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Drought and Human Mobility in Africa

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Key Points:

- A new methodology integrating satellite data is developed for evaluating drought-induced human displacements in Africa
- We found that 70%–81% of African countries exhibit larger displacements during droughts, as compared to non-drought periods
- Human displacement toward rivers and urban centers is triggered, other things being equal, by drought occurrences

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract

Human mobility from droughts is multifaceted and depends on environmental, political, social, demographic and economic factors. Although droughts cannot be considered as the single trigger, they significantly influence people's decision to move. Yet, the ways in which droughts influence patterns of human settlements have remained poorly understood. Here we explore the relationships between drought occurrences and changes in the spatial distribution of human settlements across 50 African countries for the period 1992–2013. For each country, we extract annual drought occurrences from two indicators, the international disaster database EM-DAT and the standardized precipitation evapotranspiration index (SPEI-12) records, and we evaluate human settlement patterns by considering urban population data and human distance to rivers, as derived from nighttime lights. We then compute human displacements as variations in human distribution between adjacent years, which are then associated with drought (or non-drought) years. Our results show that drought occurrences across Africa are often associated with (other things being equal) human mobility toward rivers or cities. In particular, we found that human settlements tend to get closer to water bodies or urban areas during drought conditions, as compared to non-drought periods, in 70%–81% of African countries. We interpret this tendency as a physical manifestation of drought adaptation, and discuss how this may result into increasing flood risk or overcrowding urban areas. As such, our results shed light on the interplay between human mobility and climate change, bolstering the analysis on the spatiotemporal dynamics of drought risks in a warming world.

Plain Language Summary

Prolonged water shortages induced by droughts can have severe consequences on both the environment and society. For instance, the mobility of people can be influenced by drought events. In order to test this assumption, we relate the movement of people to drought occurrences, without considering any additional factor. We focus on Africa, since it is one of the most drought-prone continents and the movement of people is more prominent compared to other areas. We find that people tend to move closer to rivers and to urban centers during droughts, as compared to non-drought periods. This pattern is found for the majority of African countries, which suggests a large-scale signal. The increased movement of people toward rivers during droughts might generate larger human losses if flood events take place in the future.

1. Introduction

Drought is a complex slow-onset phenomenon, characterized by prolonged water shortages triggered by both natural (precipitation deficit) and anthropogenic (e.g., increased water demand) factors (Aghakouchak et al., 2021; Mishra & Singh, 2010; Van Loon et al., 2016). Climate change and increased human pressure on available water resources have contributed to enhance the frequency and severity of drought events in many regions of the world (Aghakouchak et al., 2014; Caretta et al., 2022; McDonald et al., 2011; Mishra et al., 2019). In most African countries, droughts have become more intense, frequent and widespread over the past 50 years (Masih et al., 2014), with increased multi-year droughts in some parts (Archer et al., 2022; Caretta et al., 2022). Although droughts accounted for 7% of all disaster events reported during the period 1970–2019, droughts contributed to 34% of disaster-related deaths, whereof the majority was in Africa, with global average annual losses ranging around 50 billion USD (WMO, 2021).

Human displacements due to climate and weather extremes are dramatically increasing worldwide, mainly across areas where extreme events interact with high vulnerability and low adaptive capacity, such that they are now recognized as a primary humanitarian challenge of the 21st century (Black et al., 2013; Caretta et al., 2022; Hossain et al., 2022; Kakinuma et al., 2020; Robalino et al., 2015; UNDRR, 2021). Disaster displacements regularly reach around 25 million people each year, being three-fold higher than people displaced by conflicts and violence (IDMC, 2020).

Droughts have been linked to both short-term human mobility (Black et al., 2011; Linke et al., 2018), as a solution to diversify income, and long-term migration (Borgomeo et al., 2021; IDMC, 2020). So far, the nexus between human displacement and climate-related extremes, such as droughts, has remained underexplored (Hermans & McLeman, 2021; Thalheimer et al., 2021). Moreover, while the occurrence of climate-related extremes can be associated with human mobility, poverty, conflicts or other social processes also play a major role as determining factors (Abel et al., 2019; Barnett & Webber, 2010; Czaika & Reinprecht, 2020). Concurrently, as the ability to move is also correlated with wealth, vulnerable people are also the less mobile ones and can often become trapped (Black et al., 2013). A review of mobility studies in Africa suggests that environmental change is more often related to short-distance mobility, rather than long-distance international migration (Jonsson, 2010; Trisos et al., 2022; Xu & Famiglietti, 2023). Droughts, through adverse effects on livelihoods or unsustainable agricultural practices, can influence temporary and permanent migration (Black et al., 2011; Caretta et al., 2022; IDMC, 2020; Linke et al., 2018). For example, drought periods can increase incentives to settle closer to rivers (Zaveri et al., 2021), as floodplains often have easier access to water resources, or closer to cities (Jayawadhan, 2017), as urban areas typically offer alternative labor opportunities. It has been reported that at least 1.6 million new displacements linked to droughts had occurred from 2009 to 2018 in Africa, with Somalia, Ethiopia, Angola, Botswana, Burkina Faso, Chad, Namibia and Niger being the most drought-affected countries (IDMC, 2019). For example, during the Somalia drought (2016–2017), there were 926,000 newly displaced people reported that were accommodated in Mogadishu and other cities, leading to increased population and overcrowding in urban areas (World Bank, 2018). However, these reports and studies are not fully representative of Africa since human displacements to droughts are only reported for some countries and partially (IDMC, 2019).

Here we explore the relationships between drought occurrences and changes in the spatial distribution of human settlements across 50 African countries for the period 1992–2013. We base our continental study on urban population data (World Bank, 2020) and nighttime lights (NOAA, 2020), as a proxy for the spatial and temporal distribution of human settlements. For each country, we evaluate annual relative urban population (%) and human distance to rivers [km] (Ceola et al., 2015; Mård et al., 2018). To identify drought years, we extract annual drought occurrences from two indicators, the international disaster database EM-DAT (EM-DAT, 2020) and the standardized precipitation evapotranspiration index (SPEI-12) records (Beguería et al., 2014). We then compute human displacements as variations in human distribution between adjacent years, which are then associated with drought (or non-drought) years. We finally examine the consistency between drought occurrences and changes in human settlement patterns to identify macroscopic trends at the continental scale.

2. Materials and Methods

2.1. Data on Human Settlement Patterns

Since long-term yearly data on human displacements are not consistently available for the entire African continent, we employ both country-based and spatially explicit data sets as reliable proxies. Country-based yearly values of urban and total population estimates are obtained from the freely available World Bank data set (World Bank, 2020), which combines census data gathered from different sources. Spatially explicit yearly data on human presence and activity are derived from nighttime lights, provided by the Defense Meteorological Satellite Program, Operational Linescan System and freely accessible from the NOAA National Geophysical Data Center (NOAA, 2020). Nighttime lights provide yearly averaged nocturnal luminosities (from 0 to 63), proportional to radiance, which identify lights from cities and towns. Data, available at 0.00833° spatial resolution (nearly 1 km at the Equator), are intercalibrated (Ceola et al., 2014; Elvidge et al., 2009) before any further application.

We define two different variables for evaluating yearly variations in human distribution at the country level, $h(c,y)$, where c and y refer to country and year, respectively. The first one is the relative urban population, namely $h(c,y) = \mathrm{urb}(c,y)$ [%], computed for each country c and each year y as the ratio between urban and total population yearly data. Urbanization rates are widely used as a proxy for internal migration, which represents the main water-driven migration pattern (Gray & Mueller, 2012; Xu & Famiglietti, 2023), although they may overlook certain forms of migration and displacements such as rural-to-rural, urban-to-rural and urban-to-urban (Hoffmann et al., 2020). The second variable describing human distribution is represented by the human distance to rivers, namely $h(c,y) = rd(c,y)$ [km], where for each country c and each year y we couple nighttime light intensity

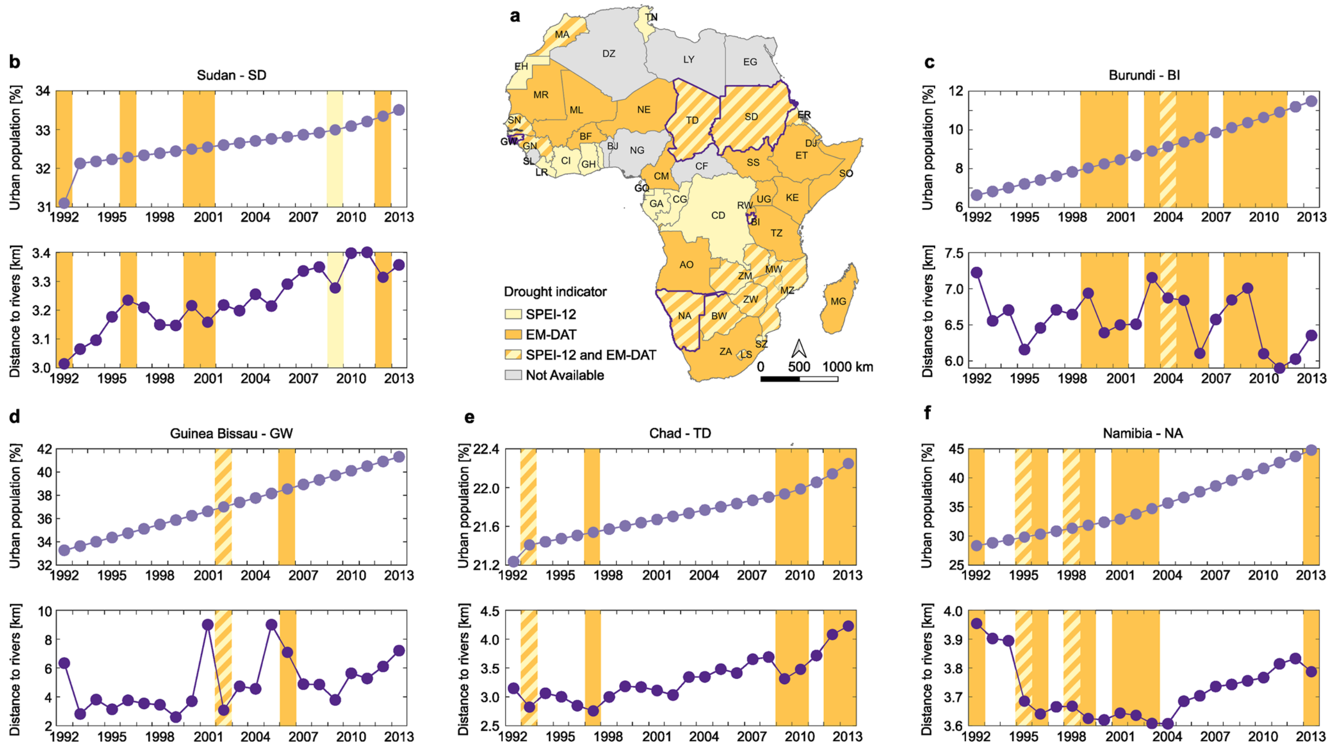

Figure 1. Drought occurrence and variations in human settlement patterns for representative countries within the UN subregions for Africa. (a) Country-based availability of drought records according to SPEI-12 (light yellow) and EM-DAT (orange) indicators. Countries that experienced droughts according to both indicators are shown with a striped light yellow and orange pattern. Countries shown in panels (b–f) are highlighted with a purple boundary. (b) Temporal evolution of yearly urban population (top, light purple circles), human distance to rivers (bottom, purple circles) and drought occurrence according to SPEI-12 (light yellow background) and EM-DAT (orange background) records for Sudan (Northern Africa). (c) Same as in b, but for Burundi (Eastern Africa). (d) Same as in (b) but for Guinea Bissau (Western Africa). (e) Same as in (b) but for Chad (Central Africa). (f) Same as in (b) but for Namibia (Southern Africa).

with the geographical location of the river network, following the methodology developed in Ceola et al., 2015. More specifically, from the identification of river network grid cells gathered from HydroSHEDS (Lehner & Grill, 2013), which have the same spatial resolution as nighttime lights and have at least 1,000 km^2 contributing area, we identify 10 distance classes from rivers based on Euclidean distance, and compute $rd(c,y)$ as follows:

$$rd(c, y) = \frac{\sum_{j=1}^{10} j \cdot \mathrm{SOL}_j(c, y)}{\sum_{j=1}^{10} \mathrm{SOL}_j(c, y)} \tag{1}$$

where $\mathrm{SOL}_j(c,y)$ is the sum of nighttime lights in distance class j, country c and year y. Variations in human distribution patterns, as relative urban population and human distance to rivers, are shown in Figures 1b–1f for some representative countries.

2.2. Data on Drought Occurrences

In order to identify drought occurrences, hydrologically based indices and/or inventories data gathered from for example, UN agencies, non-governmental organizations, reinsurance companies, research institutes and press agencies, could be effectively used. For each country, we hereby extract drought occurrences in each calendar year (Figure 1) using two indicators, the international disaster database EM-DAT (EM-DAT, 2020) and the standardized precipitation evapotranspiration index SPEI (Beguería et al., 2014). The EM-DAT database provides data on the occurrence and impacts of technological and natural hazard-related disasters, including droughts. For a disaster to be entered into the EM-DAT database at least one of the following criteria must be fulfilled: (a) 10 or more people reported killed, (b) 100 or more people reported affected, (c) declaration of a state of emergency, (d) call for international assistance. Drought records from the EM-DAT database refer to a period of below-normal water availability, including precipitation, soil moisture, surface and subsurface water deficits. The SPEI is among the most acknowledged drought indexes used for the identification of anomalies in surface and subsurface water (Van Loon, 2015). We employ SPEI data at

12-month timescale available from SPEIbase (SPEIbase, 2020), a global SPEI database with a 0.5° spatial resolution (nearly 25 km at the equator) and a monthly time resolution. For each country c and each year y, we calculate yearly average country-based values and apply a threshold equal to -1 to classify them as drought or non-drought years, that is, ≤ -1 or > -1, respectively. Figure 1 shows the availability, at the country level, of drought records according to EM-DAT and SPEI-12 indicators and the occurrence of drought years for some representative countries.

2.3. Drought-Induced Changes in Human Settlement Patterns

To check if droughts induce incentives for moving toward rivers or urban centers, all other things being equal, the following computational steps are performed. For each country c:

1. Compute human displacements for every year y as the difference in human distribution between two adjacent years with respect to either the antecedent year, $\Delta h_{\mathrm{ANT}}(c,y) = h(c,y) - h(c,y-1)$, starting from 1993 (i.e., not available for the initial year 1992), or the subsequent year, $\Delta h_{\mathrm{SUB}}(c,y) = h(c,y+1) - h(c,y)$, ending in 2012 (i.e., not available for 2013).
2. For both $\Delta h_{\mathrm{ANT}}(c,y)$ and $\Delta h_{\mathrm{SUB}}(c,y)$, in what follows simply listed as $\Delta h(c,y)$, attribute $\Delta h(c,y)$ either to drought years if y is a drought year, y_D, that is, $\Delta h(c,y_D)$, or to non-drought years if y is a non-drought year, y_{ND}, that is, $\Delta h(c,y_{\mathrm{ND}})$, and compute median values of human displacements for drought, $\Delta h_{50}(c,y_D)$, and non-drought years, $\Delta h_{50}(c,y_{\mathrm{ND}})$.
3. For both $\Delta h_{\mathrm{ANT}}(\mathrm{c},y)$ and $\Delta h_{\mathrm{SUB}}(c,y)$, compute the average human displacement in the whole period, $\langle \Delta h(c) \rangle$, without distinguishing between drought and non-drought years.

Based on these steps, increased human displacements toward rivers during droughts occur if, during these years, there is a reduction in human distance to rivers (i.e., people move toward rivers, corresponding to an increased human proximity to rivers) compared to non-drought years or to the whole study period. In mathematical terms this reads $\Delta rd_{50}(c,y_D) < \Delta rd_{50}(c,y_{\mathrm{ND}})$, when comparing drought versus non-drought years, and $\Delta rd_{50}(c,y_D) < \langle \Delta rd(c) \rangle$, when comparing drought years versus the whole period. Similarly, increased human displacements toward urban centers during droughts occur if, during these years, there is a larger increase in relative urban population (i.e., people move toward urban areas) compared to non-drought years or the whole study period. Thus, this reads $\Delta \mathrm{urb}_{50}(c,y_D) > \Delta \mathrm{urb}_{50}(c,y_{\mathrm{ND}})$, when comparing drought versus non-drought years, and $\Delta \mathrm{urb}_{50}(c,y_D) > \langle \Delta \mathrm{urb}(c) \rangle$, when comparing drought years versus the whole period.

3. Results

3.1. Drought-Induced Incentives for Human Displacements Toward Rivers and Urban Areas Across Africa

Our analysis shows significant macro-trends of drought-induced incentives to settle closer to rivers or urban areas across Africa (Figure 2; Figure S1 and S2 in Supporting Information S1). According to EM-DAT and SPEI-12 records, 33 and 27 African countries, respectively, experienced droughts during this period (Tables S1 and S2), with 63%–81% of countries showing increasing human displacements likely associated to droughts (Figure 3; Figure S3 and Table S3 in Supporting Information S1). In a drought-prone continent such as Africa, where human mobility is more prominent compared to other continents, we find that human settlements have got closer to rivers during drought years in the majority of the considered countries (48%–74%). Our interpretation of this trend is that drought occurrences provide additional incentives for people to settle closer to available water resources in order to sustain their livelihood. The assessment of human mobility toward urban centers during drought years is less clear, with an increase of 30%–55% in the considered countries. Nonetheless, this pattern is one- to three-fold larger than the occurrence of a reverse human displacement pattern (i.e., toward rural areas). During droughts, cities and urban areas attract people to diversify their income, since agricultural activities are no longer feasible in dry rural areas.

3.2. Sensitivity Analysis

Country-based variations in human displacements to droughts between adjacent years depend on which human distribution variable (relative urban population or human distance to rivers) and drought indicator (EM-DAT or SPEI-12 records) are employed, whether the antecedent or subsequent year is considered and whether drought years are opposed to either non-drought years or the whole study period. Given the variety of the proposed approaches, differences and similarities need to be acknowledged to highlight relevant implications for further analysis as well as possible shortcomings.

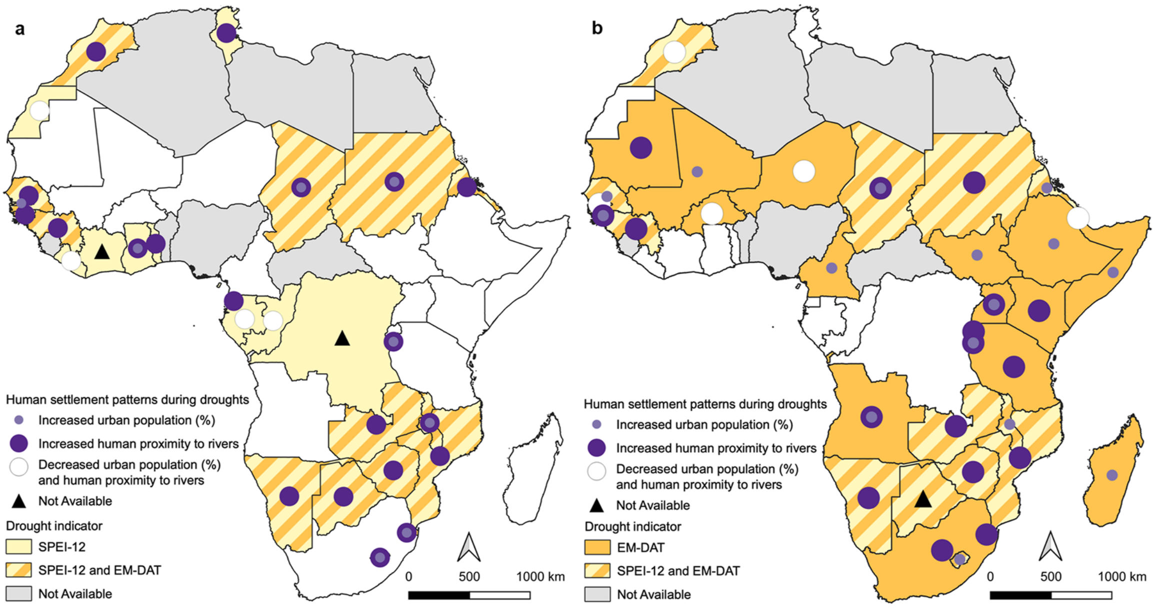

Figure 2. Drought-induced variations in human settlement patterns across Africa. (a) Country-based patterns of increased human displacement toward rivers (purple circles) and urban centers (light purple circles) between adjacent years (drought year and antecedent year), derived by comparing median values during drought and non-drought years, according to SPEI-12 drought records (light yellow). (b) Same as in a, but according to EM-DAT drought records (orange). Countries that experienced droughts according to both indicators are shown with a striped light yellow and orange pattern.

First, we perform a sensitivity analysis to compare and check the consistency of human displacement patterns toward rivers and urban centers by considering both drought indicators. Overall, 17 countries across Africa experienced droughts during 1992–2013 according to both EM-DAT and SPEI-12 records (Table 1), with

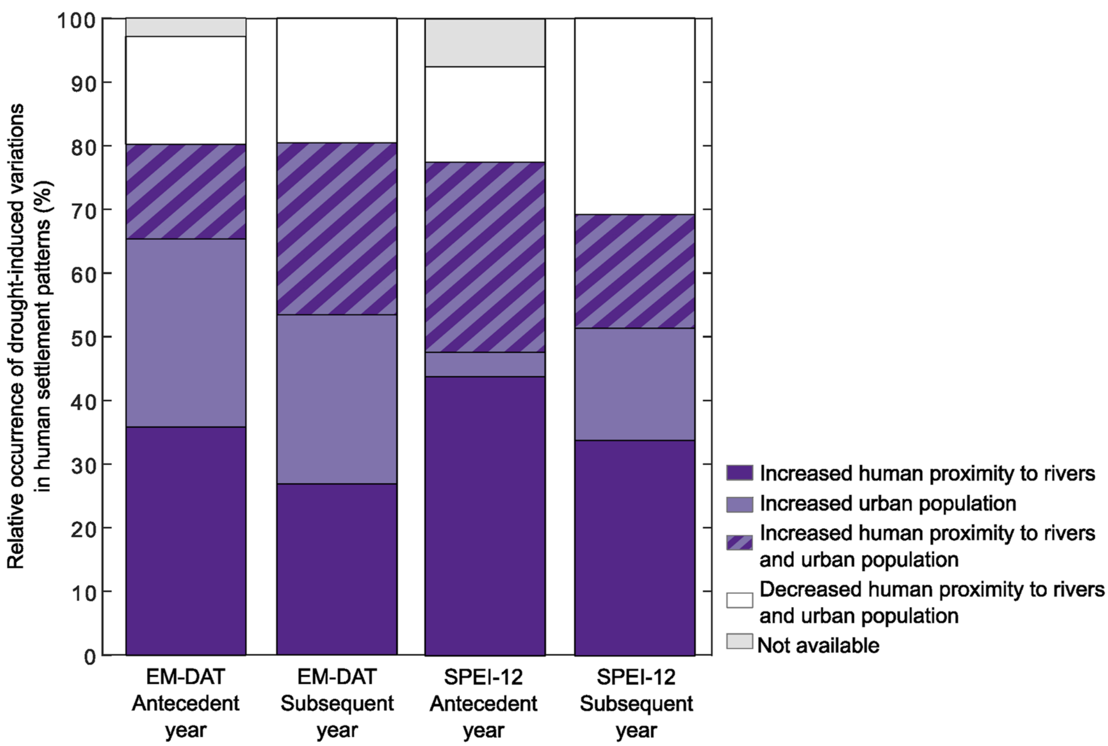

Figure 3. Relative occurrence (%) of drought-induced variations in human settlement patterns across Africa. Statistics are derived by comparing drought and non-drought years and are grouped according to the availability of drought records (EM-DAT and SPEI-12 records), whether the antecedent or subsequent year is considered.

Table 1
Comparison Between Human Settlement Patterns for African Countries Experiencing Droughts According to Both SPEI-12 and EM-DAT Records

UN subregion	Country name	Number of drought years	Drought years	Human settlement patterns during drought years, Δh_{ANT} §	Human settlement patterns during drought years, Δh_{ANT} #
Northern Africa	Morocco (MA)	2	1995, *2001*	●	●
		3	1999, 2000, *2001*	○	○
	Sudan (SD)	1	2009	◉	●
		5	1992, 1996, 2000, 2001, 2012	●	●
Eastern Africa	Burundi (BI)	1	*2004*	◉	◉
		11	1999, 2000, 2001, 2003, *2004*, 2005, 2006, 2008, 2009, 2010, 2011	◉	◉
	Eritrea (ER)	1	2012	●	●
		7	1993, 1999, 2000, 2001, 2002, 2003, 2008	•	•
	Malawi (MW)	5	*1992, 1994, 1995, 2005, 2006*	◉	•
		10	*1992*, 1993, *1994*, *1995*, 2002, *2005*, *2006*, 2007, 2012, 2013	•	○
	Mozambique (MZ)	2	*1992, 2006*	●	●
		12	*1992*, 1998, 1999, 2001, 2002, 2003, 2005, *2006*, 2007, 2008, 2009, 2010	●	●
	Zambia (ZM)	2	*1992, 1995*	●	●
		3	*1992, 1995*, 2005	●	●
		2	*1992, 1995*	◉	◉

Table 1
Continued

	Zimbabwe (ZW)	15	*1992*, 1993, 1994, *1995*, 1998, 2001, 2002, 2003, 2007, 2008, 2009, 2010, 2011, 2012, 2013	●	●
Central Africa	Chad (TD)	1	*1993*	◉	◉
		7	*1993*, 1997, 2001, 2009, 2010, 2012, 2013	◉	◉
Western Africa	Gambia (GM)	1	*2002*	•	•
		2	*2002*, 2012	○	○
	Guinea (GN)	2	2002, 2007	●	●
		1	1998	●	●
	Guinea Bissau (GB)	1	*2002*	●	●
		2	*2002*, 2006	◉	◉
	Senegal (SN)	3	1992, 1993, *2002*	●	●
		4	*2002*, 2011, 2012, 2013	•	◉
Southern Africa	Botswana (BW)	3	*1992*, 1993, 1995	●	●
		1	*1992*	NA	NA
	Lesotho (LS)	5	*1992, 1993*, 1995, *2003*, 2005	◉	◉
		9	*1992, 1993*, 1994, 2002, *2003*, 2007, 2008, 2011, 2012	•	○
	Namibia (NA)	2	*1995, 1998*	●	●
		9	1992, *1995*, 1996, *1998*, 1999, 2001, 2002, 2003, 2013	●	●
	Swaziland (SZ)	2	*1992, 1995*	◉	◉
		9	*1992*, 1993, 1994, *1995*, 2001, 2002, 2003, 2004, 2007	●	●

Note. Countries are grouped according to the five UN subregions for Africa. Drought years, total number and list, are reported (common drought years are in italic). Changes in human settlement patterns, as increased urban population (light purple circles), increased human proximity to rivers (purple circles), decreased urban population and human proximity to rivers (white circles), are based on the difference between the drought year and the antecedent one. § (#) refers to the comparison between drought years and non-drought years (the whole study period).

some variability in the identification of drought years. About 35%–65% of the countries show increased human displacements toward rivers during drought years from both drought indicators, with the largest agreement rates observed when the antecedent year is considered (Table 1 and Table S4). Lower values characterize the level of agreement between drought indicators in terms of increased displacements toward urban centers during drought years, with only 12%–29% of the countries. In this case, the largest agreement rates are found when the subsequent year after drought is considered. We compare our assessments based on the antecedent and subsequent year and find that the level of agreement between drought indicators decreases remarkably from 71% to 53%, respectively, in the case drought years are juxtaposed with non-drought years, and from 65% to 41%, respectively, when drought years are compared against the whole study period (Table 1 and Table S4).

Next, EM-DAT and SPEI-12 drought records are considered separately. Identical human displacement patterns during droughts, as compared against either non-drought years or the whole study period, are found for about 67% and 69% of EM-DAT countries (76% and 85% of SPEI-12 countries), evaluated by considering the antecedent and subsequent year, respectively (Tables S1 and S2). When comparing the assessments based on the antecedent and subsequent year, consistent drought-induced displacement patterns emerge for about 69% of EM-DAT countries (64% of SPEI-12 countries), where increased displacements toward rivers and urban centers are found across 39% and 45% of the countries, respectively (40% and 24% for SPEI-12, Tables S1 and S2).

Our results show that human displacements toward rivers, as derived from nighttime lights, are more detectable on the drought year compared to the antecedent one. Nighttime lights provide an annual average value, which may embed occasional decreasing luminosities when droughts occur and likely show a response associated to droughts. On the contrary, the effects on population data (i.e., human displacements toward urban centers) are more evident on the year following the drought, since population data are midyear estimates. Furthermore, more pronounced evidence of increased human displacements during droughts is found when drought years are juxtaposed with non-drought years rather than the whole study period without any distinction.

3.3. Subregional Patterns of Human Displacements During Droughts Across Africa

Results are then grouped according to the five UN subregions for Africa. Following EM-DAT records, droughts have occurred particularly across Eastern and Southern Africa, then followed by Western, Central and Northern Africa (Figure 1). Drought events derived from SPEI-12 records have mainly affected Central, Southern, Western (concentrated in the southern extreme) and Eastern Africa (all located along the Guinea Gulf). Our results (Tables S1 and S2) show that the largest occurrence rates of increased human displacements toward rivers during drought years are found in Southern Africa (50%–100% and 100% of countries, for EM-DAT and SPEI-12 records, respectively), followed by Eastern Africa (43%–64% and 50%–100%), Western Africa (38%–63% for both drought indicators), Central Africa (33%–66% and 40%) and Northern Africa (0%–50% and 25%–75%). Clear signals of increased human displacements toward rivers during droughts are consistently found across Burundi (Figure 1c), Mozambique and Zimbabwe for Eastern Africa, Chad (Figure 1e) for Central Africa, Guinea and Guinea Bissau (Figure 1d) for Western Africa and Namibia (Figure 1f) and Swaziland for Southern Africa. Similar outcomes can be drawn from the analysis of human displacements toward urban centers during droughts, with plain evidence of increased patterns typical of Burundi (Figure 1c) and Malawi for Eastern Africa, Chad (Figure 1e) for Central Africa and Lesotho for Southern Africa. We also explored if distinctive features characterize these countries and analyzed the role played by the GINI Index (i.e., a deviation from a perfectly equal distribution of income and consumption among individuals, ranging from 0—perfect equality, to 100—perfect inequality, World Bank, 2020) and the Agricultural Gross Domestic Product (GDP, expressed as % and per capita values in current international dollars converted by purchasing power parity (PPP) conversion factor, World Bank, 2020). As expected, these countries share a larger GINI index, as compared to the median value characterizing the whole African continent. They also tend to present lower than average values for the Agricultural GDP (both % and per capita), thus revealing a potential contribution to an increased vulnerability to drought-induced human displacements (Table S5 in Supporting Information S1).

4. Conclusions and Discussion

Human mobility from droughts is multifaceted and depends on environmental, political, social, demographic and economic factors (Black et al., 2011). These external factors refer to the magnitude, severity, duration and spatial extension of drought events from an environmental view point, the development of policy incentives or subsidies from a political perspective, the level of education and family/kin obligations from a social perspective, the size and density of population, the proportion between urban and rural population, the age structure from a demographic side and the employment opportunities and livelihoods from an economic side. Besides these external factors, internal adaptive capacities interact also with people's decision to move, which conjunctly reflects individual and household contexts and can be mediated by institutions, who could either prevent or enhance migration. A controversial discussion is currently taking place in the scientific literature: a lot of empirical studies exist, but with different levels of contribution (i.e., drought influences/does not influence human mobility) and with different spatial and temporal levels of analysis. However, an extensive literature review (see Hoffmann et al., 2020) clearly reports that environmental factors are considered to be a key driver of human migration and mobility in the majority of the examined studies. Although droughts cannot be considered as the single trigger, they significantly influence people's decision to move (Xu & Famiglietti, 2023). Furthermore, economic shocks and conflicts associated to droughts are known to trigger human mobility (Cattaneo et al., 2019; Hoffmann et al., 2020).

Human mobility and migration represent increasingly important strategies for climate change adaptation and disaster risk reduction. Focusing on Africa, future socio-economic and climatic scenarios will likely enhance impacts of droughts on society (Ahmadalipour et al., 2019; Wanders & Wada, 2015). There are concerns that a >2°C global warming will significantly increase the frequency of precipitation deficits and double drought duration from 2 to 4 months over Northern Africa, western Sahel and Southern Africa (Trisos et al., 2022). With up to 3°C global warming, droughts are projected to increase between 3- and 20-fold for most of Africa (Trisos et al., 2022). Meanwhile, population living on African drylands are expected to double by 2050 (Mirzabaev et al., 2019). Urban extent in drylands is projected to increase by ∼300%-700% in Africa by 2030 when compared to 2000, without considering climate change (Güneralp et al., 2015). Rapidly growing cities in Africa are anticipated to be risk hotspots for climate change and climate-induced human displacements, which can amplify pre-existing vulnerabilities (Trisos et al., 2022). Thus, it is timely to unravel the interplay between human mobility and hydrological extremes (Kreibich et al., 2022; Ward et al., 2020).

In this context, we explored the interplay between drought occurrence and variations in human settlement patterns across Africa, benefiting from the recent availability of spatially explicit data. Moving from this, we identified a consistent signal of larger human displacements toward rivers and urban areas during droughts for 70%–81% of African countries, other things being equal. This large-scale trend clearly highlights that the occurrence of drought events, although not being the single driving factor, significantly influences human mobility. By interpreting this outcome from a broader perspective, which includes compound hydrological extreme events, such as consecutive drought-to-flood events, adverse consequences might occur. An increased human presence in urban areas and close to rivers may result into an increased human exposure to floods, either pluvial, fluvial or coastal, and thus leading to a potentially increased flood risk. In this regard, Alfieri et al. (2017) recently assessed changes in flood risk at the global scale under specific warming levels associated to climate change and found an uneven distribution of changes, where statistically not significant changes seem to characterize most of the African countries. Further investigations are foreseen and encouraged to better understand the interplay between human mobility and climate change in order to increase the resilience of vulnerable areas and population to hydrological extreme events and support the development of sustainable and effective planning strategies for the near future.

Data Availability Statement

All data needed to evaluate the conclusions in the paper are present in the paper and are available publicly online. Input data for the assessment of human settlement patterns are openly available online at https://data.worldbank.org/indicator/SP.URB.TOTL and https://data.worldbank.org/indicator/SP.POP.TOTL, for urban and total population, respectively, and at https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html, for NOAA nighttime lights. River network data are openly available online at https://www.hydrosheds.org/products/hydrorivers#downloads. Drought occurrence records are openly available online at https://public.emdat.be/data (Disaster classification: Natural - Climatological, Location: Africa, from 1992 to 2013) for EM-DAT and at https://digital.csic.es/handle/10261/153475 (SPEIbase v.2.5) for SPEI-12. All custom codes are direct implementations of standard methods and techniques, described in detail in the paper.

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