Analyze the Three Dimensions of Vulnerability to Climate Change to Better Understand Environmental Injustice: An Interdisciplinary Case-Study in Abidjan, Cote d'Ivoire

Stéphanie Dos Santos, Abdul Wahab Karamoko, Attoumane Artadji and Eric-Pascal Zahiri

Worldwide, extreme events related to climate are becoming more and more frequent, mainly because of an ever-increasing number of urban floods and storms. From 1995 to 2015, floods alone represented 47 per cent of all climate-related disasters, affecting more than two billion people (UNISDR 2015). In Africa, cities are particularly vulnerable to flooding (Douglas et al. 2008). Since the 1990s, the need to consider the vulnerability of populations in risk-management analysis has been widely recognized. Turner et al. (2003), and later Birkmann and Wisner (2006), have provided a comprehensive conceptual framework that integrates the multidimensional nature of vulnerability at different scales and in different contexts. Turner et al (2003) define vulnerability in terms of three dimensions: exposure, sensitivity and resilience. The literature on vulnerability to flooding highlights the multiple dimensions of risk factors. However, little research has analyzed these three joint dimensions. For exemple, there is a clear lack of research on effects of environmental and social factors on flood risk at the household level in African cities. Through an interdisciplinary research project (demography, geography, physics and hydrology) in Abidjan, the major city of Côte d'Ivoire, we have been able to carry out research on the three dimensions of vulnerability.

First, we analyzed the exposure through historical rainfall data from 1961 to 2014 in order to determine the mean trend of rainfall that reflects an increase in the occurrence of extreme events. In addition to this historical analysis, we analyzed the extent of rainfall variability during the same extreme event, from a measurement network of 25 stations distributed throughout the city of Abidjan. This analysis made it possible to highlight differential exposure within the same city.

Then, we use an interdisciplinary population survey to analyze the differentiated significance of social and environmental variables associated to the status of 'flood victim'. The data used were collected in a quantitative survey of 503 households residing in two contrasting neighborhoods of Abidjan (Figures 1).

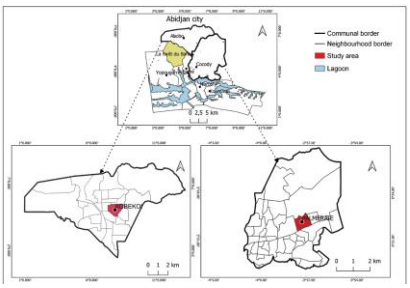

Figure 1. Localisation of Agbekoi (bottom left) and Palmeraie (bottom right) neighbourhoods in the city of Abidjan (top)

The descriptive results show that there is significant variability in risk exposure reported by households themselves. Thus, households surveyed at Agbekoi (the poorest neighbourhood) less often declare that they have been victims of flooding in their dwelling during the period 2009-2018 than the households in the Palmeraie (the richest neighbourhood), with a proportion of flooding victims of respectively 13.5% and 39.4% (Figure 2).

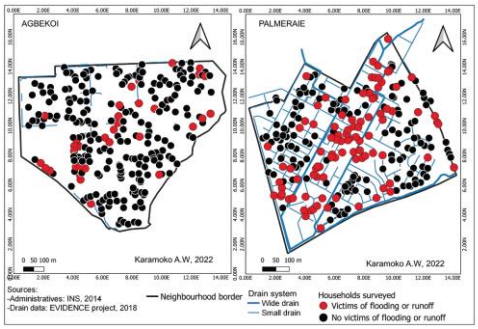

Figure 2. Spatial distribution of households surveyed in Agbekoi (left) and Palmeraie (right) and drainage pipes

Modelling data with logistic regressions, the results show that physical variables (the slope of the housing plot), environmental variables (liquid and solid waste disposal) and social variables (the gender of the head of household or the composition of the household) are factors jointly associated with flood risk (Table 1).

Table 1. Frequencies and multivariate models with estimated net effects [odds ratios and adjusted significance levels] on the status "affected by flood", taking into account physical, environmental/housing, socio-economic and neighbourhood variables – Abidjan, Côte d'Ivoire. Source: EVIDENCE.

Independent Variables	***Frequencies %***	**Model 1 OR**	**Model 2 OR**	**Model 3 OR**	**Model 4 OR**
Outdoor gutter (yes)	*(28.8)*				
No	*71.2*	0.58**			0.80
Distance to the rainwater pipe (continuous var.)		0.99***			0.99
Slope (small)	*(34.4)*				
Medium	*32.4*	0.70			0.64*
High	*33.2*	1.22			0.95
Roof (metal or tile)	*(72.2)*				
Concrete slab	*25.6*		1.56		0.71
Plastic sheet	*2.2*		1.22		1.62
Wall (cement or brick)	*(91.2)*				
Wood	*8.8*		1.21		0.10***
Ground (tiles)	*(45.3)*				
Cement	*45.5*		0.98		2.12**
Other (sand, etc.)	*9.2*		3.07**		6.84***
Wastewater management (sewer)	*(44.1)*				
Septic tank	*36.4*		0.84		2.68**
Other (thrown outside, street, etc.)	*19.5*		0.96		3.38**
Solid waste disposal (public sector collection system)	*(25.9)*				
Private sector collection system	*42.7*		1.89**		1.62*
Other (thrown outside, street, etc.)	*32.4*		0.60		1.10

Sex of the household head - HH (male)	*(80.1)*		
Female	*19.9*	1.61*	2.27***
HH's age (less than 45 years)	*(40.2)*		
45-59 years	*35.0*	1.29	1.32
60 years and over	*24.8*	1.17	1.33
HH's education (none)	*(24.8)*		
Primary	*15.9*	1.41	1.39
Secondary	*22.5*	1.87*	1.68
Higher	*36.8*	1.66	0.83
HH's place of birth (Abidjan)	*(34.6)*		
Other towns	*38.2*	1.12	0.89
Rural area	*17.7*	0.95	0.95
Abroad	*9.5*	2.11*	1.30
HH's duration of residence in the neighborhood (< 10 years)	*(30.0)*		
10-19 years	*31.6*	1.02	1.27
20 years and over	*38.4*	0.53+	1.04
HH's residential status (owner)	*(46.1)*		
Tenant	*40.6*	0.65	0.93
Hosted	*13.3*	1.25	1.58
Number of usual members in the household (1-4)	*(24.4)*		
5-9	*53.3*	1.47+	2.03**
10 and over	*22.3*	1.03	1.60+
Life level index (low)	*(39.2)*		
Medium	*28.6*	1.28	1.60
High	*32.2*	1.18	0.69
Neighbourhood (Agbekoi)	***(50.1)***		
Palmeraie	*49.9*		40.0***

Reference category in parenthesis. Significant levels : *** p<1% ; ** p<5% ; * p<10% ; + p<15%

Finally, to complete this analysis of vulnerability, field observation data and interview surveys were used to study the 3rd dimension, namely resilience, and in particular the ability to give oneself the right and to have the right to rebuild. In particular, the content analysis of 51 interviews was carried out as part of this project in Agbekoi and Palmeraie neighborhoods. These include 22 individual interviews and 3 discussion groups in Agbekoi and 2 focus groups and 24 individual interviews in Palmeraie.

The analysis of flood management by people themselves, by communities and by public authorities, is particularly revealing of environmental injustices. For example, we can highlight the differentiated post-crisis management between these two types of neighborhood by authorities. In the poorest neighborhoods (Agbekoi) public authorities carry out forced resettlement to "protect the population from future risk" (Figure 3). However, this type of phenomenon does not exist in the most of the wealthy neighborhoods (Palmeraie) affected by the disaster. The authorities' response in these wealthy neighborhoods is largely based on major infrastructure works. In this respect, the political management of forced resettlement is particularly emblematic of the differential resilience between the city's inhabitants.

Figure 3 – Forced resettlement of the population following the floods of 2023, Abidjan

On the other hand, in poor neighborhoods, material aid and financial support following forced resettlement can be seen as a fairer mitigation of environmental ills. Hence, public action can also be seen as a temporary compromise, making situations of injustice temporarily acceptable. However, in view of the very low level of compensation and the various consequences of a forced resettlement for an individual and its family, these management reflect, in reality, a response unequal (forced resettlement versus infrastructure) and unjust related to relationship to rights and power: residents of Palmeraie have higher levers of power (sometimes they themselves have the decision-making power) than the residents of Agbekoi.

Understanding resilience as the ability to give oneself and have the right to rebuild, highlights the way in which vulnerability of floods in this city is territorially and socially situated. This case study in Abidjan is particularly revealing of the complexity of environmental injustices linked to climate change.

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