Urban Gestalt and Social Vulnerability: A Case Study of Kampala, Uganda

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The concept of the urban resilience nexus encompasses various sectors of the urban dynamics and aims for a better understanding of linkages and interplays. This paper[1] looks at these interrelations, mainly of water in the field of flooding-related risk exposures, the environment, and provision of basic services in Kampala and how they are – in combination with the exposure to climate change-related risks, varying levels of social vulnerability as well as infrastructure- and socio-economic sensitivity – unequally distributed in the city and stress the already most marginalised groups further, with the objective to provide a foundation for better policy interventions.

1 Introduction

Rapid urbanisation steadily increases the importance of sustainability in urban planning while it equally contributes to rising spatial injustice, mostly in sub-Saharan Africa: Access to land, services, employment opportunities and therefore the city itself varies strongly between different income and social groups. These gaps are significant and disadvantage the already most marginalised groups even more, specifically under the increasing threat of climate change and its accompanying risks. The understanding thereof as well as realising which factors influence spatial justice is crucial for tackling these inequalities. To examine these dynamics, a case study of Kampala is undertaken. The research intends to increase the understanding of spatial justice in the field of climate change vulnerability to support better-informed policy and spatial intervention strategies.

Therefore, this paper analyses the current situation and urban transformation in Kampala and the distribution of risk and adaptive capacity to investigate spatial injustice as well as its driving forces and consequences. The anticipated outcome of the research is to improve the understanding of urban dynamics, justice, and accessibility, specifically in the context of Uganda, and to build a better foundation for informed policy decisions and spatial interventions. Even if the results are context-specific, general conclusions apply to other urban areas and add to a more comprehensive understanding of spatial injustice in sub-Saharan African cities.

2 Background

The global population continues to increase rapidly and is concentrated in the urban areas of the Global South. More specifically, the African continent is experiencing the highest population rise in the present century. Adding to the pressure on cities by more residents and spatial expansion, climate change further stresses these urban systems. Cities became the centre of the current development and sustainability debates. Their importance is widely acknowledged and

[1] This paper builds upon and contains sections of the author's master thesis research at the Institute for Housing and Urban Development Studies (IHS), Erasmus University Rotterdam, and is integrated in the broader research project 'Spatial Inequality in Times of Urban Transition', conducted by the IHS, the Development Planning Unit (University College London) and IPE Tripleline and is funded by the British Government's East Africa Research Fund. It builds upon a previously presented methodological approach (Gall 2018, forthcoming).

continuously highlighted by international and national institutions around the world, representing a central aspect in the Sustainable Development Goals (SDGs) of the United Nations. For example, SDG 11 focuses on making "cities and human settlements inclusive, safe, resilient and sustainable" while the city itself functions as the arena for achieving almost all the other goals (UN 2015, p. 14).

The questions arise, what this development will mean for the population within cities and how it can be managed and steered into a sustainable direction. The report 'Our common future' already highlighted spatial injustice in 1987, together with the necessity to identify the most vulnerable groups and tackle the social and environmental risks which accompany the population surge (WCED). However, more than three decades went by, and even if sustainability is a primary concern nowadays, more people than ever before are living in risk-prone circumstances, and environmental depletion does not slow down either (Adger 2006; Brecht et al. 2013; UN-Habitat 2014; UN 2015 & 2016).

With urban areas as the primary habitat of the world's population, fast urbanisation patterns in sub-Saharan Africa (SSA) increase the demographic pressure, while climate change stresses the cities, and their adaptation is challenging because the responsible institutions often lack resources and capacity to tackle the rising complexity and quantity of issues (Pieterse and Parnell 2010; Myers 2016). In 'Africa's Urban Revolution', Parnell and Pieterse emphasise the general growth which occurs in both urban and rural areas but the strong concentration in urban agglomerations. This development is not only about the increase of the number of residents but comes along with "severe overcrowding, lack of sanitation, constant threat of bodily harm and abuse" and is "linked to the structural poverty and systemic exclusion experienced by a large proportion of the urban population in most African cities". Furthermore, unequally distributed pressures on age, income and gender groups result in negative externalities on health, productivity and economic behaviour (Pieterse and Parnell 2010; Bartlett 2008; Fainstein 2010). Lastly, climate change and global environmental change are leading to even more rural-urban and/or trans-national migration of climate refugees, unequal distribution of land, hazard risks for settlements in the shape of floods, landslides, droughts or heat waves, to just name a few of the "dynamic processes and the interplay" of these elements (Parnell and Walawage 2010).

However, inequality does not only exist amongst different social groups within the cities but also on the global scale. Climate change itself is a global challenge, induced primarily by the industrialised countries while the most impoverished countries contributed the least but suffer the most from its consequences (Althor et al. 2016). The suffering is further intensified due to a widespread lack of adaptive capacity, meaning the "potential, capability, or ability of a system to adapt to climate change stimuli or their effects or impacts" (IPCC 2001).

Parnell and Walawage (2010) further stress the importance in these complex circumstances of creating the capacity to ensure urban resilience so that the livelihood of everyone in the city is not negatively affected by the broader global demographic and environmental processes. Another important aspect is the interplay between the social and ecological systems and their cultural understanding which varies fundamentally between most Western and SSA societies. While the dominant Western notion sees them as separate entities, in most SSA cultures nature and society are interwoven. The consequences of the development in industrialised nations lead to the destruction of locally much higher valued ecosystems, while differing perceptions result in complications in cooperation, the transfer of 'knowledge' and coping mechanisms (Myers 2016). All these issues emphasise the plethora of challenges which cities in SSA are facing. Tackling them will be one of the critical tasks for policy makers and planners of the coming decades. Starting with the predominant injustice and its spatiality in urban agglomerations, this research tries to contribute to the understanding thereof by looking at ways to quantify the interrelation between urban form and social vulnerability with a focus on risk exposure, adaptive capacity and sensitivity. UN-Habitat (2014) called the development in SSA cities an "urbanisation of poverty". This led to plenty of unplanned and underserviced settlements with fundamental and increasing material injustice and lack of opportunities between them and their affluent neighbourhoods. Understanding these different settlements patterns and their integration in the urban fabric will be the core of the analysis of urban form, while the varying level and types of risk exposure and the interdependence between social variables and adaptive capacity will serve as comparative values.

Urban form, defined by Williams as "the physical characteristics that make up built-up areas, including the shape, size, density and configuration of settlements" (2014, p. 6) is moving towards the centre of interest in the sustainability debate, while its importance on the social and ecological risk exposure is further emphasised (Jabareen 2006; Hillier 2009; Louf and Barthelemy 2014; Fragkias et al. 2013; Oliveira et al. 2014; Pelling and Wisner 2009 and others). Myers adds to the definition of urban form, in his words *cityshape*, that in the context of SSA it is the physical as well as the "socially and culturally produced environment" (2016, p. 19), highlighting non-spatial characteristics. Jane Jacobs already described the strong interrelation between the built environment and social dynamics of cities in 'The death and life of great American cities' (1961), where she states that cities should be a place for people, even if that is often not the case (anymore). Building upon Jacobs' perspective, Gehl (2010) further embraces the interconnection of urban form and social life, sustainability and health through variables of density, compactness, and diversity while also highlighting its relation to risk (e.g., traffic accidents, robbery). Additionally, he argues that high-quality urban space can fuel interaction and social inclusion, and therefore a higher sense of community which again can lead to better cooperation and assistance in case of disaster regardless of their type or scale (Gehl 2010). Jacobs further describes the impact of being better interconnected on adaptive capacity, supporting the interrelation between the spatial and social dynamics of cities.

The particular issue of justice in cities—the broader context of this research—was famously put into focus by Susan Fainstein in 'Just Cities'. She gives a broad overview of different notions of justice, how it can be conceptualised and quantified and also states that injustice rises and the urban poor, mostly women and children, represent the most vulnerable groups (2010). This link between poverty and vulnerability in the field of environmental risks was further studied by UN-Habitat (2014), naming the lack of decision-making power and resources, mostly in time of disasters, as the primary reasons. They also emphasise the disproportionate distribution of risk exposure among different age and gender groups (see also Bartlett 2008).

But what does “urban risks” or “vulnerability” mean and what do they encompass? Brooks (2003) distinguishes between social and biophysical vulnerability. Social vulnerability includes everything related to the human and is the focus of this research, while biophysical vulnerability focuses on the ecosystem and biophysical environment. Risk, on the other hand, is normally composed of different types of hazards, their occurrence and scale. The last two aspects are adaptive capacity as the "potential, capability, or ability of a system to adapt to climate stimuli or their effects or impacts (IPCC 2001, p. 881) and sensitivity as "how affected a system is after being exposed to the stress" (Engle 2011, p. 649, compare to Adger 2006 and IPCC 2001).

The applied methodology in the case study of Kampala attempts to quantify the key elements – urban form, climate change related risk exposure, adaptive capacity and sensitivity – with a view to understanding their interplay in the context of socio-spatial justice as shaping elements of urbanisation and livelihoods. The example of Kampala provides a compelling case, due to its fast urbanisation and current as well as predicted spatial expansion but early development stage in comparison with other Eastern African cities (Karolien et al. 2012; UN-Habitat 2014). At the same time, it experiences severe climate change-related consequences, and has high levels of informality, low levels of land tenure security and building regulations, basic service provision and faces institutional challenges which further complicate the situation (Karolien et al. 2012; Nyakaana et al. 2008; Insunju 2016; Richmond et al. 2018; UN-Habitat 2014). Therefore, it is an compelling case study to analyse itself while its comparability to many other cities in SSA provides the opportunity to transfer and apply the same approach in other geographical contexts.

3 Methodology

Based upon the development of a comprehensive, theory-rooted methodology, a list of indicators divided into various concepts and sub-variables (Table 1) is developed. A more detailed description of the underlying methodology part can be found in another paper (Gall 2018).

CONCEPT	VARIABLE	DEFINITION	INDICATOR	DEFINTION
URBAN FORM	1.1. Street Network: Space Syntax	Space Syntax analysis of streets regarding road segments role in the overall road network.	Integration (Space Syntax)	The number of turns which need to made from one street segment to reach all others streets through the shortest path.
			Choice (Space Syntax)	The probability of each street segment to be used by users to reach another segment.
			Depth Distance (Space Syntax)	Linear distance from each street segment to the total number of street segments.
			Connectivity	Number of spaces immediately connecting a space of origin.
	1.2. Street Network: Accessibility	Network and infrastructure related aspects which define the accessibility to various physical elements of the urban area and interconnection of one area in comparison to others.	Accessibility to economic centres	The average distance of each household to economic centres through the shortest path.
			Accessibility to educational facilities	The average distance of each household to educational facilities through the shortest path.
			Accessibility to health institutions	The average distance of each household to health facilities through the shortest path.
			Accessibility to public transport nodes	Average distance of each household to public transport nodes through the shortest path.
			Distances to health facilities	Percentage of households with access to health facilities under 5 KM
			Distances to educational facilities	Percentage of households with access to educational facilities under 5 KM
	1.3 Built Environment	Physical structures in a certain area and their individual and aggregated characteristics.	Building density	Buildings per sqkm
			Site occupancy index	Percentage of ground covered by buildings
			Average building size	Average size of residential and commercial buildings
			Building proximity	Average distance to next 25 buildings
	1.4 Land Use	Land use analysis incl. green percentage and the type of settlements	Amount green space	Percentage of green space in relation to total space
			Settlement type	Primary settlement type according to EARF residential settlement classification
RISK EXPOSURE	2.1 Probability	The exposure to risk, the distance to flood-prone areas and the perception of risks of the residents living within.	Location in watershed area	TIN-based water runoff model
			Distance to flood prone area	Distance to the nearest flood prone area defined by KCCA
			Disaster occurrences in last 2 years	Subjective perception of number of disasters in area in the last two years
ADAPTIVE CAPACITY	3.1 Resources	The financial and property resources of the residents.	Range of income from household	Total income per household based on EARF household survey in selected areas
			Household expenses	Food, electricity, water, other energy, healthcare, education plus 3* transport expenses
			Area of plot	Average plot size of residential and commercial buildings
			Cost of purchase	
			Current price	Current price of property
			Household relation to site	Relationship of household to property/site
			Percentage ownership	Percentage of owner property instead of rented/subsidised
	3.2 Access to Services	The access to basic services and the type and quality thereof.	Access to water	Availability of water
			Connection to sewerage network	Availability of sewerage network
			Septic tank	Availability of septic tanks
			Sanitation facility	Availability of sanitation facilities
			Solar Panel	Availability of solar panels
			Water access	Type of water accessible
			Water quality	Satisfaction with water quality
	3.3. Behaviour	Social characteristics which influence behaviour of residents	Social integration	Integration in community measured by the number of years living there
			Initial location	Location before moving to current plot
			Satisfaction with neighbourhood	Satisfaction with living in present neighbourhood
			Plan to relocate	Existence of plan to move to another place within 2 years
			Prevalence of improvements on plot	Type and quantity of improvements undertaken

			Cost of improvements	Amount of money invested in improvements
	3.4 Knowledge and information	Access and prevalence to internet and the level of education.	Internet use	Prevalence of internet use in area measured by number of tweets
			Level of Education	Highest level of education in household based on EARF household survey in selected areas
SENSITIVITY	Human sensitivity	Characteristics of the urban population which affect the sensitivity to climate change risks.	Population density	People per hectare based on 2014 survey
			Household size 2	Household size based on EARF household survey in selected areas
			Gender 1	City-wide gender distribution
			Gender 2	Gender distribution based on EARF household survey in selected areas
			Age groups	Age distribution in households based on EARF survey in selected areas
			Female headed households	Percentage of female-headed households based on EARF survey in selected areas
			Economic resilience	Sufficiency of current household income.
			Type of employer	Type of main employer
			Type of occupation	Type of main occupation
			Expropriation	Prevalence of evictions or expropriations the past five years
			Safety	Level of safety (regarding crimes, harassment, violence) for the women of household
			Household affordability	Easiness for household to afford current property
			Property restrictions	Prevalence of restrictions in process of finding a place in the area
			Property ownership	Type of owner of used property
	Building sensitivity	Characteristics of the built environment which influence the severity of disasters.	Type of dwelling	Categorical type of dwellings in area.
			Dwelling material	Quality and type of built material of buildings
			Built floor quality	Quality of floor from 2014 survey
			Built wall quality	Quality of walls from 2014 survey
	Infrastructure sensitivity	The quality and quantity of infrastructure in affected areas which are at risk.	Street density	Weighted length of primary and secondary roads per sqkm
			Nearest road	Nearest paved road
			Travel time	Average time to travel to work/school

Table 1: Operationalisation of four main research concepts (Author 2018)

In order to quantify the above-presented indicators, various methods are applied. The analysis is conducted in various scales and in the end always converted to a grid size of 100 * 100 m to achieve the highest possible comparability. While some data is already existing and geo-referenced, other indicator values need to be calculated or compromised based upon different information to compound scores. Two different grid-sizes were chosen for the study on city level and the analysis of the EARF household data inside the specified research corridors. Most values are directly calculated or converted to the 100 * 100 m grid, while some values (i.e. EARF survey results, street density, space syntax) are first calculated for 500 * 500 m cells. Both cell-sizes are chosen to establish a balance between large enough cells to guarantee a certain level of representativity while still being small enough to distinguish high-resolution differences in the urban fabric. Finally, all indicator values are geo-referenced and assigned to the smaller size cells in ArcGIS.

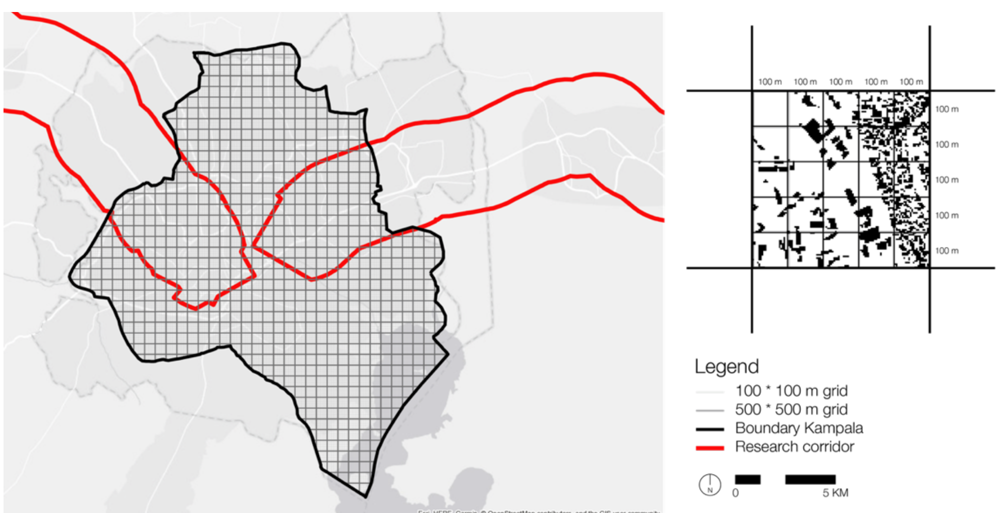

Figure 1: Grid division and scale reference incl. buildings (Author 2018)

3.1 Sample size and selection

The spatial analysis was conducted on two levels; the city and the EARF research corridors. However, due to the scope of this paper, only the analysis on the smaller scale with more available data, is presented. The two research corridors were selected through a purposive sample process: One from the centre to the north-west, and a second one to the east. For the household survey which was carried out as part of the EARF research compendium, 2750 households and 10,109 household members were enumerated, equally distributed over eight strata (four different residential housing types and core and peripheral locations; Fig. 2). Inside, households are selected through a random generation of coordinates. Enumerators started from these coordinates and then approached the closest household. However, as some part of the coordinates lie outside the research demarcation, and others have no spatial reference, only about two-thirds of the data can be used for the analysis.

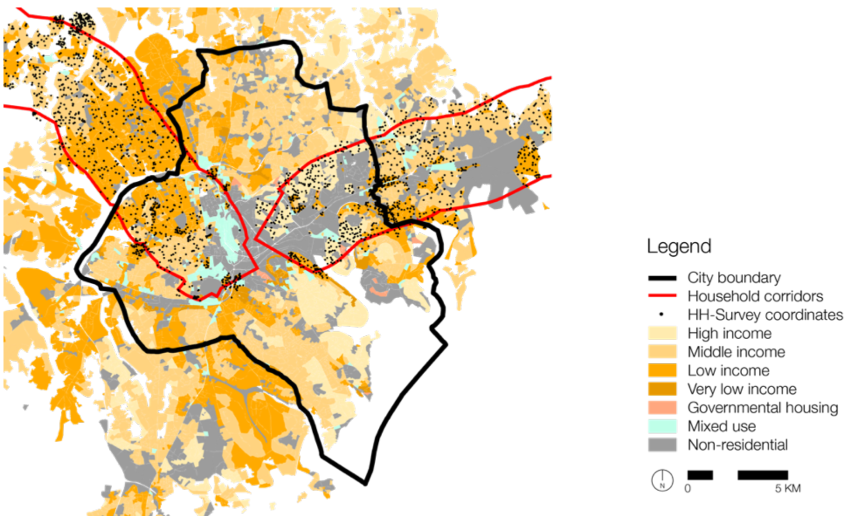

Figure 2: EARF settlement types, research corridors and survey coordinates (Author 2018)

The collected secondary quantitative data comes from various sources. Firstly, numerous information like the jurisdictional boundaries, the national household survey of 2014 as well as the flood-prone areas are from governmental institutions. Secondly, various information is produced as part of the EARF project, e.g., different housing typologies (Fig. 2). Additionally, numerous sources come from a range of datasets and reports of the last years which examine one particular issue in detail. These are, amongst others, the reports on the vulnerability of Kampala (UN-Habitat 2011), Building Outlines: An Atlas of Kampala (GeoGecko 2016) or the World Bank report on economic centres (Goswami and Lall 2016). Lastly, for quantifying urban form and accessibility to various facilities, in-depth spatial data is required which is collected from OpenStreetMap and extended through own mapping.

The collected spatial data or, e.g., socio-economic data, which can be associated with jurisdictional boundaries (in case of Kampala parishes), exists in four different types (Fig. 3):

- Points: E.g., Bus station, facilities, survey coordinates or building centre points
- (Poly-)Lines: E.g., Streets or rivers
- Polygons: E.g., Census data, buildings or settlement types
- Raster: E.g., Digital elevation model or image analysis results

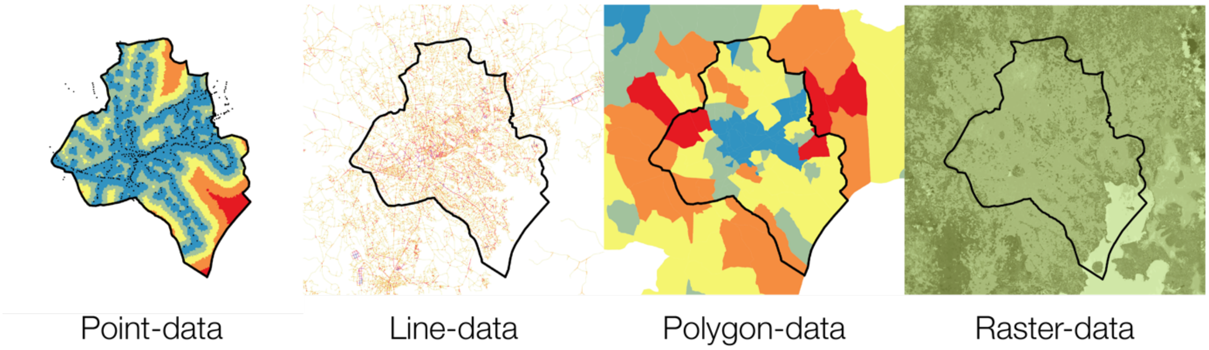

Figure 3: Four different underlying spatial data types (Author 2018)

The conducted data assessment of the spatial elements consists of four different parts:

1. The first is assigning existing geo-referenced data to the cells.
2. The second is comprised of various types of spatial analysis and includes basic calculations like counting the number of buildings or the length of streets per cell.
3. In order to calculate the Space Syntax indicators (integration, choice, depth distance, connectivity), DepthMapX for QGIS is used, based upon the infrastructure data from OpenStreetMap.
4. Lastly, the accessibility to economic centres, different facilities or functions is calculated through the Variable-width Floating Catchment Area (VFCA) method, building upon the Two-step Floating Catchment Area Method (2SFCA). These accessibility measurements are conducted through the Network Analyst Toolbox of ArcGIS.

The outcomes of this study are therefore partly descriptive and partly prescriptive. Some outcomes solely represent already existing information in combined and more detailed manners and can provide a better understanding, while others, like specific interrelations between factors, help to quantify influencing factors and give an indication about expectable developments in the future and how one might affect another one and therefore also where and what kind of interventions might be more fruitful to anticipate further marginalisation and spatial injustice.

4 Findings

This sub-chapter presents various findings from five regressions models (Fig. 4), in which different sections of the operationalisation (Table 1) are statistically analysed.

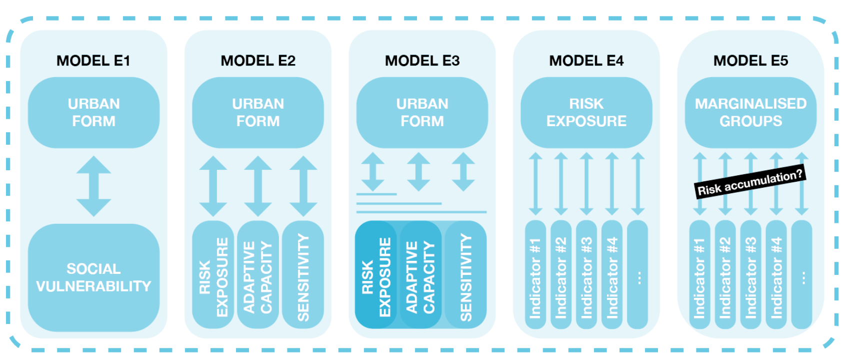

Figure 4: Regression models for city and EARF-level (Author 2018)

After the descriptive statistics, the data is normalised (between 0 and 1), and a Pearson's correlation test is conducted. Various correlations were found which lead to the selection of individual and aggregated indicators for the following regression analyses.

4.1 Model E1: Social Vulnerability to Urban Form

The first regression model looks at the correlation between Urban Form and Social Vulnerability. A strong correlation exists (*b* = .5, *t* = 38.224, p < .001), and explains a significant proportion of variance in Social Vulnerability (R^2 = .23, *F* = 1461.048, *p* < .001). The maps below (Fig. 5) show the values for both concepts inside the research corridors, while skipping areas which are mostly non-residential and have, therefore, not enough underlying data to be included and furthermore do not lie in the focus of this research. Old, high-income area in the centre (south of eastern corridor) have the lowest Social Vulnerability and simultaneously the lowest compound score of Urban Form. The surrounding areas beneath, as well as the upper part of the western corridor, have lower scores in both variables. This finding shows a clear interrelation between Urban Form and Social Vulnerability; however, the following regressions attempt to dismantle and quantify these relations further.

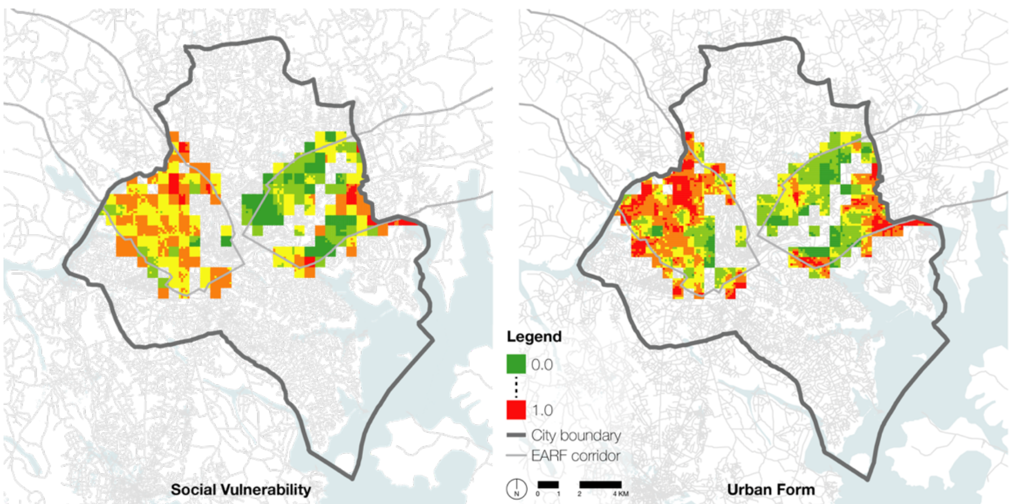

Figure 5: Scores Social Vulnerability (left) and Flooding Risk Exposure (right) (Author 2018)

4.2 Model E2: Urban Form to Risk Exposure, Adapt. Capacity & Sensitivity

In order to understand the above-described correlation better, a more detailed look into the correlations between Urban Form and the three components of Social Vulnerability is taken. This shows, that all three are significantly correlated (Table 3) but vary in their strength and their percentage of explained variance. In this case, opposing to the study on city-level, the Sensitivity (SE) shows the strongest correlation with the highest R^2, followed by Adaptive Capacity (AC) and Flooding Risk Exposure (RE). One observation, which can be drawn, is, however, that Urban Form affects, or is affected, by all components. SE and RE increase while AC decreases in if the Urban Form value in increases, emphasising the existing correlation.

	b	t	p	R^2	F	p
RE	.212	10.107	<.001	.021	102.146	<.001
AC	-.323	-24.758	<.001	.112	612.969	<.001
SE	.374	37.828	<.001	.227	1430.974	<.001

Table 3: Correlations between Urban Form and components of Social Vulnerability (Author 2018)

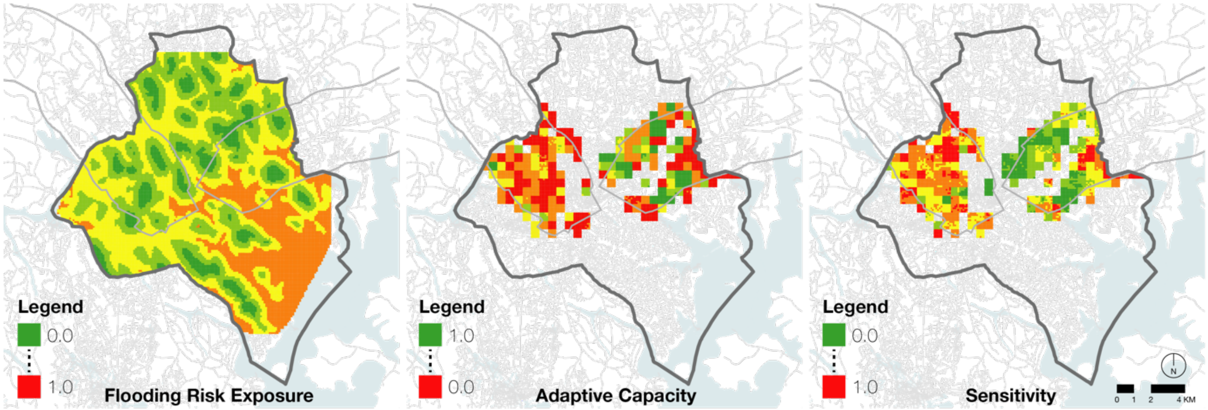

Figure 6: Scores Flooding Risk Exposure (left), Adaptive Capacity (middle) and Sensitivity (right) (Author 2018)

4.3 Model E3: Urban Form and blocks

In order to test for the improvement of the model by adding each component, a multiple linear regression is carried out with the objective to result in a formula explaining Urban Form through an OLS-regression analysis. The model improves if all three components are included.

	b	t	p
MODEL 1		**R^2 = .227, F = 1430.974, p < 0.001**	
SE	.374	37.828	<.001
MODEL 2		**R^2 = .246, F = 794.178, p < 0.001**	
SE	.321	29.438	<.001
AC	-.148	-11.041	<.001
MODEL 3		**R^2 = .250, F = 540.973, p < 0.001**	
SE	.317	29.017	<.001
AC	-.141	-10.464	<.001
RE	.096	5.130	<.001

Table 4: Multiple regression of correlations between Urban Form and three models (Author 2018)

4.4 Model E4: Risk Exposure to individual indicators

Furthermore, a closer look at some of the stronger (according to the Pearson's r) correlating individual indicators to RE is taken. In the case of Model E4, these are the accessibility to educational and health facilities, the perceived hazard risk, the aggregated indicator of access to basic services as well as the road proximity, meaning the perceived proximity to the next paved street by the household survey respondents (Table 5). The results show that a higher risk exposure implies higher distance to educational and health facilities, as well as paved streets, while the hazard perception expectantly increases and the access to basic services decreases. Therefore, already supporting some aspects of the hypothesis of worse access to the city and its services in areas of higher risk, while introducing the last regression model which further looks at the anticipated effect of risk accumulation.

	b	t	p	R^2	F	p
Education	.291	20.859	<.001	.082	435.092	<.001
Health	.281	18.441	<.001	.065	340.076	<.001
Hazard Perception	.171	14.746	<.001	.043	217.456	<.001
Service Access	-.123	-15.053	<.001	.044	226.580	<.001
Road Proximity	.090	13.573	<.001	.036	184.217	<.001

Table 5: Correlations between Flooding Risk Exposure and individual indicators (Author 2016)

4.5 Model E5: Risk accumulation

In this regression analysis, the interrelations between the indicator age group are tested for the strongest correlations. The objective is to test for expected risk accumulation, meaning the overlap of several unfortunate characteristics for particular, marginalised groups like the youth which make up a vast majority in Kampala. Furthermore, the female population would have been interesting to study further. However, their disadvantage is more complex to quantify – a topic which will be further discussed below. Table 6 shows the various indicators which correlate with lower (!) age-groups. The findings are manifold, e.g. denser and higher populated areas, fewer expenses, years lived in the area, lower level of education, bigger household sizes, more females, less economic resilience, lower quality of floors and higher proximity to paved streets but at the same time longer travel times to reach school or work. This data can support the argument of the accumulation of risks for, in this case, the younger populations which are challenged in various ways through economic, social and spatial characteristics of their living environment and have fewer resources and (formal educational) knowledge to cope with them.

	b	t	p	R^2	F	p
Space Syntax (REV)	.149	17.612	<.001	.06	310.182	<.001
Number of Buildings	.152	16.743	<.001	.054	280.342	<.001
Proximity	.299	18.276	<.001	.064	334.013	<.001
Hazard Perception	.2	17.021	<.001	.056	289-706	<.001
Expenses	-.324	-18.253	<.001	.064	333.165	<.001
Years since Moving	-.152	-16.905	<.001	.057	285.783	<.001
Satisfaction	-.164	-21.142	<.001	.084	446.983	<.001
Education Quality	-.264	-25,267	<.001	.116	638.408	<.001
Population Density	.166	22.056	<.001	.091	486.477	<.001
Household Size (EARF)	.187	16.951	<.001	.056	287.337	<.001
Female Population (EARF)	.106	14.623	<.001	.042	213.846	<.001
Economic Resilience (REV)	.155	21.449	<.001	.086	460.044	<.001
Floor Quality (REV)	.210	18.608	<.001	.066	346.239	<.001
Road Proximity	.178	27.922	<.001	.138	779.613	<.001
Travel Time (REV)	.207	19.356	<.001	.071	374.657	<.001

Table 6: Correlations between reversed Age-Group and individual indicators (Author 2018)

4.6 Primary data collection

Additional to the collection of secondary data, qualitative primary data was collected through semi-structured expert interviews and an online weighting survey during the field research. Following, a quick overview of some of the interesting findings from the interviews is presented. The respondents were urban experts from two academic institutions, the municipality KCCA, the Ministry for Land, Housing and Urban Development, intergovernmental organisations, as well as a few experts from related fields. While one of the central purposes was collecting and accessing the main data required for the quantitative research, their input could further be used for the triangulation and adaption of the methodology, understanding the roles of various involved actors, distinguishing some of the most affected areas (Bwaise, Kawempe, Maine, Kisenyi, Kalerwe, Nsoba, Ndeba, Natete, Kyanbogo, Queens Way, Namungona, Namasuba, Busega, Banda) and adapting the operationalisation accordingly. In the initial operationalisation, spreading of water-borne diseases was included, which was supposed to be measured through the number of cases in all health facilities in Kampala. However, it proved to be too spatially unprecise as the catchment areas of the clinics and hospitals are too generic or at least not understood and documented sufficiently. For example, one private clinic might be very close to an area with a high flooding risk exposure, but the affected people of that area would more likely visit a farther away public hospital due to financial reasons. Furthermore, mosquitos, as one main spreader, fly up to 5 KM and therefore can affect areas far away from flood-prone areas. Also, in some cases, interviewees questioned the impact of floods on water-borne diseases because of the short timespans of flooding which are not sufficient for breeding, however, others refuted this by stating the opposite: Floods in combination with uncollected solid waste – a common challenge in the lower-income, underserviced settlements of Kampala – can lead to water captured in small containers which heat up under the sun and therefore provide even better breeding grounds. Therefore, disease-spreading was seen as a secondary risk, but neither its spatial occurrence nor its possibility to measure with a sufficient level of detail does make it viable to be included in the research.

On the other hand, the above-mentioned areas with frequent flooding events serve as another dimension of understanding the spatial distribution and test simultaneously the conducted research. While not all areas could be located perfectly and the below map (Fig. 7) shows the administrative boundaries of the mentioned parishes instead of the actual location of floods, they support in both maps of Social Vulnerability and Urban Form the research method. In all ten parishes shown below (several are adjacent to each other), areas exist which have high values of Social Vulnerability and at the same time significantly built-up settlements.

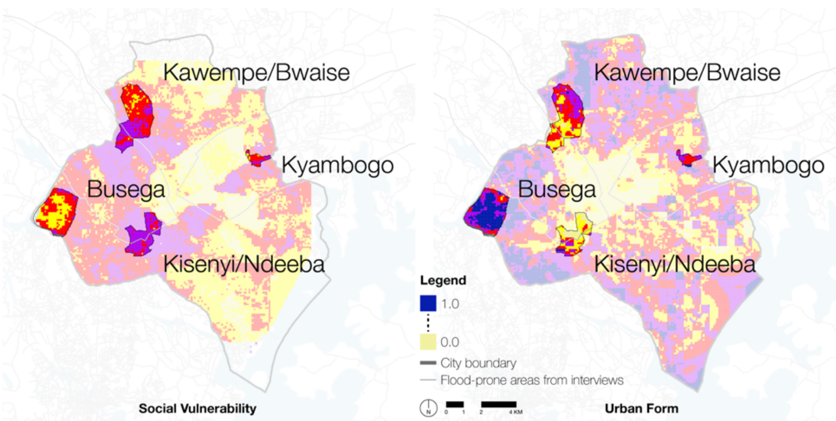

Figure 7: Flood-prone areas from interviews, compared to Social Vulnerability and Urban Form (Author 2018)

Lastly, a short discussion of the apparent remnants of the colonial urban structure and its presumably still visible consequences on spatial injustice follows, as well as the role of the female population and their disproportionate distress due to flooding.

Regarding the consequences of racial-spatial segregation during the colonial times, maps of social vulnerability today and more in-depth the flooding risk exposure, which should not have changed significantly since then, give a better perspective. On the below-shown maps (Fig. 8,) different residential areas of the three racial classifications from the structure plan of 1951 are visualised (Kendall 1955 in Omolo-Okalebo 2011). The green boundaries show the settlements of "African" settlers, which are mainly outside the centre and either autonomous or connected to an "Asian" settlement. The latter (pink) surrounds mainly the "European" areas and were often described as a kind of protection or buffer between the "European" and "African" residents. The blue outlines represent the "European" area and constitute the past's and today's centre of Kampala. Several observations can be made: Firstly, the "European" areas are the most central and mainly on hilltops with, according to this research's classification, very low social vulnerability scores. The "African" areas, however, are not adjacent to the "European" settlement, mainly in lower lying areas which have higher flooding risk exposures and have still today much higher social vulnerability scores, while partially overlapping with some of the subjectively defined flood-prone areas. One exception of the "African" settlements is a small area in the north of the central "European" shape, which might be related to the Luganda Kingdom which also today inhabits one of the hilltops in Kampala. The "Asian" settlements are somewhere in between, spatially as well as regarding their exposure to flooding risks and their social vulnerability scores. While this is a secondary observation and just applies to a small portion of today's city, the overlap is apparent and shows one of the originy of the spatial segregation and injustice in relation to flooding risks, the sensitivity as well as the ability to cope with it.

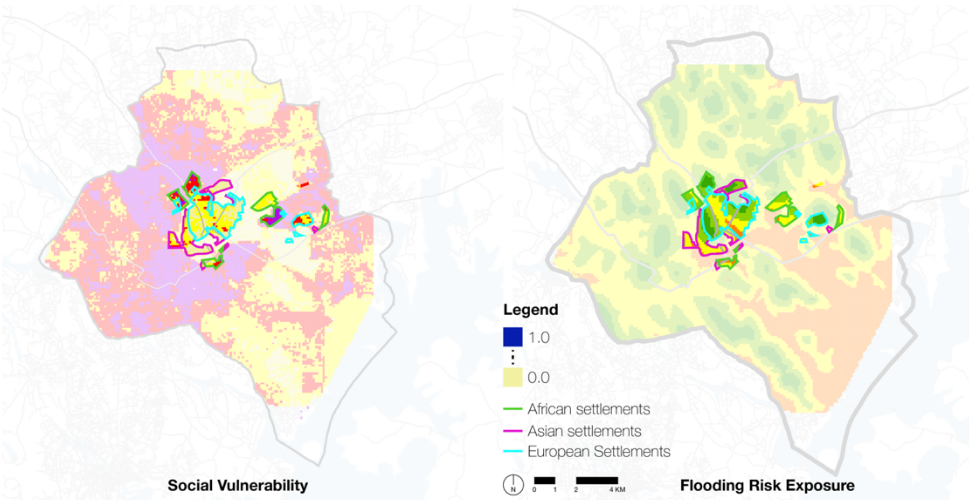

Figure 8: Maps of Social Vulnerability and RE overlaid with historical racial segregation of residential areas in 1951 (Author 2018, based on Kendall 1955 in Omolo-Okalebo 2011)

Furthermore, a quick discussion of females as a marginalised group adds to the findings. While few statistically significant correlations could be found which also are partly correlate in the opposite direction as expected based on the theory review (e.g., better access to schools and health facilities, higher economic resilience, lower risk of expropriation, higher wall quality), some expected correlation exist as well (e.g., smaller buildings, more likely to live in very low- or low-income settlement). However, the findings are too weak and ambiguous to draw conclusions from. Furthermore, a higher female population does not imply that the female population lives by themselves or is part of larger families with a male household head. The indicator of female-headed households considers this and leads to small correlations between higher values to, amongst others, lower accessibility to economic centres and bus stations, lower street densities, much lower ownership rates, as well as higher population densities. However, the correlations and underlying data vary too much to prove the disproportional sensitivity to flooding risk exposure. However, it shows some plausible interrelations and does not conclude in no marginalisation but instead asks for more focused qualitative analyses of the role and effect of floods on women.

5 Conclusion

The conducted research tried to explore the relationship between the spatial characteristics of Kampala and its social vulnerability in the specific field of flood-related risks. The central objective was to quantify and understand the interplay between the socio-spatial urban dynamics and climate change-related risks better. Hence, a more detailed look was taken at flood-related hazards as the most critical risks of urban Kampala. In particular, the flooding risk exposure, adaptive capacity of the population, as well as the sensitivity of the society and built environment was measured and contrasted with urban form, to provide new perspectives and understandings on how inequalities are enforced, counteracted or interrelated with spatial characteristics.

The primary objectives were, therefore, to measure the threat of climate change consequences and more specifically of flooding on urban residents, to improve the understanding of Kampala's urban form as well as the spatial distribution of risk exposure, adaptive capacity, and sensitivity as the elements of social vulnerability, quantify advantages and disadvantages for urban populations in different locations and it's assumed manifestation in spatial injustice for the already most vulnerable groups.

The broader hypothesis of the findings was that the residents of the most flood-prone and climate change risk affected areas are already the most marginalised and therefore suffer even more, reinforcing the spatial injustice in Kampala. Furthermore, it was expected that the spatial characteristics (urban form) are negatively affected by the existing risks while at the same time also increasing the vulnerability of those areas. Moreover, specific marginalised groups were expected to be more at risk than others. While the first two general statements are supported by the results of this study, the last aspect of marginalisation could only be partly quantified, however, requires further and more in-depth studies to conclude in a solid outcome. Lastly, very few unexpected results could be established. Mainly smaller correlations, like a generally better quality of the buildings (floor and wall quality) in areas with higher female population, as well as higher property ownerships in areas with higher risk. While the first finding is just partly fruitful, as the applied method does not build upon sufficient data of gender aspects, and the reduction to solely numeric information for a complex topic like this seems insufficient, the second finding could have various explanations resulting from the expert interviews and underlying data: Mainly, the different and intertwined land ownership systems in Kampala were not included in the data of ownership and can therefore mean that the population in the more flood-prone areas had indeed more likely one type of ownership which, however, is more likely to be an informal and undocumented one, while these types are rarer in the officially integrated and planned areas. Furthermore, property investments and renting make up a significant percentage of the overall land markets in Kampala, which is, however, more prevalent in the higher-income and value.

Finally, the broader concept of spatial injustice shall be discussed, together with how it is manifested through the studied concepts. Therefore, a general comment about the approach and the numeric results is necessary: While the above-reported numbers prove the general hypothesis of a significant interrelation between the elements as mentioned earlier, they have a margin of error and do not always apply. Furthermore, no numeric conclusion can be drawn on which variable is *dependent* and which *independent*, as there is no simple "*this-leads-to-that*" situation. Instead, according to the literature review, interviews and observations, the studied interplay is highly complex, and its constituents can initiate, reinforce, attenuate or even reverse their counterparts. For example, the risk exposure is higher at one particular location, therefore the property values are lower and people with fewer economic resources and simultaneously often less formal education move there, build houses of lower quality, therefore reinforcing their sensitivity, and creating different, more dense spatial environments, with less space for formal infrastructure. At the same time, their location is less fortunate, and their interests are often underrepresented, which leads to lower accessibilities to basic services and longer times to commute to work. This interplay is much more complex, however, highlights the vicious cycle which reinforces itself and is hard or even impossible to break under the current circumstances (compare to Hardoy and Pandiella 2009). One quite constant factor, at least under the applied assessment approach, is the flooding risk exposure, which stays the same at any location and just generally increases over time due to the higher and more frequent precipitation events. Therefore, the resulting spatial injustice through lower adaptive capacity and higher sensitivity is not induced due to changes of flooding risk exposure, but instead, lead to the location and spatial concentration of residents with specific characteristics in the beginning. And Urban Form, on the other hand, is also a factor which developed over a long time and works two-directional. Lower adaptive capacity comes, amongst others, from fewer resources, including smaller plots and buildings, while the high-income residential settlements are situated on hilltops, therefore are exposed to less or no flooding risks, and simultaneously have bigger plots and buildings, as well as lower densities. Also, to fully understand these dynamics, a single snapshot of the current situation just gives a very limited answer to the questions of the manifestations of spatial injustice.

As already introduced in the above chapter, many dimensions of Kampala's current spatial injustice originate from the colonial times and the accompanying spatial structure. Uganda's capital did not grow to become a spatially unjust city but has always been one and was planned as one from the beginning (see Omolo-Okalebo 2011). While the injustice in the past was originating from racial segregation, today it is between different income groups, while the "European" and "Asian" part of the population, even if today constituting much smaller percentages of the overall population, is still much less affected due their predominant belonging to the higher-income class. Climate change-related risks and floods in particular, as well as the according, different measured variables of urban form and social vulnerability, are therefore not the direct reason for the unjust distribution of (appropriate) land and access to the city but reinforce spatial injustices which were initially drawn out over a century ago. To best describe the consequences for the most affected, marginalised and vulnerable urban population, it makes sense to go back to the literature and introduce the concept of the capability approach. Initially developed by Amartya Sen (1979) and further specified by Nussbaum (2003), the capability approach builds upon the idea of liberalism and attempts to define justice not as the same situation for everyone, regardless of its embodiment, but that everyone should have the same capabilities. As Fainstein states it in the context of just cities:

> *"Capabilities do not describe how people function (i.e., end state) but rather what they have the opportunity to do. One need not exercise one's capabilities if one chooses not to, but the opportunity must be available, including a consciousness of the value of these capabilities" (2010, p. 55).*

This way of defining or measuring justice, or in this case injustice, goes well together with the above-described situation. On the one hand, the current distribution of risk exposure and resources is unjust, while the underlying problem and injustice is less about the current moment but the temporal development and the accompanying and rising differences of capabilities which would be necessary to change the individual's situation or break the vicious cycle – mostly due to being a fundamental and historically embedded ingredient of Kampala's spatial structure. And the flooding risks – in the past as well as today – as well as the accompanying sensitivity and limited adaptive capacity, are a critical and life-endangering element of it – but still just one of many in a complex, interwoven, but clearly unjust urban environment.

A quite clear perspective evolved: Urban form, regardless of looked at in the macro-scale of, e.g., city-wide accessibility or micro-scale of, e.g., building sizes, is strongly influenced by and reciprocally influences flood-related urban risks and social vulnerability in the whole. However, while the correlation to urban form in the macro-scale emerged from historical patterns and unjust land distribution and accessibility, the meso- and micro-scale characteristics are more of a consequence of the part of urban society, who chooses to live, or better has no other option than to live in areas with already high risk-exposures and insufficient service and facility access.

To wrap it up, this research could support some of the previous assumptions of disproportional spatial distributions of lower-income groups, the youth and up to a certain degree the female population, associated with, e.g., lower accessibility to facilities, lower quality of housing or smaller houses with lower values and higher risks of expropriation, some expected correlation could not be proved. However, this does not mean that they do not exist and are part of the challenge but highlight the need to study Kampala's dynamics more in detail. The methodological approach which was developed and applied in this research, as well as the development of more indicators which are less data- and work-intensive could provide salutary findings if repeated in frequent intervals and the larger functional urban area. Also, data accessibility proved to be crucial and a major challenge for researchers working in similar contexts. On the one hand, it is difficult to find out what exists and on the other hand where and how to access it.

Most of these challenges and findings should be able to provide a valuable and more spatially accentuated picture of the urban form of Kampala's diverse settlement as well as the distribution of exposure to flooding risk and the severity of potential disasters as well as the differing ability to cope or respond to it. This spatial understanding should be able to provide more empirically information on the scale of challenges as well as where and in which sectors interventions or further studies would be bear the highest potential. While numeric relationships do not mean that one value can be simply calculated or assumed based on one of the others; they provide a way of measuring, e.g., the development over time, or quantify the success of intervention projects instead. Lastly, on a larger scale, the research did not result in findings which were utterly unexpectable or differ from major academic concepts. However, they should be able to support some by proving them in the specific and profoundly affected case of Kampala, while also providing an innovative and more spatially-detailed approach to visualise, measure and compare it.

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