firstly, some authors show that disorganized urbanization increases the risk of natural disasters by creating an ecological imbalance (World Economic Forum, 2012). Urban growth alters a region's land use, with adverse consequences for natural ecosystems.

Cities, particularly in developing countries, are vulnerable to flash floods due to the lack of adequate drainage systems. Indeed, if rainfall is heavy, buildings, roads, infrastructure and other paved areas prevent infiltration into the ground, leading to increased runoff. In all cities, heavy and/or prolonged rainfall generates vast quantities of surface water, which can easily overwhelm drainage systems (Satterthwaitte et al., 2010 ; Chinnarasri & Porkaew, 2015). The use of concrete can also reduce the soil's capacity to capture water, resulting in flash flooding. Similarly, the destruction of forests can lead to slope erosion, exposing populations to landslides caused by heavy rainfall (Quarantelli, 2003).

The second line of research shows that urbanization is the direct cause of natural disasters, through its major role in destroying the environment. Several papers have analyzed the links between urbanization and vulnerability to climate change (Hallegatte et al., 2016; Romero-Lankoa and Dodman, 2011; Solecki et al., 2011). The results of this research focus on managing the risks associated with extreme events and disasters, in order to promote adaptation to climate change.

In addition, integrated climate change acknowledges that urbanization should be considered and specified in a new set of baseline scenarios as one of the main factors influencing shared socio-economic pathways and shaping future vulnerability conditions research (van Vuuren et al. 2012; Kriegler et al. 2012) . Most studies conclude that urbanization will increase sensitivity to climate change. According to Chen et al. (2023), urbanization can have both positive and negative impacts on the overall adaptive capacity of cities and regions. Also, the type of urbanization and the context in which it takes place determine whether these processes contribute to increasing or reducing people's vulnerability.

3. Methods and Data

3.1.Methods

This work aims to analyze the effet of urbanization on natural disaster consequences on a set of African countries. This study retains two main natural disasters widely observe upon the continent, flood and drought.The population-averaged model (or pooled model) is defined as follow :

$$y_{i,t} = \beta_0 + x'_{i,t}\beta + \varepsilon_{i,t} \quad (1)$$

Where $y_{i,t}$ represents the dimensions of natural disasters consequences, $x'_{i,t}$ is a set of variables, including urbanization and $\varepsilon_{i,t}$ represents the error term.

The dependent variable has two items : total number of people affected and the total number of death are used to capture the natural disaster consequences. The total affected people are the persons who have been injured or lost their houses during the catastrophe. Due to the nature of these variables, the empirical approach considers two different specifications. The variable 'total affected people' is considered as a continuous variable while the variable 'total deaths', with an impressive occurrence of zeros, is analyzed as a count variable.
The first model is described as follow :

$$total\_affect_{i,t} = \beta_0 + \beta_1 Urban_{i,t} + \beta X_{i,t} + \varepsilon_i + \mu_t + \pi_{i,t} \quad (2)$$

Where $Urban_{i,t}$ captures the urbanization level and $X_{i,t}$ is a set of variables. This model is estimated using two main estimators. Traditional fixed effects and random effects estimators have been shown to be inappropriate when there is an endogeneity bias. In the case of this study, this bias is pervasive. First, there is a simultaneity bias between certain explanatory variables and the dependent variable. Thus, to take this risk into account, the use of Generalized Moment Method would be more appropriate (Roodman, 2009). But given the nature of data used, we are not able to use this method. In fact, the data used are consistent with the use of count data methods.
First, we use the ordinary least squares (OLS) with robust standard deviations. This method is the most-known Method-of-Moment in the literature. We also estimate this model using quantile regression. This method provides a richer and more detailed description of the dependent variable than conventional regressions (Givard et d'Haultfoeuille, 2013). In fact, quantile regression models relationship between a set of independent variables and specific quantile of the dependent variable. This method has two main advantages. First, it tends to resist the influence of outlying data. Secondly, it makes no assumptions about the distribution of the dependent variable (Givard et d'Haultfoeuille, 2013). The second model is described as follow :

$$total\_deaths_{i,t} = \beta_0 + \beta_1 Urban_{i,t} + \beta X_{i,t} + \varepsilon_i + \mu_t + \pi_{i,t} \quad (3)$$

Secondly, the total deaths variable is analyzed in a count data model, mainly for three reasons highlighted in Cameron and Trivedi (2005, 2010), which helps to handle complications generated: (i) the pervasive unobserved heterogeneity, (ii) atypically high proportion of zeros, (iii) the inherent discreteness and heteroscedasticity. The Fixed-effects (FE) Poisson estimator is applied to estimate this second-panel model. This estimator provides consistent estimates of β in short panel. Also,it assumes strict exogeneity of regressors and in case of weak exogeneity assumption, the FE Poisson estimator can handle endogenous regressors.

3.2.Data

Data on disaster consequences are collected from the Emergency Events Database (EM-DAT). The data cover the 1980 to 2020 period and are considered every five years on a sample of 40 African countries: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo (the Democratic Republic of the), Congo (the), Cote d'Ivoire, Djibouti, Egypt, Ethiopia, Gambia (the), Ghana, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger (the), Nigeria, Rwanda, Senegal, Somalia, South Africa, Sudan (the), Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.
The dependant variables are the total number of people affected and the total number of death. The main variable of insterest is the urbanization rate in Africa. This variable is captured by the share of urban population (% of total population). This indicator is calculated from World

Bank population estimates and urban ratios from the United Nations World Urbanization Prospects. Urban percentages are the number of people living in an area defined as 'urban' per 100 inhabitants. The others independent variables include ICT (mobile phone and internet) to capture the fact that the availability of information could lower the impact natural disasters (Djoumessi and Eyike, 2022) ; the Gross Domestic Product (GDP) that measures the level of economic activity; the population that give information on the density of people in the country and the corruption to capture the effects of public governance on the management of natural ressources consequences. These variables are expected to have a mitigated impact on natural disaster consequences. Table 1 defines the variables used while table 2 summarizes the descriptive statistics of the series used.

TABLE 1. Variable definition

Variable	Definition	Unit	Source	Frequency
Urbanization	Urban population (as % of total population)	%	World Bank	5 years
Total_Affected	People injured or displaced by disaster	Count	EM-DAT	5 years
Total_DEATH	Number of deaths due to natural disaster	Count	EM-DAT	5 years
GDP per capita	Real GDP per capita	USD	World Bank	5 years
Internet	Internet users per 100 peaple	%	World Bank	5 years
Mobilecell	Mobile phone subscription per 100 people	%	World Bank	5 years
Coruption	Corruption perception index	Index	ICRG	5 years

Source : authors

TABLE 2: descriptive statistics of the series used

Variable	Obs	Mean	Std. Dev.	Min	Max
Total_Affected	350	410411.4	1257607	8	1.25e+07
Deaths	340	344.6844	5591.442	0	100000
Internet	267	5.418641	10.30143	0	57.08
Mobilecell	359	19.11881	34.37605	0	163.8752
GDPpercapita	360	1480.382	1486.035	168.6387	7613.698
Population	360	1.90e+07	2.42e+07	358960	1.81e+08
Corruption	345	-.3315624	.502675	-1.7482	.9768112
Urbanisation	342	4.53e+07	1.29e+08	5503	1.07e+09

Source : Authors calculations

4. Results and discussions

Baseline results are obtained with OLS, quantile regression and the Fixed-effects (FE) Poisson estimator. The results suggest that urbanization increases the number of victims of natural disasters in Africa. In the first column, the results show that urbanization increases the number of people affected by natural disasters, while the second column shows that urbanization increases mortality due to natural disasters. This result is in line with theoretical predictions. Similarly, the results suggest that income level is negatively related to the scale of disasters. Indeed, GDP per capita (in logarithm) is negatively and significantly correlated with the number of people affected by the occurrence of a natural disaster (at the 10% threshold) and with disaster-related mortality (at the 5% threshold). This result can be explained by the fact that the richer a country is, the firmer are its urban and regional planning standards. What's more, the richer a country is, the better equipped it is to deal with the consequences of natural disasters by setting up a more effective civil security system.

In addition, cell phones are negatively and significantly correlated with the consequences of natural disasters at the 1% threshold, notably in terms of people affected and mortality due to natural disasters. This translates into the fact that cell phone owners can easily alert and be alerted via this digital tools.

In the same vein, the coefficient associated with the internet variable is negative and significant at the 1% threshold for people affected by natural disasters and the number of deaths due to natural disasters. Like the previous variable, this reflects the fact that the Internet is a warning tool that can reduce the scale of the consequences of natural disasters.

In addition, population (in logarithm) increases the number of people affected by the occurrence of a natural disaster, as the coefficient associated with this variable is positive and significant at the 1% threshold for people affected by natural disasters and the number of deaths due to natural disasters. This result can be explained by the fact that, in the event of a natural disaster, the greater the population on the site, the greater the number of victims.

Finally, the sign of the coefficient associated with corruption is positive and significant at the 1% level. This means that corruption is positively correlated with people affected by natural disasters and the number of deaths due to natural disasters. This result can be explained by the fact that funds allocated to preventing and combating natural disasters and their consequences are diverted by corruption mechanisms.

Table 3. Regression results using ols and poisson estimators

	(OLS)	(PE)
VARIABLES	log_affect	log_death
Urban	0.336***	0.154**
	(0.0175)	(0.0684)
log_gdp	-0.106*	-0.536**
	(0.061)	(0.256)
Mobilecell	-0.00369***	-0.0125***
	(0.000982)	(0.00420)
Internet	-0.125***	-0.100***
	(0.00803)	(0.0230)
log_pop	0.210***	0.454***
	(0.0451)	(0.0845)
Corruption	0.252***	0.747***
	(0.0178)	(0.229)

Constant	2.962	3.349
	(1.808)	(2.975)
Observations	342	321

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 and 5 present the results of estimates of models using quantile regressions. We run regressions for quartiles Q1 corresponding to α=25%, Q2 corresponding to α=50% and Q3 corresponding to α=75%.

Table 4. Regression results using quantile regressor

VARIABLES	(Q25) log_affect	(Q50) log_affect	(Q75) log_affect
Urban	0.317***	0.656***	0.108***
	(0.0108)	(0.116)	(0.024)
log_gdp	-0.469***	-0.914***	-1.002***
	(0.123)	(0.285)	(0.269)
Mobilecell	0.00861	-0.00857	-0.0153
	(0.00772)	(0.00792)	(0.00972)
Internet	-0.406***	-0.181***	-0.421***
	(0.0361)	(0.0417)	(0.0319)
log_pop	0.546**	0.527**	0.509***
	(0.236)	(0.239)	(0.183)
Corruption	0.979***	0.457***	0.978**
	(0.247)	(0.170)	(0.423)
Constant	20.74***	25.95***	29.10***
	(4.986)	(4.554)	(4.178)
Observations	162	103	77

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5. REGRESSION OF LOG_DEATH USING QUANTILE ESTIMATOR

VARIABLES	(Q25) log_death	(Q50) log_death	(Q75) log_death
Urban	0.614***	0.166***	0.414***
	(0.0736)	(0.0678)	(0.0922)
log_gdp	-0.318***	-0.176***	-0.211***
	(0.0236)	(0.0180)	(0.0257)
Mobilecell	0.0111	-0.00168	-0.00691
	(0.00767)	(0.00541)	(0.00726)
Internet	-0.173***	-0.758***	-0.167***
	(0.0252)	(0.0170)	(0.0179)
log_pop	0.409**	0.195	0.171
	(0.171)	(0.135)	(0.182)
Corruption	0.474***	0.322***	0.244***

	(0.0362)	(0.0274)	(0.0378)
Constant	-1.736	0.434	2.931
	(3.367)	(2.592)	(3.631)
Observations	117	101	103

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Two main results that emerge from the estimations of equations 2 and 3 using quantile regression. First, the results are robust: on the one hand, the positive links between urbanization, population, corruption and the number of people affected by the occurrence of natural disasters are robust whatever the quartile level. On the other hand, the negative relationships between economic growth, the use of internet and the number of people affected by natural disasters are robust. Secondly, concerning total_deaths, the quantile regression confirms the results obtained with the Fixed-effects (FE) Poisson estimator and the main determinants of the total of deaths due to natural disasters are urbanization, GDP, internet diffusion, population and corruption.

Transmission channels analysis

In this section, we check the transmission channels of urbanization on the consequences of natural disasters. So we construct interaction variables between urbanization and the others variables. Tables 6 and 7 provide the estimation results using OLS.

Table 6. Transmission channels of log_affect

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log_affect	log_affect	log_affect	log_affect	log_affect	log_affect
urban_gdp	-0.143***					-0.489***
	(0.0182)					(0.0464)
urban_pop		-0.0921				-0.148
		(0.0669)				(0.201)
urban_mobile			-0.0568***			-0.216*
			(0.00791)			(0.123)
urban_internet				-0.0880***		-0.0820**
				(0.0202)		(0.0328)
urban_corr					0.305***	0.245**
					(0.0654)	(0.101)
Constant	11.47***	10.33***	11.54***	11.33***	12.79***	8.665***
	(0.193)	(0.223)	(0.211)	(0.257)	(0.372)	(1.380)
Observations	342	342	342	342	342	342
R-squared	0.368	0.018	0.327	0.260	0.307	0.745

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7. Transmission channels of log_death

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	log_death	log_death	log_death	log_death	log_death	log_death

urban_gdp	-0.144***					-1.545***
	(0.0181)					(0.408)
urban_pop		0.116*				0.361*
		(0.0664)				(0.176)
urban_mobile			-0.0603***			-0.138
			(0.00763)			(0.108)
urban_internet				-0.0960***		-0.0782**
				(0.0190)		(0.0288)
urban_corr					0.346***	0.194**
					(0.0512)	(0.0886)
Constant	11.58***	10.41***	11.72***	11.38***	13.20***	8.844***
	(0.192)	(0.221)	(0.204)	(0.242)	(0.291)	(1.214)
Observations	321	321	321	321	321	321
R-squared	0.371	0.028	0.371	0.322	0.483	0.805

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results suggest that GDP tempers the positive effect of urbanization on the scale of natural disasters in studied countries. In fact, the more a country is developed, the more he could face consequences of natural disasters. Also, digital technologies –internet and mobile phones- temper the relationship between urbanization and the magnitude of natural disasters in the studied context. But, corruption speed up the negative impact of urbanization on the scale of natural disasters.

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5. Conclusion

The aim of this paper was to empirically analyze the effect of rapid urbanization in Africa on the magnitude of natural disasters. Focusing specifically on floods and droughts, we analyze the impact of urbanization on the number of people affected, on the one hand, and on mortality, on the other. Using the OLS, FE Poisson regression and quantile regression estimators, the results suggest that the rapid and anarchic urbanization observed in the African context increases the incidence of these natural disasters, by increasing both the total number of individuals affected and the total number of people who die. Among other important results, we show that income level, infrastructure (measured here by ICT infrastructure) and the quality of public governance affect the magnitude of the consequences of natural disasters in the African context. These results underline the urgent need to rethink urbanization policies in Africa to take better account of the risk of natural disasters. This requires housing and land-use policies that are better adapted to the risk of natural disasters. Political leaders and the civil society should also provide better training to populations on natural disaster management in order to reduce the impact of such events when they occur. They should also promote the adoption of ICTs and use them to communicate about the risk of natural disasters and their consequences.

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