Flood fatalities in Africa: from diagnosis to mitigation

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SUPPLEMENTARY DOCUMENT

This supplementary document includes: i) information and discussion about the four river basins having significant positive trends in floods; and ii) additional evidence that the dramatic increase of flood fatalities in Africa has been mainly caused by the increase of urban population and, in particular, human settlements in flood prone areas.

Positive flood trends

Among the four river basins having "significant" positive trends in floods (Table S1), River Congo at Kinshasa is of particular interest (Figure S1). In fact, the River Congo catchment is the second-largest drainage basin in the world, behind the Amazon, and encompasses climatic regimes ranging from humid tropical to savannah. Notably, there is no clear and unambiguous increase in flood magnitude over the entire period of record (Figure S1), although the 10-year moving average indicates that the flood magnitude increased during the period 1955-1965 and then decreased during the period 1965-1975. Similarly, no systematic change in the seasonality (Julian date) of the annual maximum is apparent.

Table S1. Summary of the 4 flood time series affected by significant positive trends

Station	River	Country	Observation Period	Catchment Area (km^2)	Climatic regime
Kinshasa	Congo	DR Congo	1902-1980	3,747,000	humid tropical/savannah
Niamey	Niger	Niger	1934-1979	700,000	savannah
Azib Soltane	Sebou	Morocco	1933-1973	17,000	dry sub tropical
Kanzene	Nybarongo	Rwanda	1956-1988	14,600	humid tropical

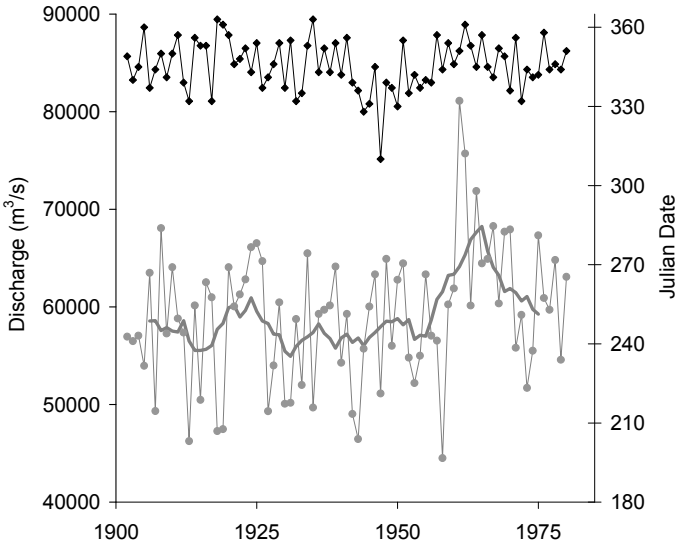

Figure S1. Time series of annual maxima flow (gray) for the Congo River at Kinshasa (Democratic Republic of Congo), its 10-year moving average, and its Julian date of occurrence (black).

Increased human settlements in flood prone areas

A simple demonstration of increased number of people living in flood prone areas can be obtained by referring to one of the standard methods for the estimation of the number of flood fatalities [e.g. *Jonkman*, 2005]:

Number of flood fatalities = Flood mortality X Number of people in flood prone areas

The Flood mortality is usually estimated by means of a dose-response function [e.g. *Jonkman*, 2007] as a function of the magnitude of the flood event. The estimation of this function is extremely difficult and uncertain. However, we have shown that, at the continental scale, the magnitude of flood event is not significantly changed. We can therefore assume that Flood mortality has not significantly changed either. By contrast the Number of flood fatalities has dramatically increased by an order of magnitude in the period 1950-2010. This implies that the Number of people in flood prone areas has increased by an order of magnitude. Furthermore, it might be worth noting that the latter means that the Number of people in flood prone areas has grown at a rate similar to the Number of people living in urban areas, which is reasonable (see below).

In addition to examples provided in the letter, this supplementary document reports additional evidence of inappropriate urban development in flood prone areas by referring to the Burkina Faso's capital, Ouagadougou, and the Senegalese capital, Dakar, strongly affected by the aforementioned 2009 flooding.

According to UN, flooding in Ouagadougou (a case among Burkina Faso's floods in September 2009, which made more than 150,000 people homeless), is a consequence of so-called "wild urbanism" [Elizabeth Byrs, U.N. Office for the Coordination of Humanitarian Affairs, *PreventionWeb*, 2009]. In fact, Ouagadougou have been developing in the last decades in areas close to the river [*Fournet et al*., 2009; Figure S2].

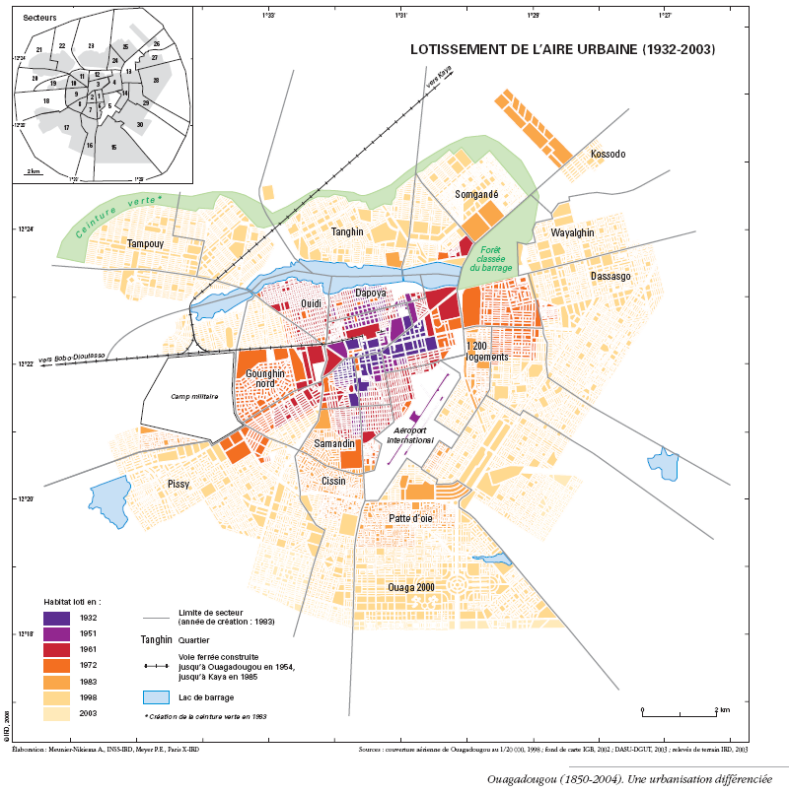

Figure S2. Urban expansion of the Burkina Faso's capital Ouagadougou (source: Fournet et al., 2009)

Another example of human settlements in flood prone areas is offered by the Senegalese capital, Dakar [*News.com*, 16 September 2009]. In particular, according to the *World Bank* [2010], 40% of Dakar's new inhabitants between 1988 and 2008 have moved into zones of high flood risk, as shown in Figure S3.

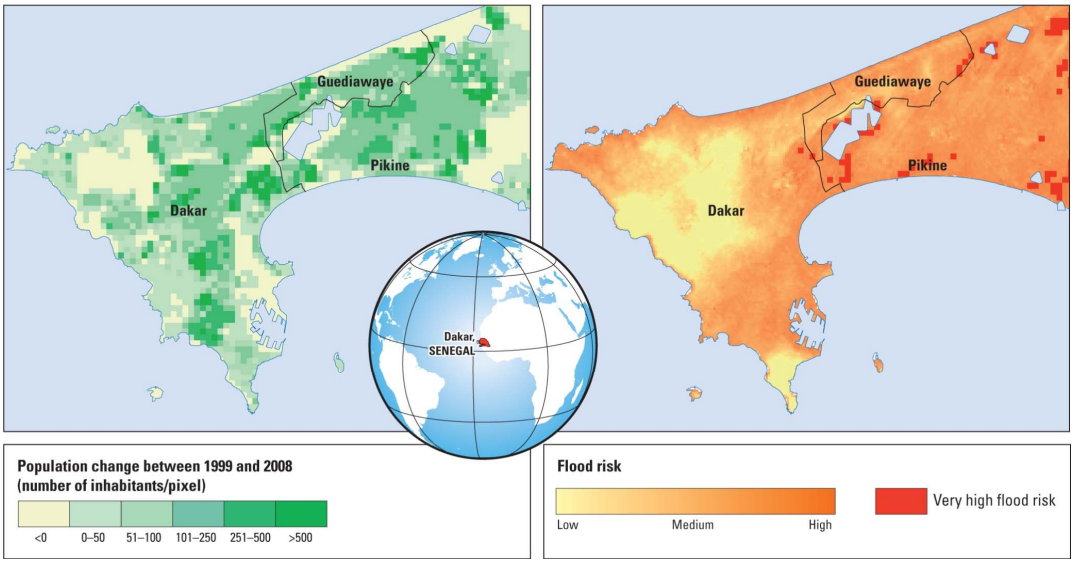

Figure S3. Dakar: change in urban population between 1999 and 2008 [left] and flood risk map [right] (source: World Bank, 2010)

Supplementary References

Fournet, F. (2009). Ouagadougou (1850-2004). Une urbanisation différenciée, Lavoisier, ISBN: 978-2-7099-1657-8.

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