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Use of blended evidence sources to build a history of flooding impact and an impact severity scale: A case study of Nairobi, Kenya

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Urban Africa Risk Knowledge

Flooding

Impacts on urban infrastructure

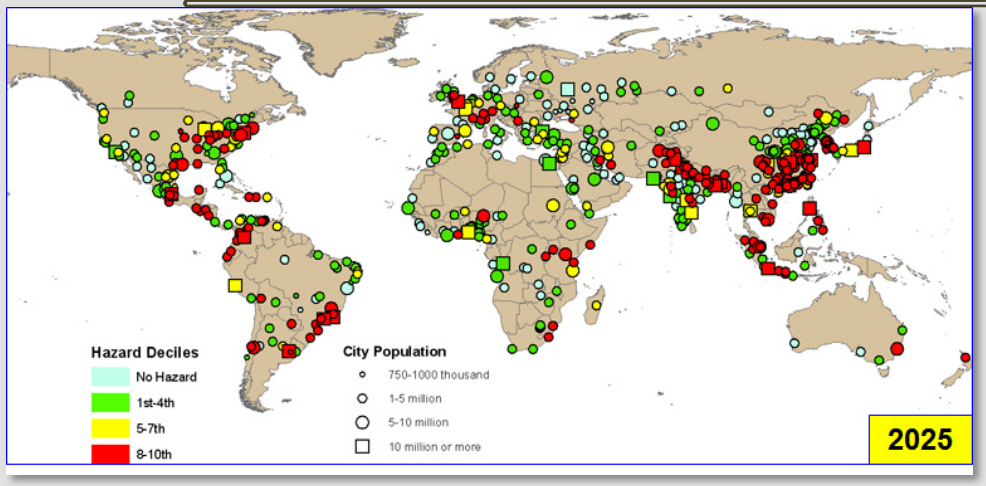

Figure 1 Global potential risk of urban flooding Source (UN 2012)

Figure 2 Location of Nairobi in Kenya.

Figure 3 Nairobi: "Green city in the sun".

Figure 4. Houses in Kibera, Nairobi hanging precariously following heavy rains November 4, 2012.

Figure 5 flood-affected houses in Kamulu and Mathare in Nairobi, Kenya.

Constructing and evaluating historical flood hazard impact databases with a case study of Nairobi, Kenya

Aim: To find **past historical flood events** and their **impact on urban infrastructure** in **Nairobi**.

Methods: Use **blended evidence sources** to build a history of flooding impacts. Extracted **flood's location**, timing, and **impact**, with impact broken up into

- **Human** (e.g., fatalities)
- **Infrastructure** (e.g., building damage)
- **Environment** (e.g., trees fallen).

Evidence used:

- Newspapers,
- Radio/TV broadcasts,
- Government and NGO reports,
- Peer-review journal articles,
- Insurance company records,
- Emergency service records,
- Online website reports, blogs, photos/video.

Constructing and evaluating historical flood hazard impact databases with a case study of Nairobi, Kenya

Results: Database with **1500 entries,** **358 unique flood events for 1978 to 2018** (41 years).

Group	Category	Sub-category - Field	Main source of evidence
1. GENERAL EVENT INFORMATION	1.1 General	1.1a ID	
		1.1b Date of Entry	
		1.1c Date of Source Publication	Section 7
	1.2 Time	1.2a Date of event	Narrative
		1.2b Day	Narrative
		1.2c Month	Narrative
		1.2d Year	Narrative
	1.3 Event Type	1.3a Hazard event	Narrative
	1.4 Location	1.4a Location	Narrative/ Visual
		1.4b Latitude	Narrative/ Visual
		1.4c Longitude	Narrative/ Visual
	1.5 Cause	1.5a Cause	Narrative
		1.5b Known natural hazard triggered	Narrative

Table B Summary of Nairobi Historical Flood Hazard Impact Database, 1974 to 2018.

Category	≤1980	1981 to 1985	1986 to 1990	1991 to 1995	1996 to 2000	2001 to 2005	2006 to 2010	2011 to 2015	2016 to 2018	Total
# reported flood events	10	18	53	42	45	33	14	87	81	358
# reported fatalities	5	3	0	5	53	48	11	29	73	227
# people reported injured	0	0	0	0	50	1	0	S	154	205
# people reported missing	0	0	0	0	30	4	0	1	63	98
# infrastructures reported as damaged or destroyed	2	S	1	1	6	S	33	14	29	88
# interacting hazard events	1	0	0	0	0	2	0	7	2	12

Flood Impact Severity scale

We developed a five-scale flood hazard severity index with 10 categories and 31 sub-categories. Used to categorise impact of flood events in Nairobi 2008 to 2018

Table A

Impact	Category	Sub-category	Weight	Flooding with Low reported impact Impact I	Flooding with Medium reported impact Impact II	Flooding with High reported impact Impact III	Flooding with Extreme reported impact Impact IV	Flooding with Devastating reported impact Impact V
HUMAN	Physical	Deaths	5	0	1-9	10-49	50 – 149	≥ 150
		Injured	4	0-5	6-19	20 – 49	50-199	≥ 200
		Missing	4	0-5	6-19	20 – 99	100 -174	≥ 175
		Affected	2	0-10	11-99	100 – 249	250-499	≥ 500
	Spatial	Displaced	2	0 – 24	25 – 49	50 – 199	200 – 399	≥ 400
		Relocations	3	0	1-59	60-120	121 – 249	≥ 250
		Evacuated	3	0	1-89	90-120	121 – 399	≥ 400
INFRASTRUCTURE	Buildings	Wall collapse	3	0	1-6	7-10	11 -19	≥ 20
		Building destroyed	4	0	1-3	4-8	9 – 19	≥ 20
		Building damaged	3	1	2-5	5 – 14	16 – 29	≥ 30
		Houses flooded	2	1- 9	10 – 24	25 – 40	41 – 69	
	Drainage/ Sewers	Flooded /burst sewers	3	1	2-4	5-9	10-20	
	Electricity poles and sub – station	Electricity poles /damaged /destroyed	4	0	1	2 – 9	10 – 19	
		Electricity station/ substation flooded	4	0	0	1	2 – 9	

Flood Impact Severity scale

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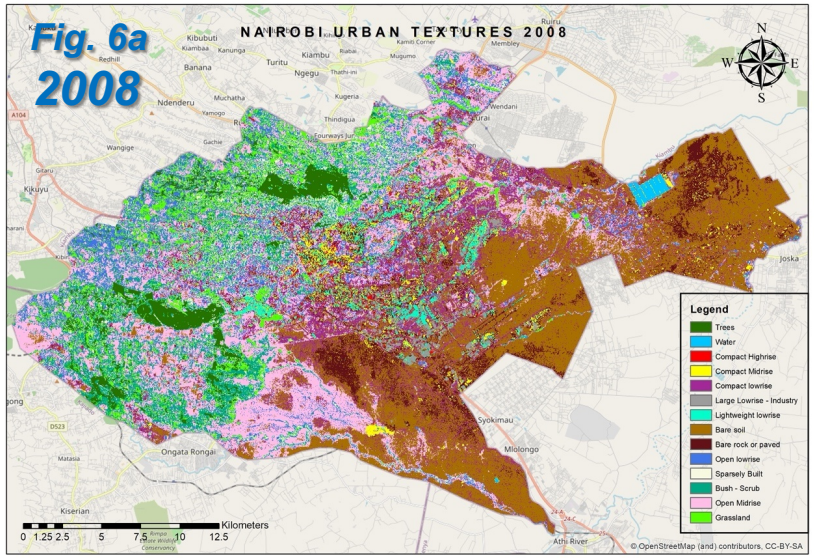
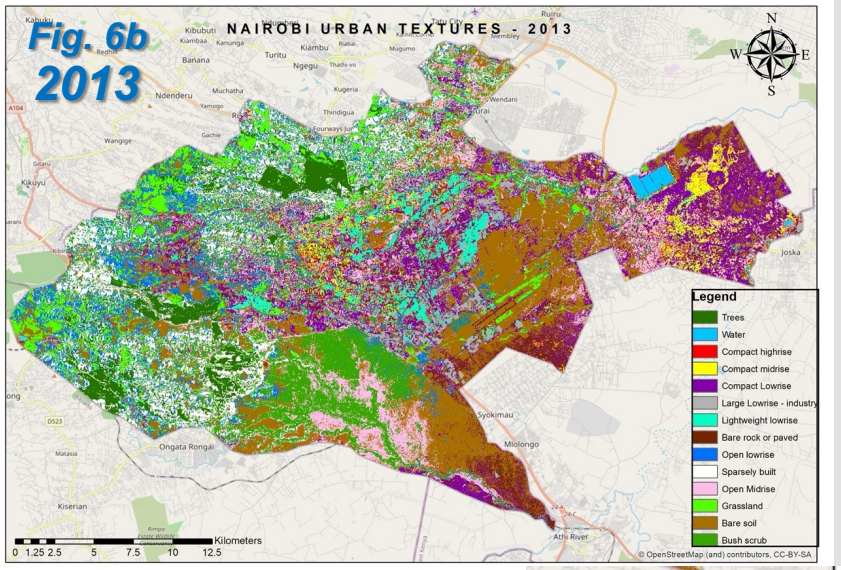
Table C

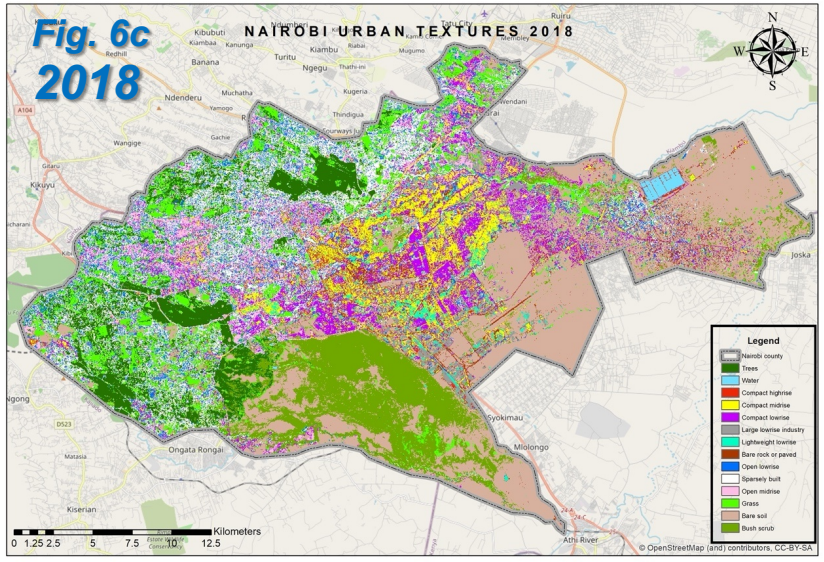
Scale	Category/ Short Descriptor	Description of Impact
I	Minor flood (Flooding with low reported impact)	• Lightly flooded passable roads, everyday floods not considered as impactful floods since they do not have infrastructural impact/destruction • Minimal impact on non-core businesses.
II	Moderate flood (Flooding with medium reported impact)	• Floods that cause flooded impassable roads, traffic snarl up
III	Serious flood (Flooding with high reported impact)	• Buildings damaged, buildings destroyed with no fatalities but injuries • Impact on business areas through delays
IV	Severe flood (Flooding with extreme reported impact)	• Buildings damaged, buildings destroyed with fatalities and injuries • Impact on organisations leading to reduced performance • Breakdown of key services
V	Catastrophic flood (Flooding with devastating reported impact)	• Floods with devastating impact • Critical failure inhibiting core running of the city

BLENDED EVIDENCE SOURCES TO BUILD HISTORICAL FLOODING IMPACT

Growth (i) **upwards** (storied buildings) and (ii) **outwards** (urban sprawl).





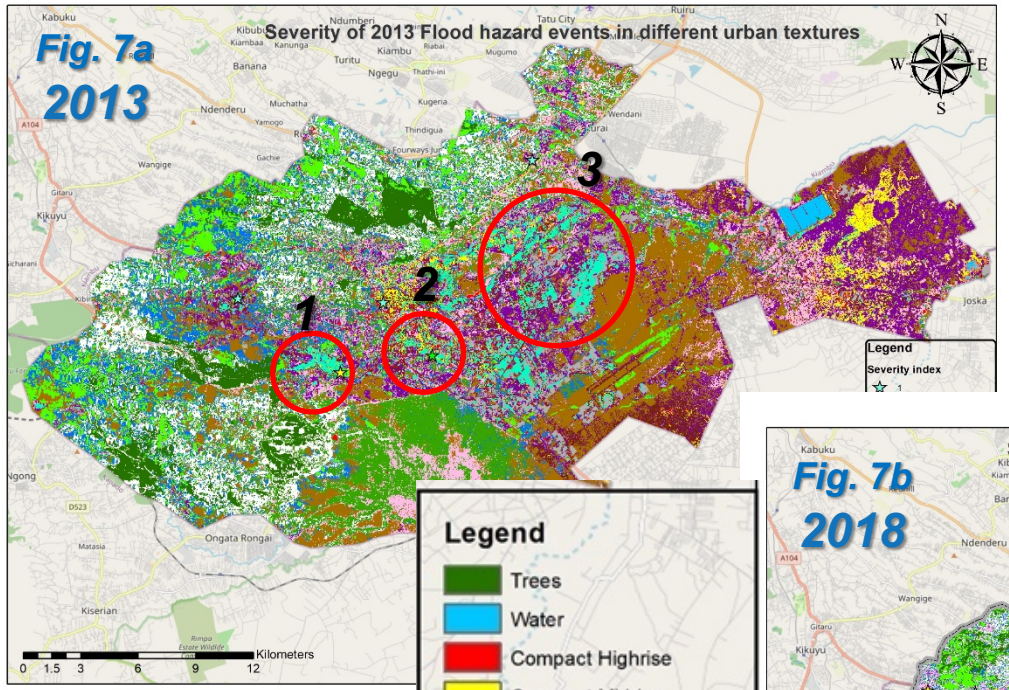


14 urban texture classes

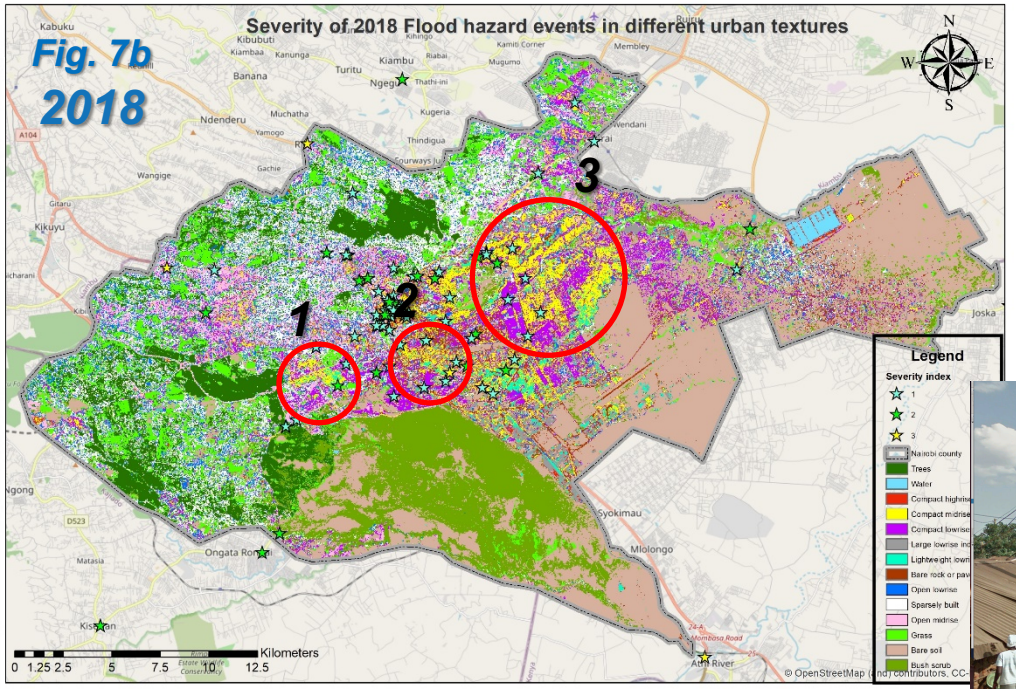
1. Compact high rise:
2. Compact midrise:
3. Compact low rise
4. Open mid rise
5. Open low rise:
6. Lightweight low rise/ informal
7. Large low rise/ industry
8. Trees:
9. Bush and scrub:
10. Bare soil:
11. Bare rock or paved:
12. Sparsely built
13. Low plants
14. Water

BLENDED EVIDENCE SOURCES TO BUILD HISTORICAL FLOODING IMPACT

Spatial and temporal characteristics of the Nairobi flood hazard and impact



- **Spatial temporal analysis of flood severity in different urban textures.**
- **Flood patterns, fatalities, damage, temporal trend for 2008 – 2018.**



No. of Unique Flood events

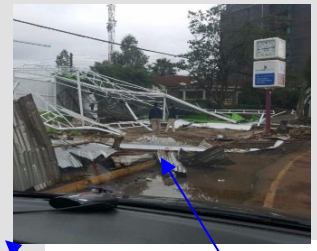
- 2013: 19 events
- 2018: 25 events

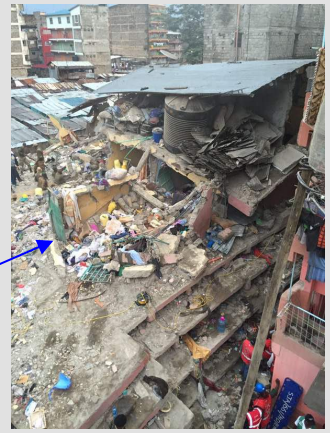
Urban texture change – **Light-weight low-rise** (photo left) to compact low rise (photo right) and **compact mid rise** (tall greenish building straight ahead).

BLENDED EVIDENCE SOURCES TO BUILD HISTORICAL FLOODING IMPACT

Nairobi flood hazard events

Flood Impact on urban infrastructure in different urban textures of Nairobi

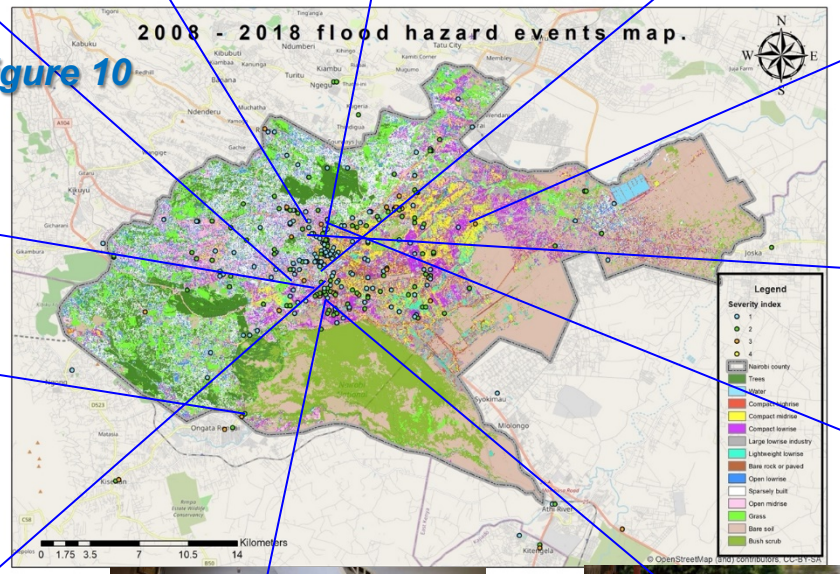
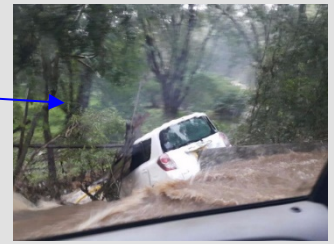
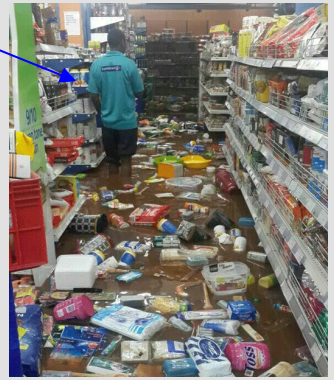


Figure 10





BLENDED EVIDENCE SOURCES TO BUILD HISTORICAL FLOODING IMPACT

Summary, conclusions

- Nairobi Flood Impact Database
  - **Resource allocation and planning for cities**
  - **Policy development**.
- **Severity index** will better enable **visualisation of flood hotspots** both in time and space.
  - **For forecasting** - utilised in decision making and **mitigation plans**.
- **Urban textures** – detailed outlook of urban growth.
- **Examine flood hazard risk/ risk accumulation** and impact in proposed Nairobi Metropolitan area (area that includes some current satellite towns) **to (for example) 2040**.

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