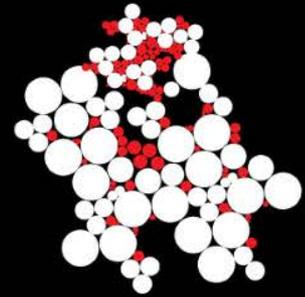


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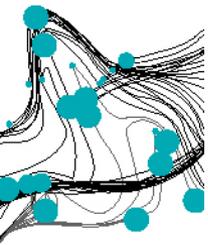


# SPATIAL PLANNING INSTITUTIONS IN URBAN FLOOD MANAGEMENT IN KAMPALA AND KIGALI AND THEIR IMPLICATIONS FOR INTEGRATED SPATIAL MODELLING

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# LAND USE PLANNING FOR FLOOD MITIGATION

## RESEARCH PROBLEM

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- To what extent can land use planning reduce the impact of flood hazard in urban contexts?
- Research experience on Kampala, Uganda (Cities and Climate Change Initiative 2012-2013), has provided insights of possible tools and articulated strategies of policy formulation, implementation and evaluation
  - Urban growth modeling (CA and SLR) and flood modeling as a basis for explorations
  - Evaluation of non-conventional drainage interventions (e.g. rain harvesting)
  - Assessment of land use strategies (flooded area evacuation, wetland protection, vegetation in drainage system)
  - Fuzzy responsibilities (Kampala) but also fuzzy space (Kigali and Kampala).



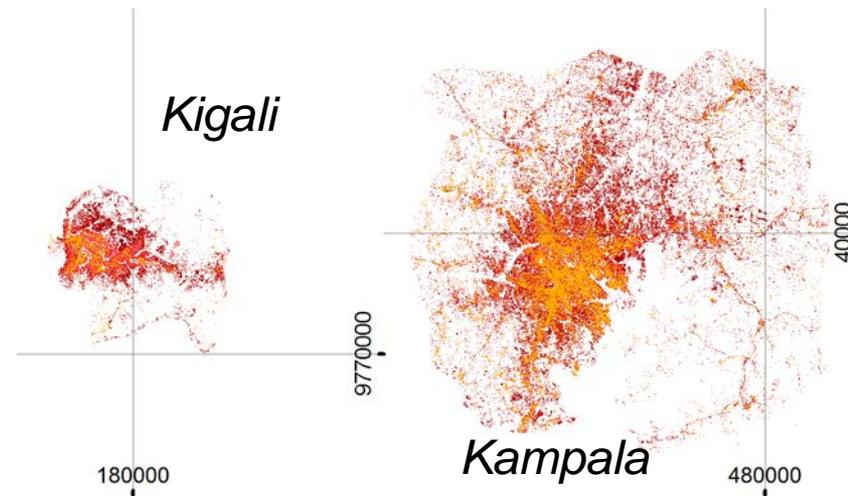
# KAMPALA AND KIGALI AS CASE STUDIES

**Kampala (Uganda) and Kigali (Rwanda) are, in many ways, similar:**

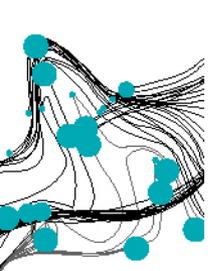
- Similar population (1-2 million), rapid growth
- Natural environment (hilly area with significant wetlands),
- Similar challenges, particularly limitations in infrastructure provision (roads and public transportation, water and sanitation, and notably drainage systems)
- Rwanda and Uganda similar countries: agricultural economies, high levels of poverty (near 70%) but with a rapidly growing economy (GDP increase over 5% p.a. in the last 5 years)

**They diverge in two important ways:**

- The more dispersed pattern of urban growth of Kampala
- The willingness of Kigali city authorities to strictly implement land use regulations



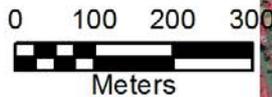
Urban growth 1990-2010



# LAND USE ENFORCEMENT IN KIGALI

## AN EXAMPLE OF RELOCATION

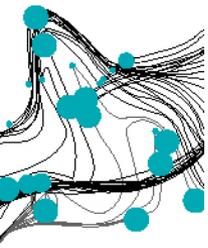
- Residents of Ubumwe slum were moved to Batsinda (5 km distant). Space partly re-developed for commercial land use but, partly retained as a riparian buffer - close proximity to a wetland (north-east part).



2004



2014

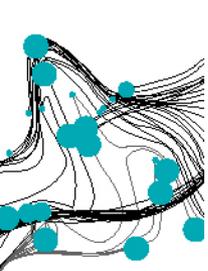


# INFRASTRUCTURE INVESTMENT IN KAMPALA

## IMPROVEMENT OF THE LUBIGI DRAINAGE CHANNEL

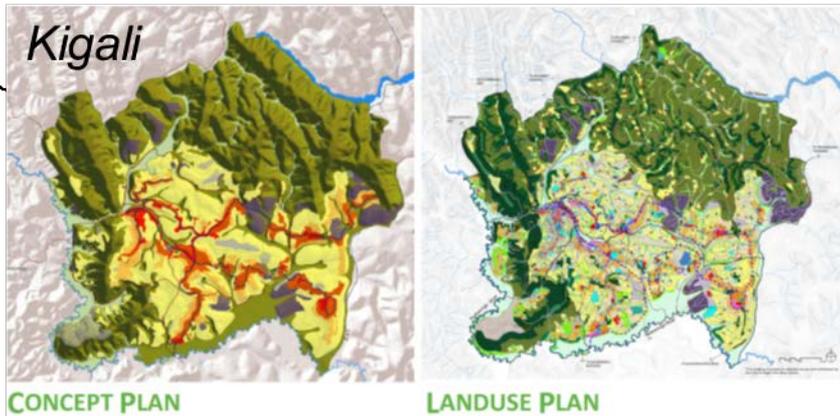
- Kampala's drainage system has been poorly developed and managed.
  - 8 primary drainage channels, two of which have been recently upgraded: the Nakivubo and the Lubigi channels
  - The upgrading of the Lubigi channel limited to its upper reaches only.
  - Upgrading through a combination of channel widening and lining and the installation of high capacity culverts at bottlenecks under roads. Recent flood events show that such improvements may not always be sufficient





# LAND USE POLICY INSTRUMENTS COMPARED

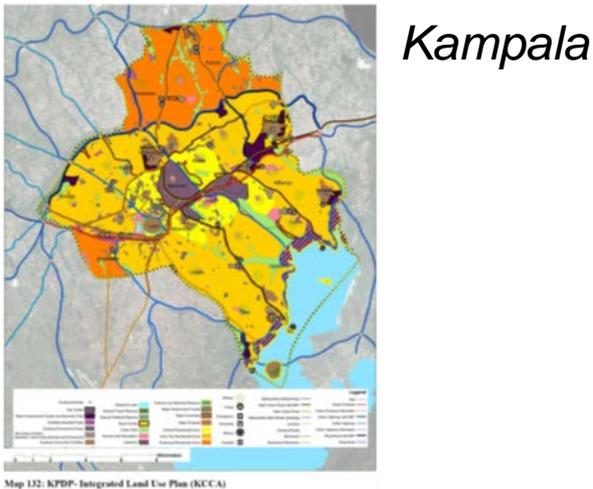
## GENERAL APPROACH



**Urban plans are recent:** the Kampala Physical Development Plan (KPDP), 2013 & the Kigali Master Plan (KMP) finalized in 2013, based on the conceptual plan existing since 2007

Both **strong focus on physical development** and in particular land use (zoning) and regional transportation (BRT and regional roads proposals)

- KMP is more detailed than the KPDP: KPDP has a conceptual approach (identify satellite towns, regional suitability), KMP defines land use conformity and includes sub-metropolitan level proposals





# LAND USE POLICY INSTRUMENTS COMPARED

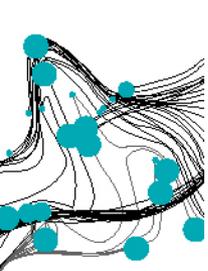
## FLOOD MANAGEMENT

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### Different approaches to flood management:

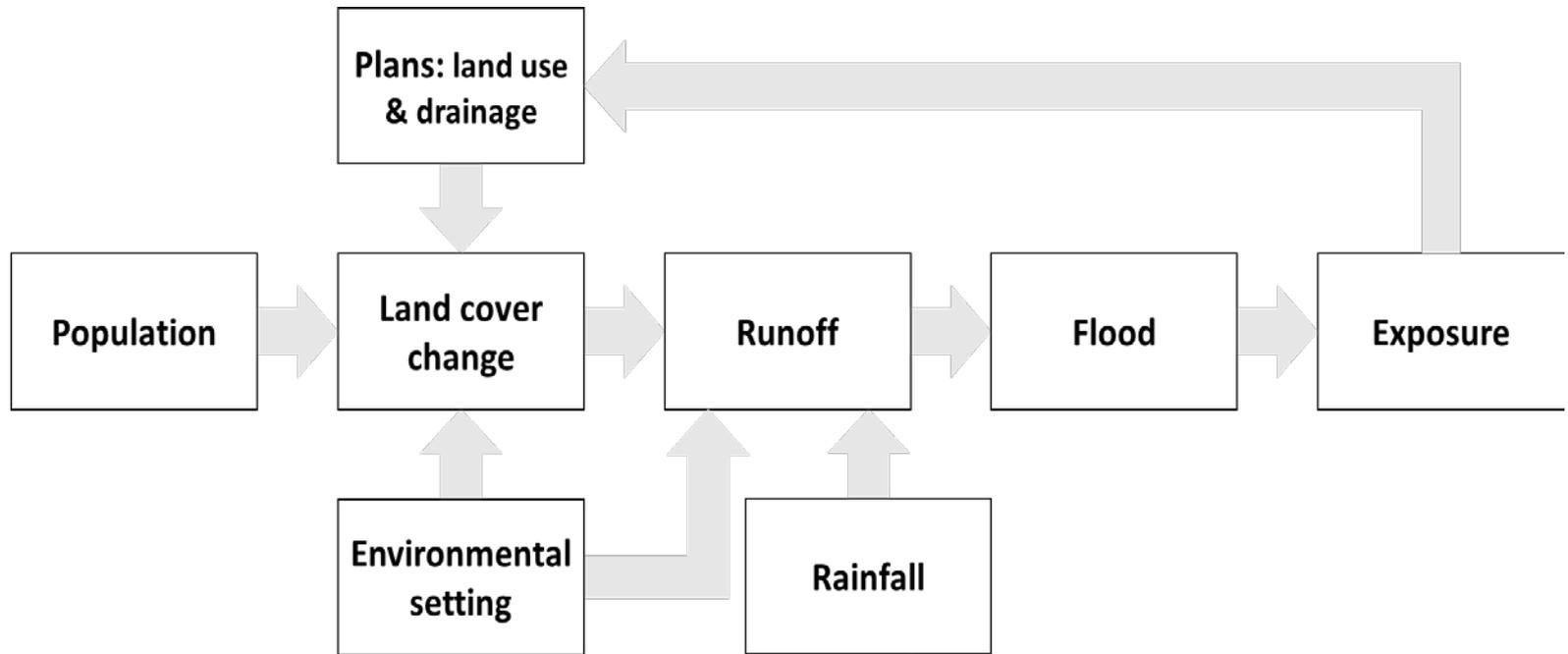
- Kampala: KPDP views it as an infrastructure problem
  - Coordination between urban development and drainage systems
  - Emphasis on detailed design of drainage systems and adequate funding to accommodate future growth
  - Land use planning has the ambition to prevent further encroachment of urban land uses on flood prone areas, but no effective instruments
- Kigali: KMP integrates flood management into its environmental strategy
  - Protecting the natural value of wetlands
  - Specific goals include zero loss of existing wetlands (to urban development) and riparian buffer zones from wetland fringes and from drainage (20 to 50 m)
  - Includes extensive wetland restoration





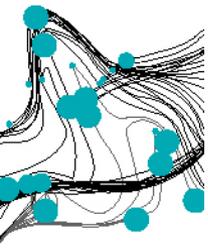
# CONCEPTUAL AND METHODOLOGICAL FRAMEWORK

## TOWARDS DESIGNING EVIDENCE BASED POLICY



- Urban growth, driven by population growth and by policy but also occurring in a specific setting, increases flooding problems: possibly the hazard magnitude (increased runoff) and certainly its impacts (increased exposure)





# URBAN GROWTH MODELING

## RESULTS FROM UPPER LUBIGI IN KAMPALA

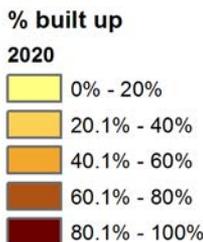
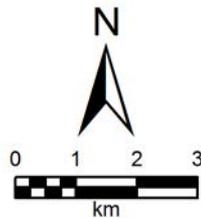
Spatially explicit scenarios of land cover change, projecting land cover conditions to 2020 were used as inputs into the flood model

- Simulated options included upgrades in the drainage system and rainfall harvesting
- Land use scenarios were obtained from Spatial Logistic Regression and from Cellular Automata models; CA better incorporated randomness

### *Future work:*

**\*Use multiple built up categories**

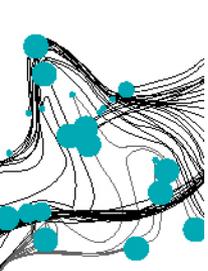
**\*Explore the dynamics and impact of non-built up categories of land**



**Spatial Logistic Regression**



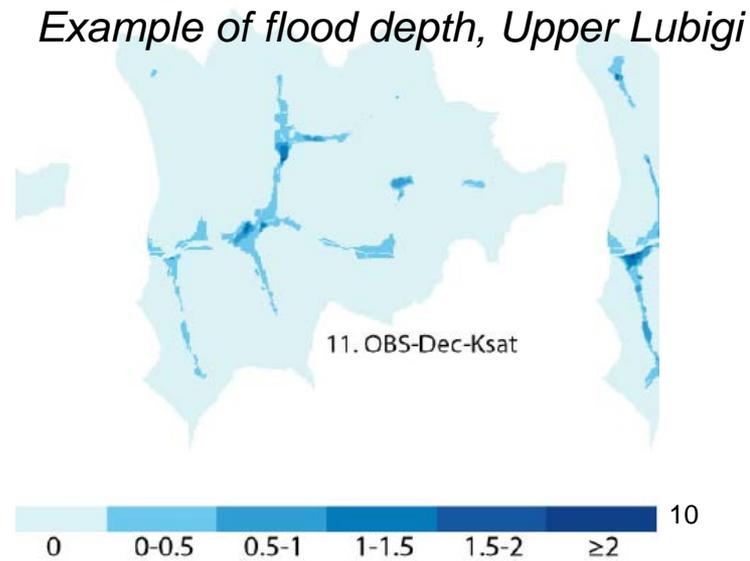
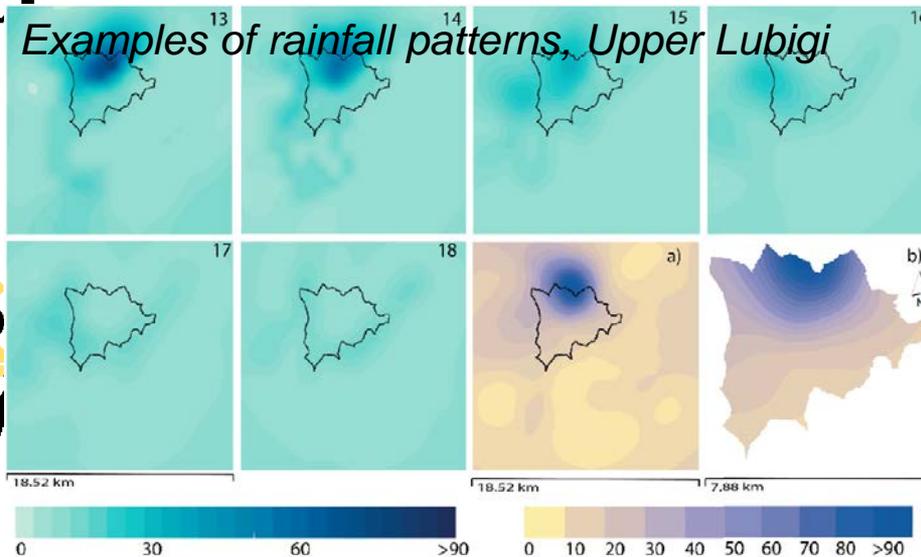
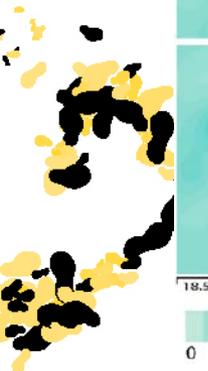
**Cellular Automata**

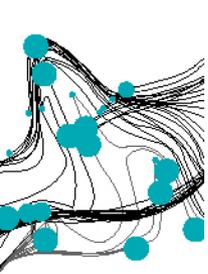


# FLOOD MODELING

## RESULTS FROM UPPER LUBIGI IN KAMPALA

- openLISEM, an event based rainfall-runoff model, is used to model flood
  - Versatile tool: issues addressed in Upper Lubigi have included strategies to promote local retention and infiltration (rainwater harvesting, infiltration trenches, and retention ponds) and the impact of the spatio-temporal variation of rainfall on flood estimates
  - Data constraints prevented incorporating more deeply climatic factors; is there an opportunity to address this in Kigali?





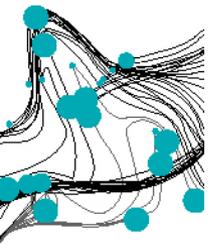
## MAIN FINDINGS OF CASE STUDIES

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- In both cases, modelling can contribute to strengthen evidence based planning and management decisions
  - Results are pertinent and there is room for improvement of existing products – element of fuzziness inherent in products (e.g. flood hazard zones are *fuzzy*)
- KAMPALA  
Ineffective urban planning and management procedures a significant factor in increasing storm water run-off rates and discharge, and in increasing the level of exposure of communities to flooding. Weak institutions and fuzzy responsibilities (Human resources, knowledge, corruption, multiple overlapping mandates 9 laws)





# MAIN FINDINGS OF CASE STUDIES

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- KIGALI  
Integrated models provide insights into potential problems through ex-ante evaluation of the impact of urban development projects. Longer term scenarios related to climate change could also be beneficial, though as in Kampala, they are likely to be less critical in the short term.
- Worst case: collapse of current regime

