URBAN FLOOD RISK

An increasing challenge for urban sustainability

Sea level rise, storm surge and coastal erosion in Saint Louis, Senegal

Urban flooding in Msimbazi River Basin in Dar es Salaam, Tanzania

Impacts of Cyclone Idai in Beira, Mozambique

A roadmap for risk knowledge and assessment for project delivery

Flooding - What is a flood hazard?

A flood:
- The inundation of an area not normally covered by water.

A flood hazard:
- A flood with the potential to cause harm

Some floods are not a hazard,
- Functional fluvial floodplain
- Coastal marshes, etc
- May be beneficial, natural process

Considerations for a Flood Hazard Assessment

1. **What stage of the analysis are you at?**
2. What is the main types of flooding?
    a. River or Fluvial Floods
    b. Flash Floods
    c. Pluvial or Overland Floods,
    d. Coastal or Tidal Floods
3. What is the scale of the area of interest (AoI) and the available resources will define what type of DTM (Digital Terrain Model) to use.
4. What type of modelling to use?
5. What are the sources and quality of:
    a. Model input data (rainfall, river conditions and tides)?
    b. Surface feature data (river channels, embankments etc)?

1. Project Development Stages

Level 1) Preliminary broadscale “Hotspot” mapping and assessment

Level 2) Strategic city (regional or small island state) scale analysis

Level 3) Detailed high resolution analysis focusing on basin or sub basin scale

Different stages of the process require different levels of understanding, assessment, and decision making.

Initial discussions and investigations

Initiating dialogue, identifying the scale of hazard or risk. Defining the problem and setting out potential actions

Project concept and preparation

Preliminary assessment and pre-feasibility, cost-benefit analysis, initial scoping and staffing

Project planning and appraisal

Feasibility, engineering and design studies, economic analysis, environmental and social impact assessment

Implementation

Procurement, contract negotiation, land acquisition, environmental licensing and permits, construction

Commissioning and Operation

Construction and project monitoring and supervision, O&M of structures, post-construction review

Source: Shah, M. A. R., Rahman, A., & Chowdhury, S. H. (2017). Sustainability assessment of flood mitigation projects: An innovative decision support framework. International journal of disaster risk reduction, 23, 53-61.

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2. Types of flooding

1. RIVER OR FLUVIAL FLOODS
2. FLASH FLOODS
3. PLUVIAL OR OVERLAND FLOODS
4. COASTAL FLOODS
5. GROUNDWATER FLOODS

Understand the characteristics of events, they are quite different, which influences their consequences

- Origin of the water (source)
- Geography of the receiving area
- Cause
- Speed of onset

Each requires a slightly different approach – some common aspects, but technical differences

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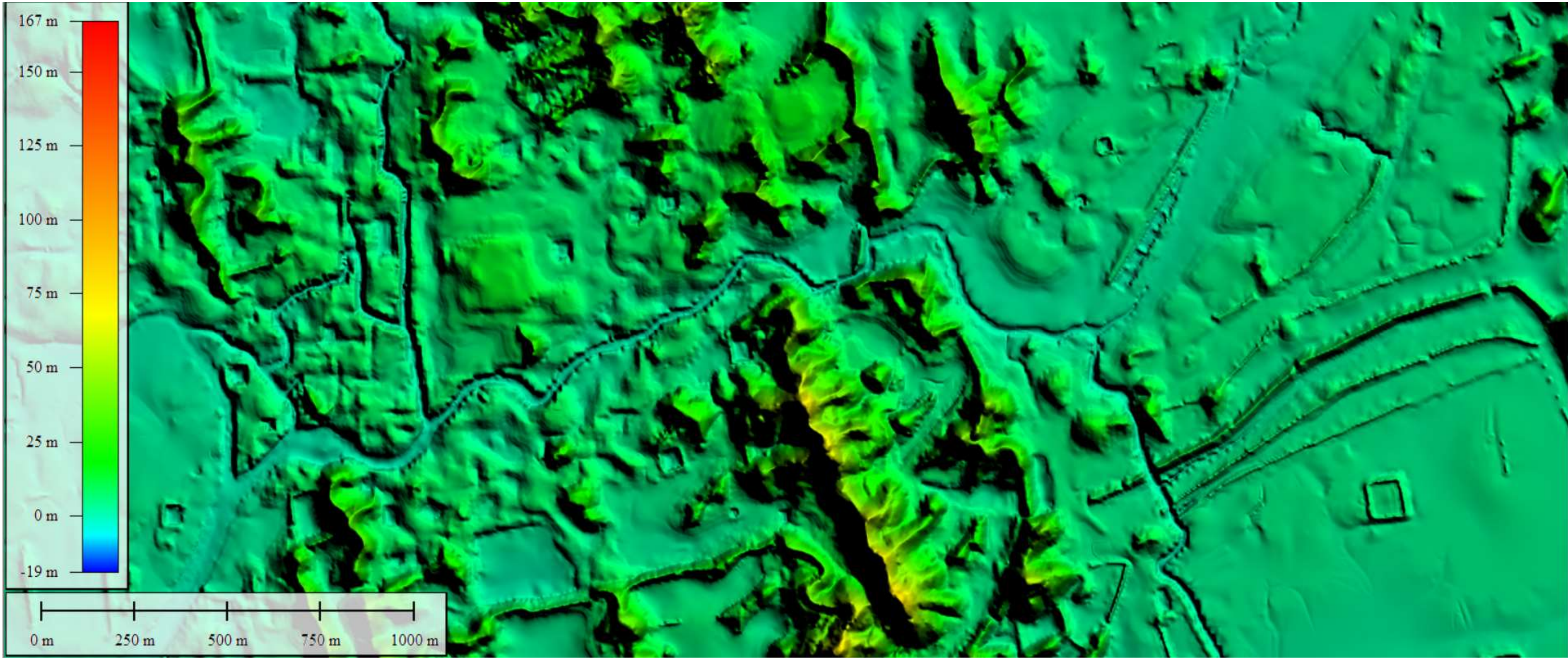
3. Digital Terrain Model (DTM): LiDAR Based DTM



3. Digital Terrain Model (DTM) is the key data set required for city scale flood modelling

- Grid data - can be used as a resampled data set depending on AoI, features and topography - typically range from 90m (STRM) to 25cm (LiDAR)
- However - vertical accuracy is key. It must be:
  - Consistent across the entire drainage basin area i.e. no steps or breaks
  - LiDAR is best – but for a strategic level assessment other less accurate options can be used.
  - Able to resolve flat areas (especially coastal) – contour data should not be used.
  - Consistent with some recognised national or international datum and projection
- This data can often be the largest cost of a modelling exercise
- Problems with the DTM are the most common reasons for poorer quality results that expected or project over-run

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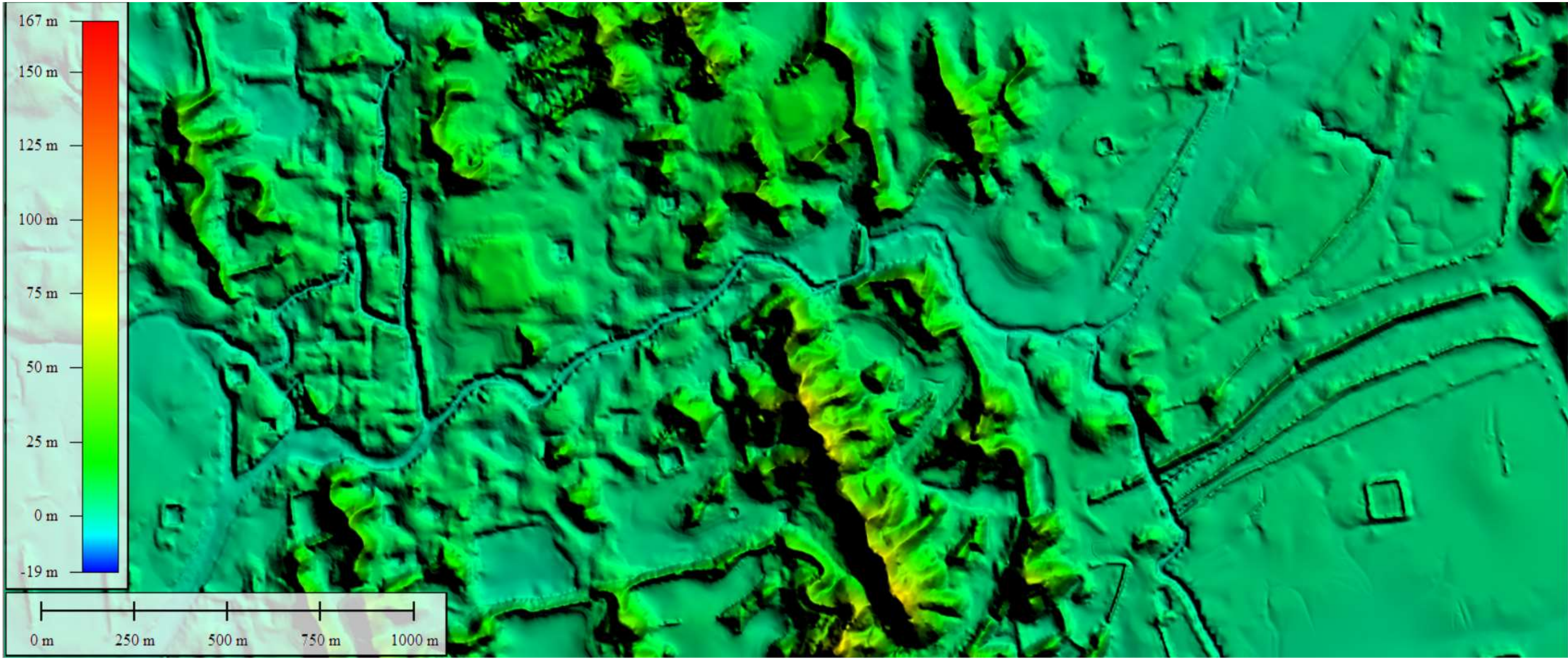
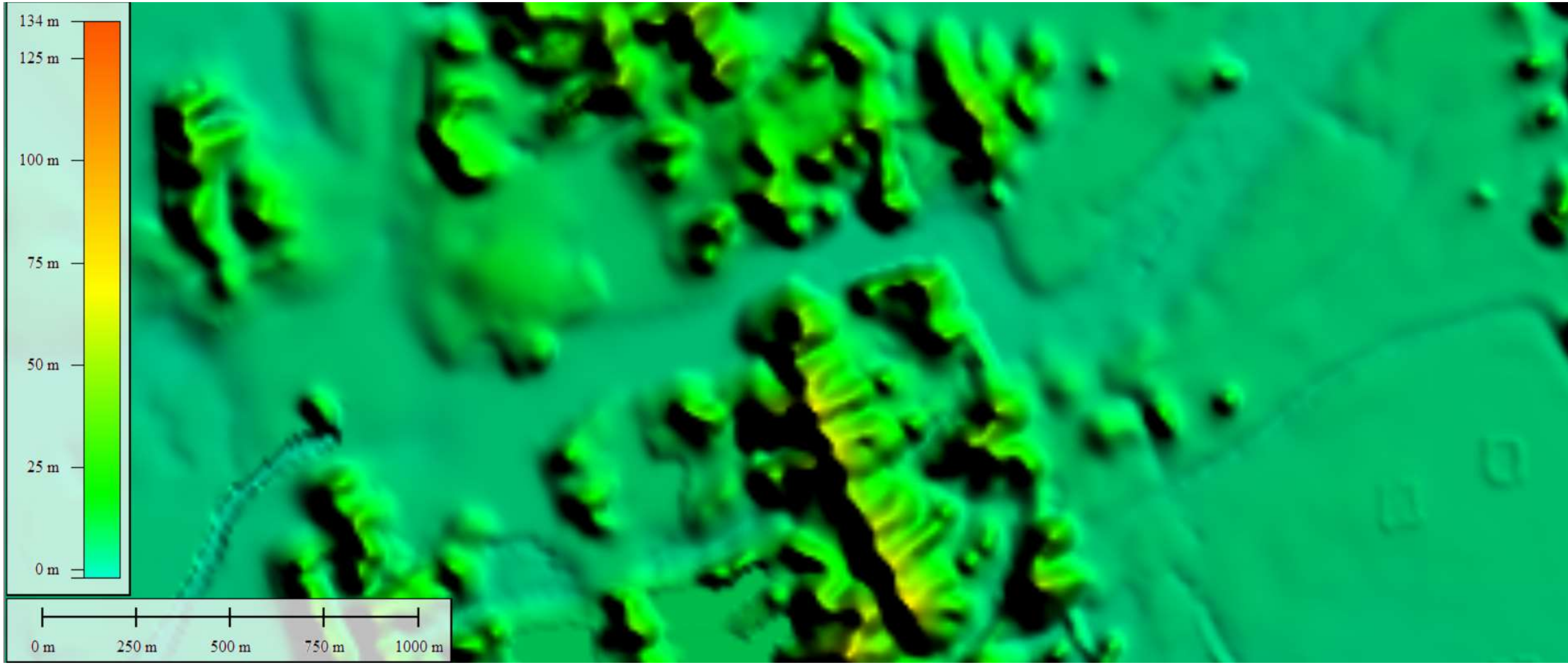


3. Digital Terrain Model (DTM): AirBus WorldDEM 12m DTM



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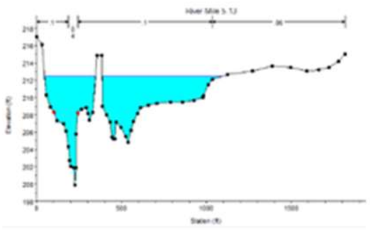
4. Modelling Approach

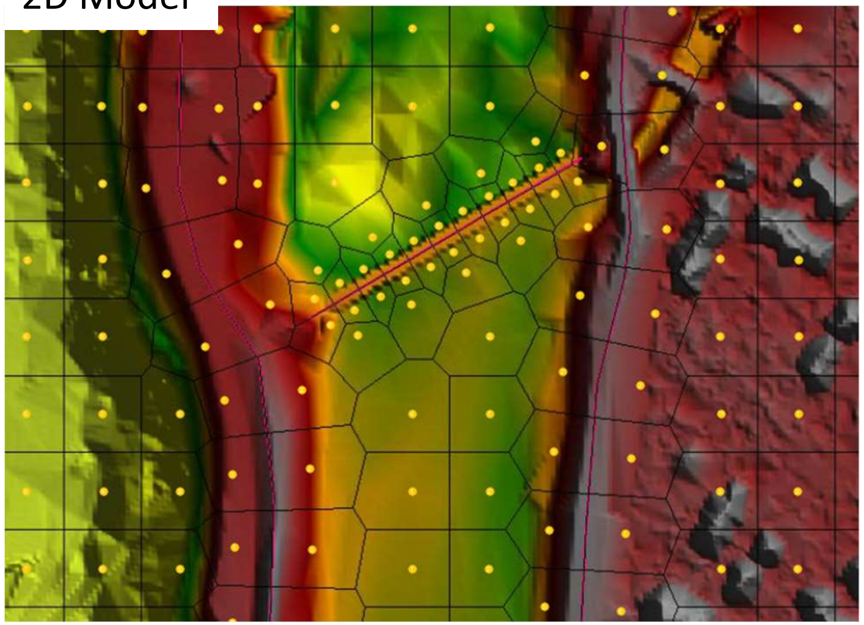
1D Model

1 D HEC-RAS model

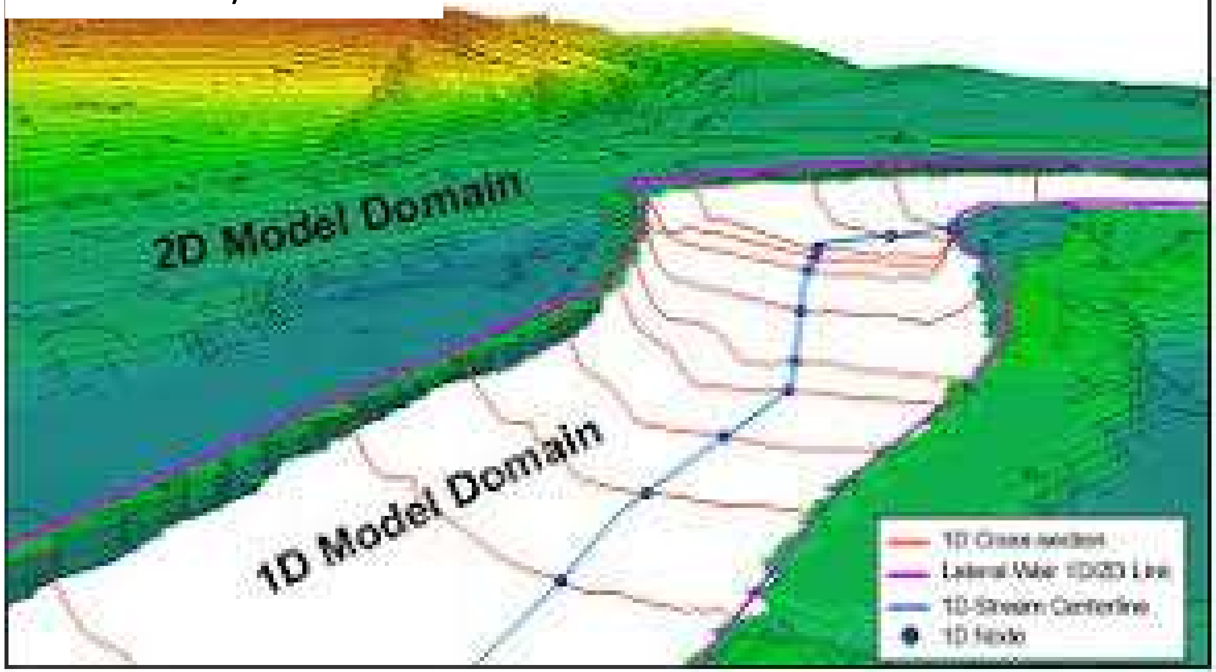


Channel cross section

2D Model



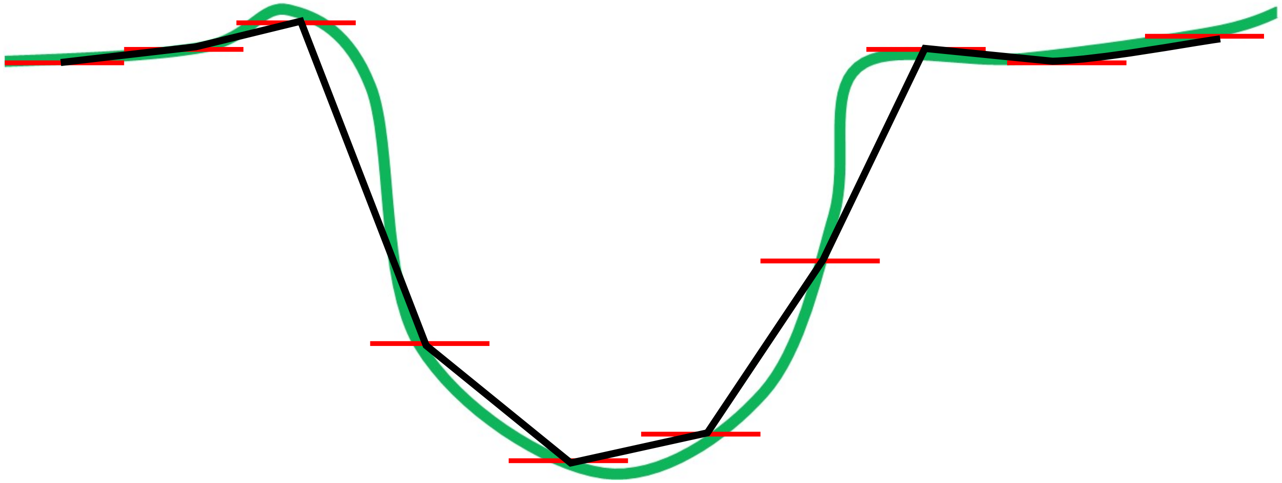
Combine 1D/2D Model



4. Modelling Approach: 2D Modelling – Importance of the DTM

5m cell size

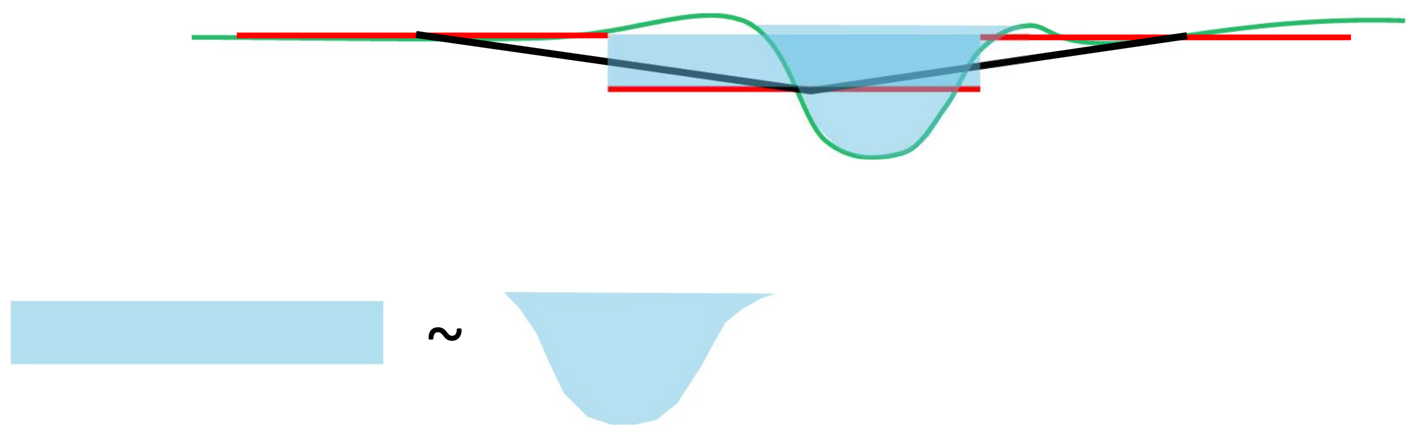
20m Wide River



4. Modelling Approach: 2D Modelling – Importance of the DTM

30m cell size

20m River



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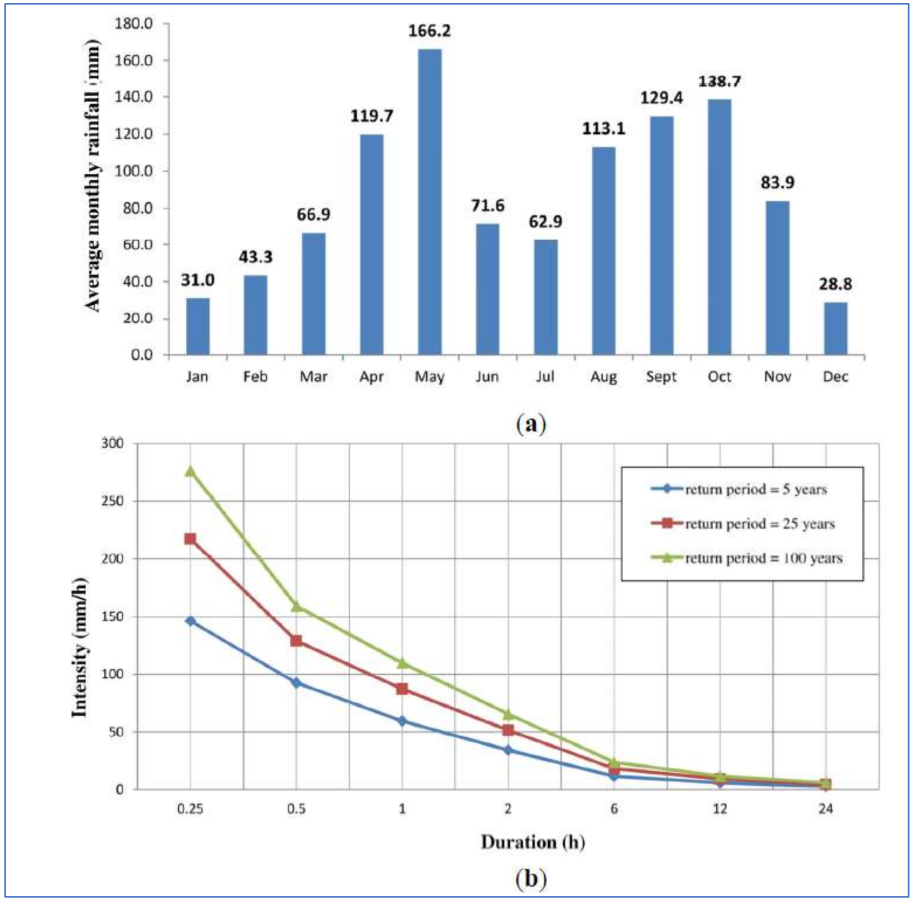
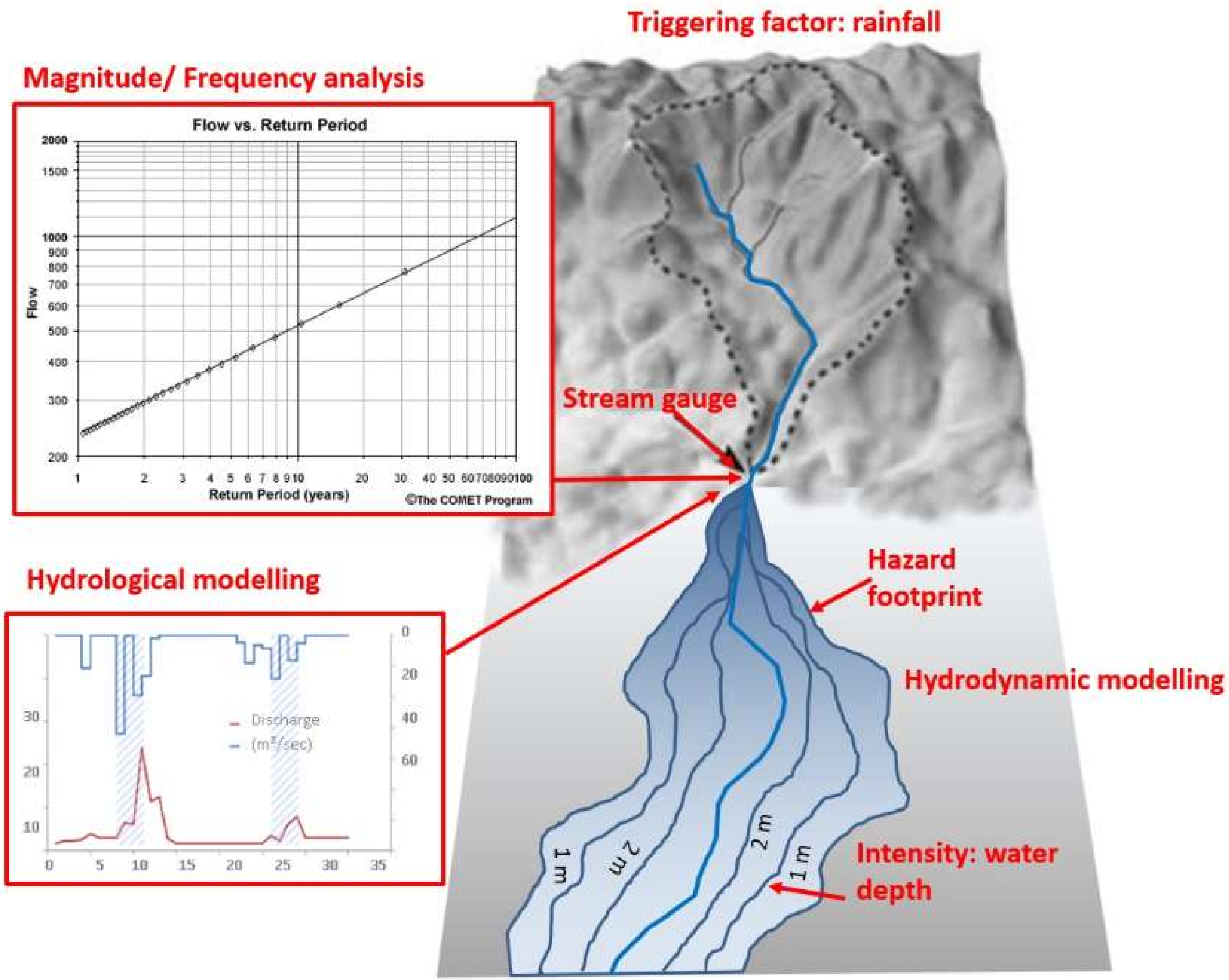
5. Data sources and quality: Rainfall analysis

- Normally derived from local historic rainfall records
- Global or regional data can be used
- Always some uncertainty – any local data should be used for checks



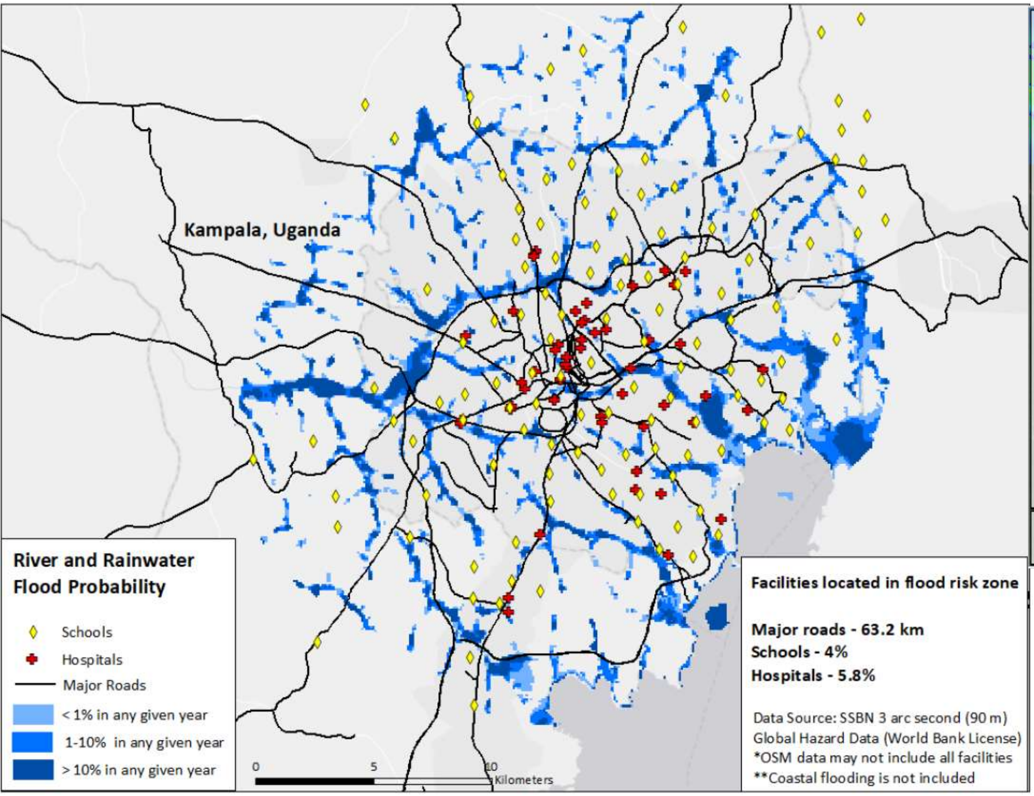
5. Data sources and quality: Flow estimation



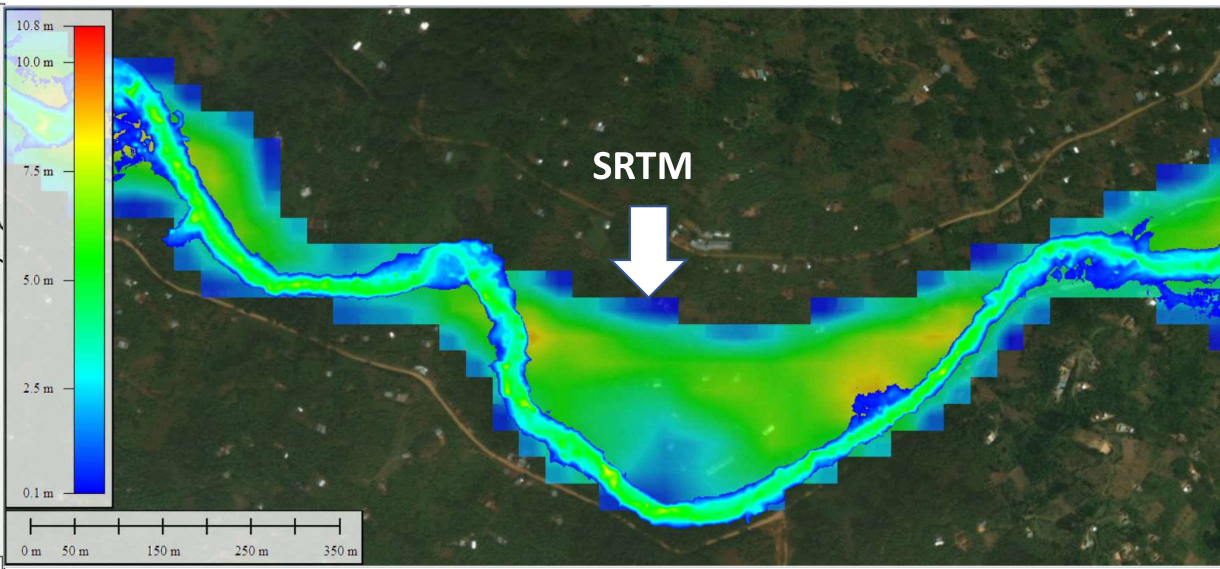
Modelling Levels – choices and options

	Level 1	Level 2	Level 3
DTM Data & Survey	Low/Zero Cost Global Data, no survey	Best Available Global Data, no survey	LiDAR + local survey
Input data	Global rainfall, flows soil type, land use, etc.	Locally refined rainfall, river flow, tide soils, land use etc.	High resolution rainfall, river flow, tide, wave, soils, land use etc.
Approach and Methodology	2D	Enhanced 2D	Enhanced 1D/2D combined
Benefits	Low cost/rapid, limited use	Reasonably low cost, very useful	Essential for scheme or project design
Cost and Time	Data - zero Assessment <$25k - 1 month	Data – $100k Assessment <$40k – 2 months	Data - $0.5m Assessment <$250k – 9 months

Examples of Level 1 Analysis

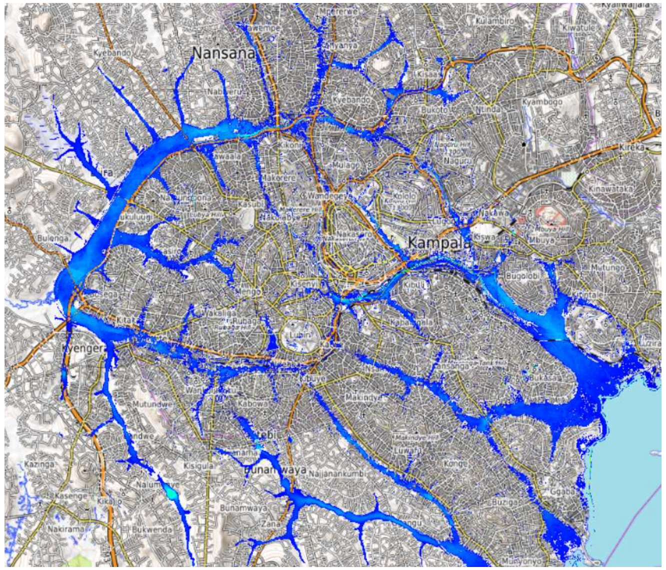


City Scan Modelling using SRTM Satellite DTM (Kampala, Uganda)

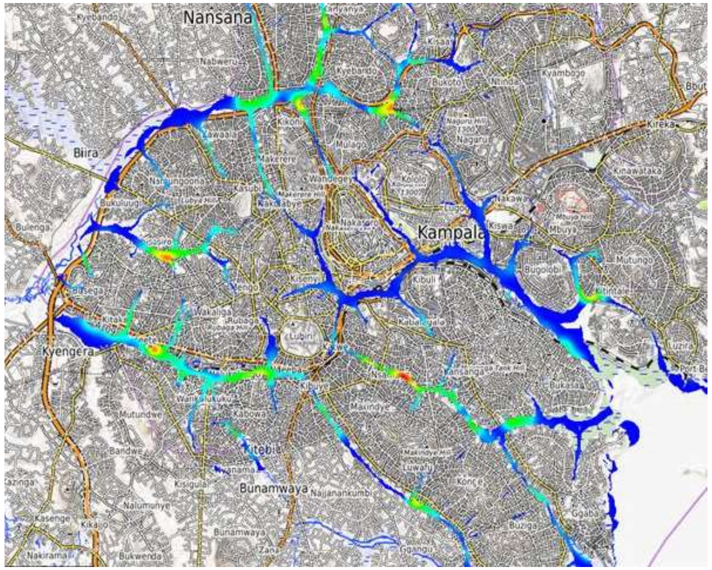


Identical 2D modelling approach, using low resolution (30m) STRM Satellite DTM, compared with a high resolution (1m) DTM captured using a drone and photogrammetry (Bukalasi, Mt Elgon, Uganda)

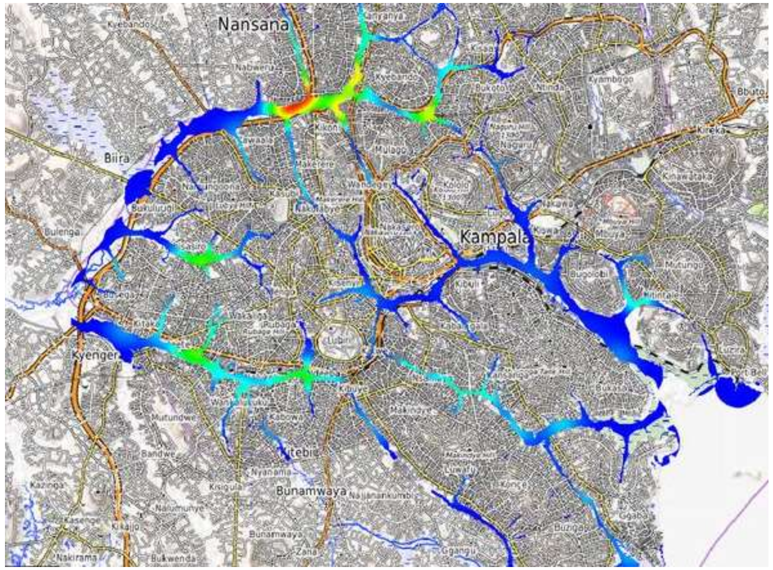
Example of Level 2 Analysis – typical outputs



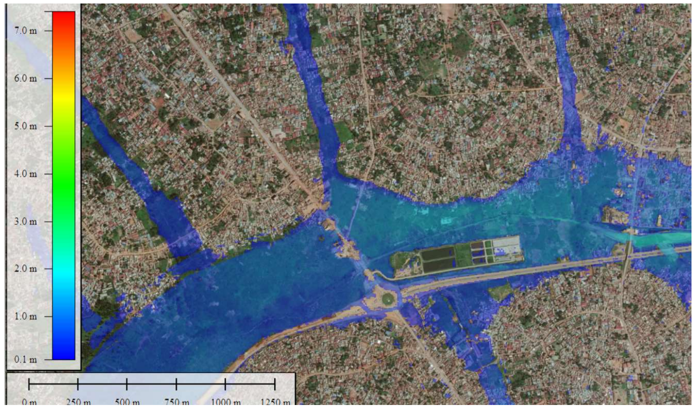
Flood Hazard (1:50yr event)

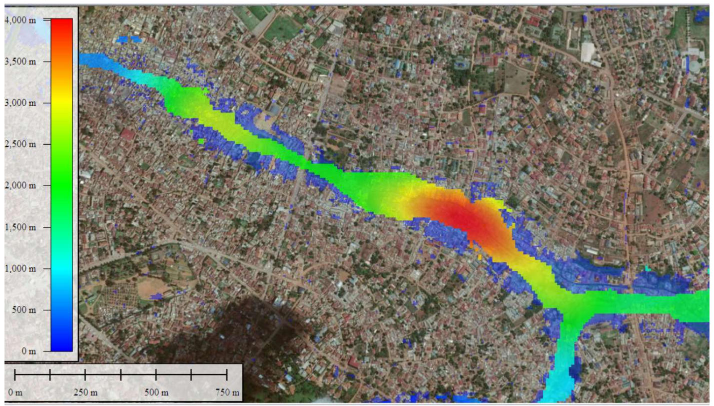


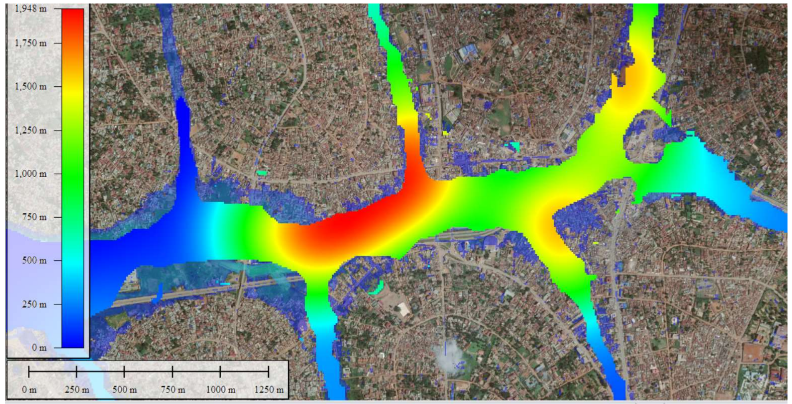
Flood Risk (Economic)



Flood Risk (Social)

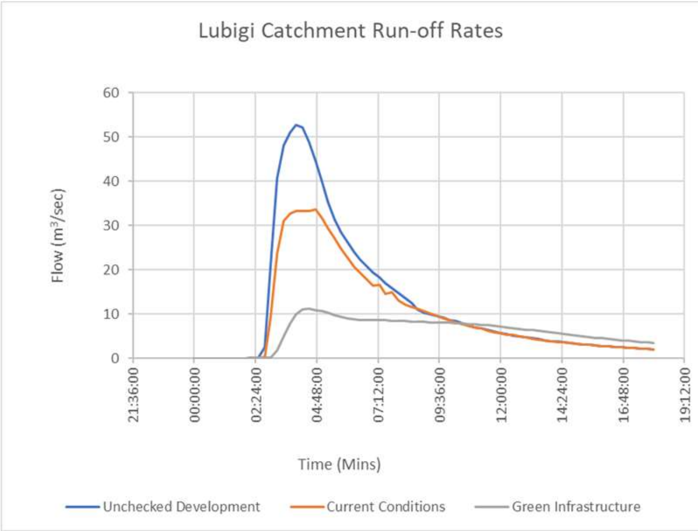




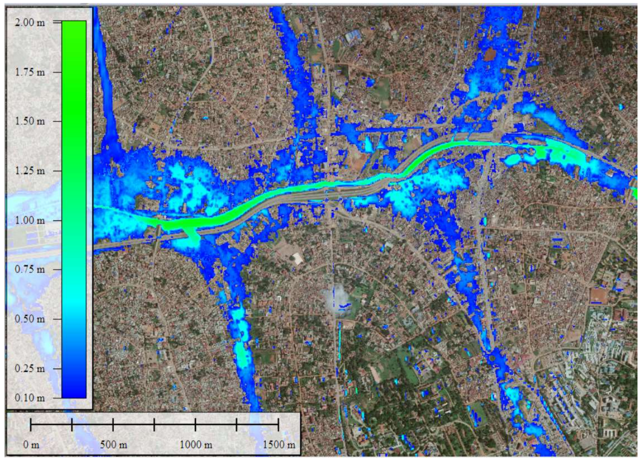


Impact of continued unchecked future development against implementation of green infrastructure

- Unchecked development will result in continued increase in run-off from the upper parts of the Lubigi basin
- Current conditions already result in high run-off rates
- Implementation of green infrastructure in the upper basin results in significant reductions in run-off and associated flooding

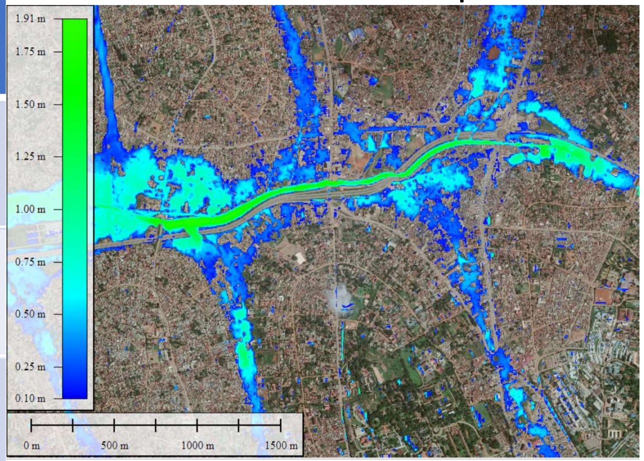


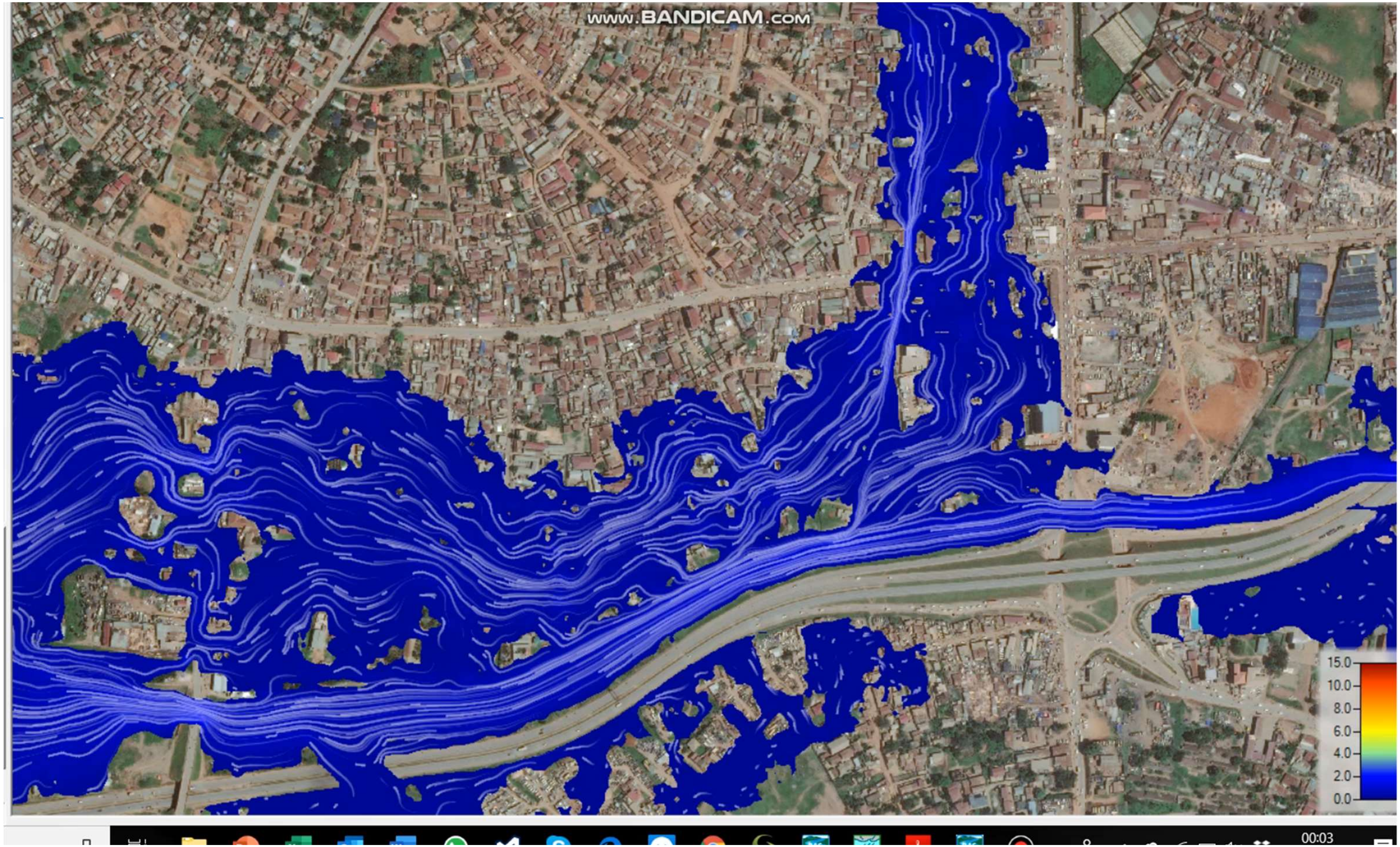
Green Infrastructure



Scenario	Number of buildings flooded	Annual Average damages	Extreme event (100yr) damages
Current situation	6,624	$26m	$65m
Unchecked development	6,850	$46m	$118m
Green infrastructure	5,900	$14m	$50m

Unchecked Development

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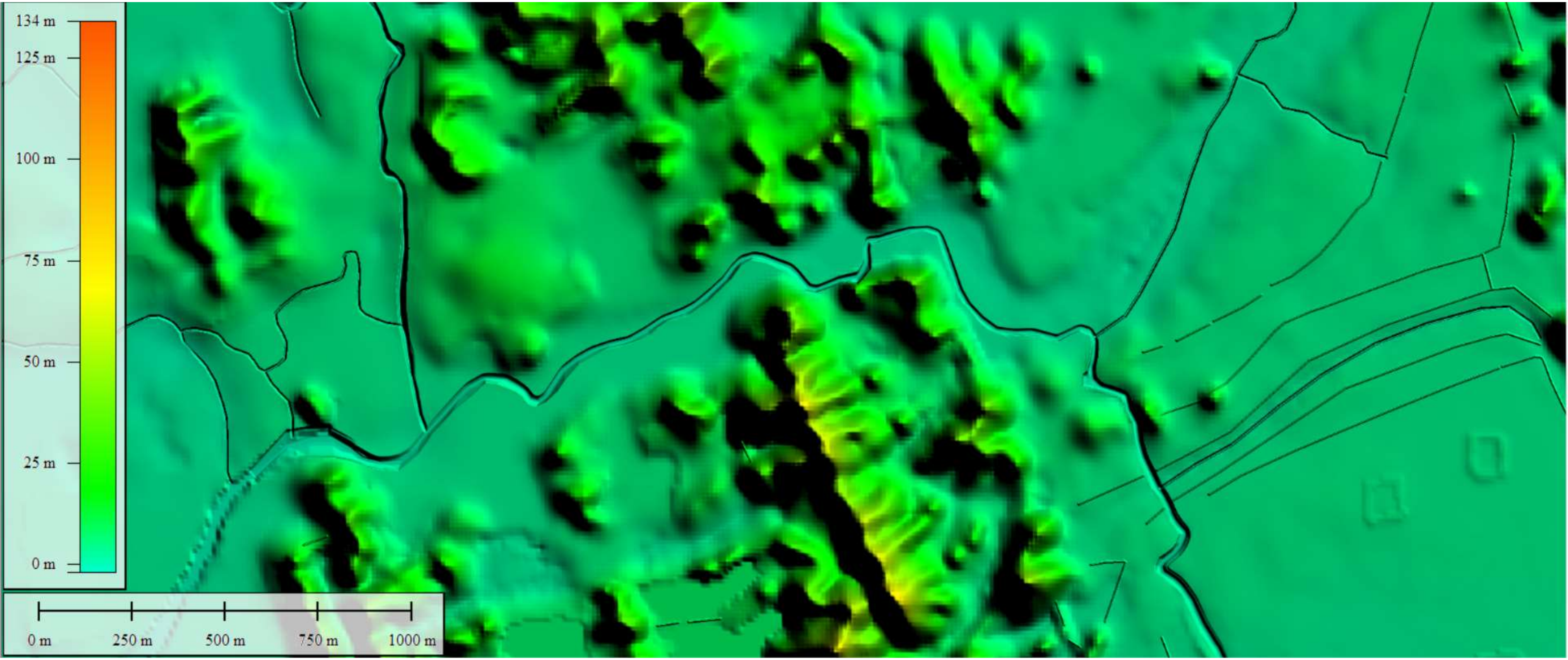
If you don’t have a high resolution DTM: What you can do about it?



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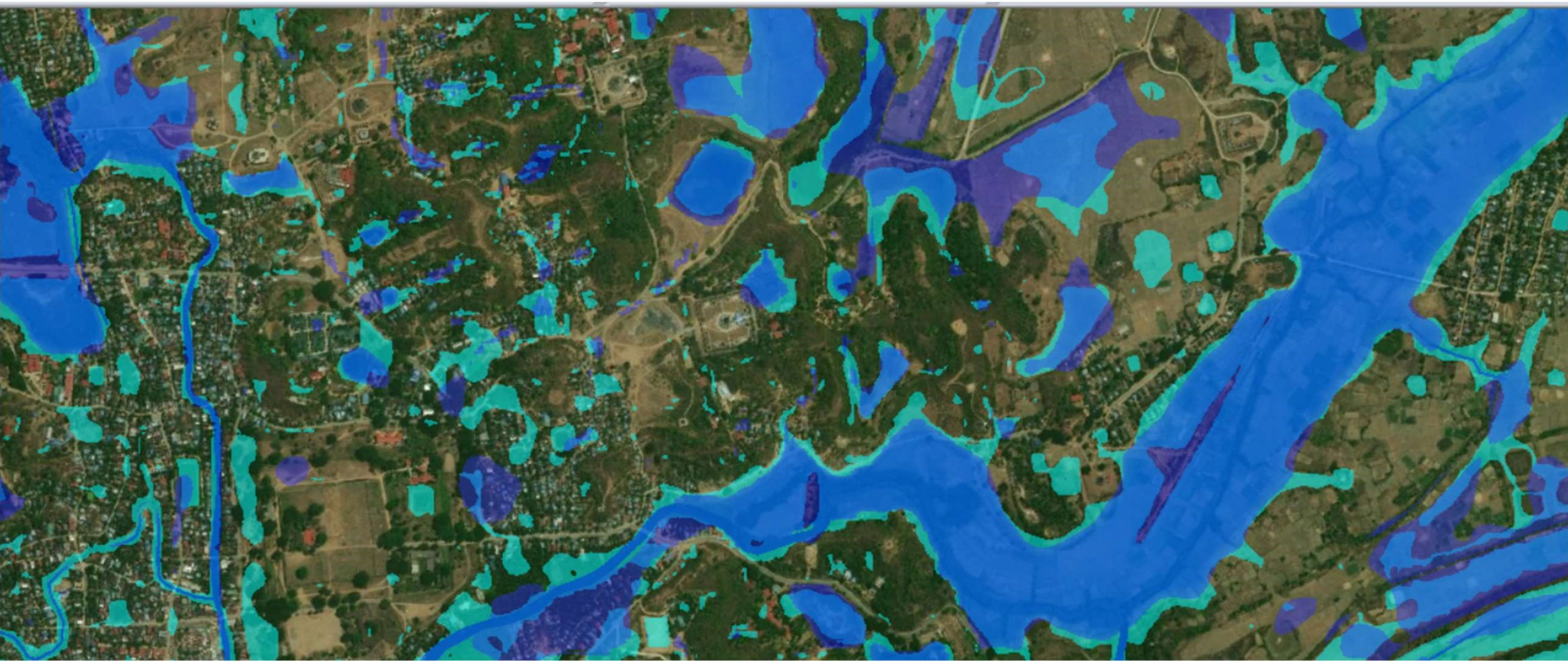
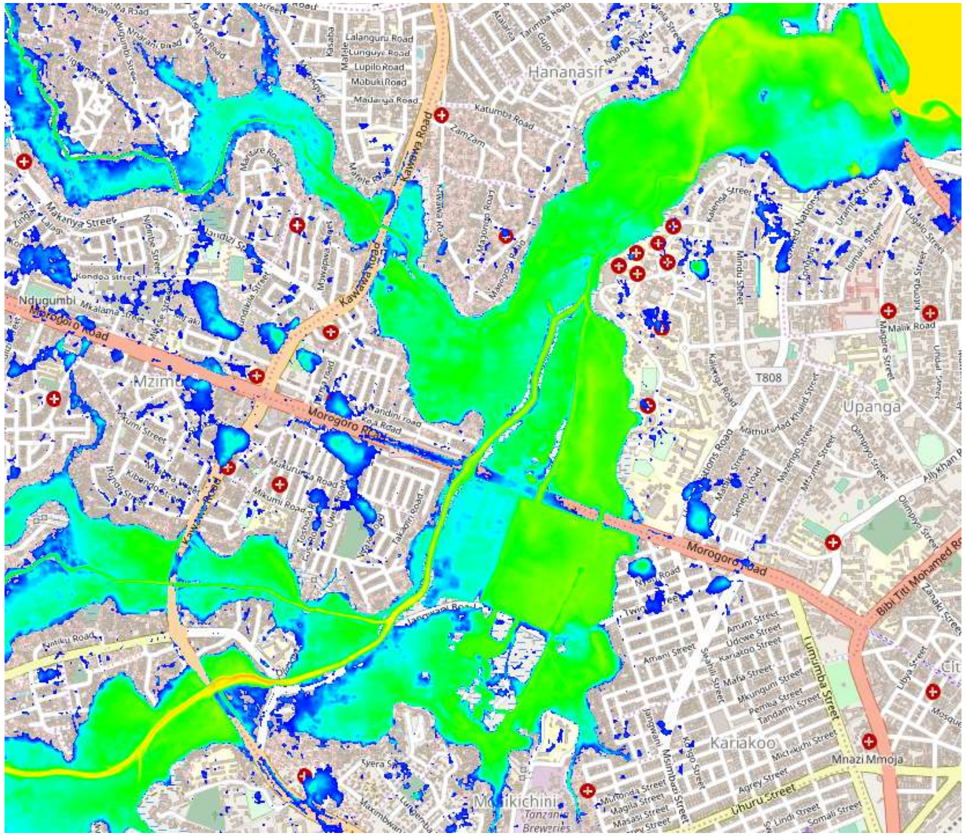
What difference does it make?



Level 2 Analysis – Selecting model type



High resolution 2D Only Model (HEC-RAS): with same return period storm, same DTM, direct rainfall approach

More complex 1D/2D Model (Sobek): with same return period storm, same DTM, but applying inflow hydrograph boundary conditions

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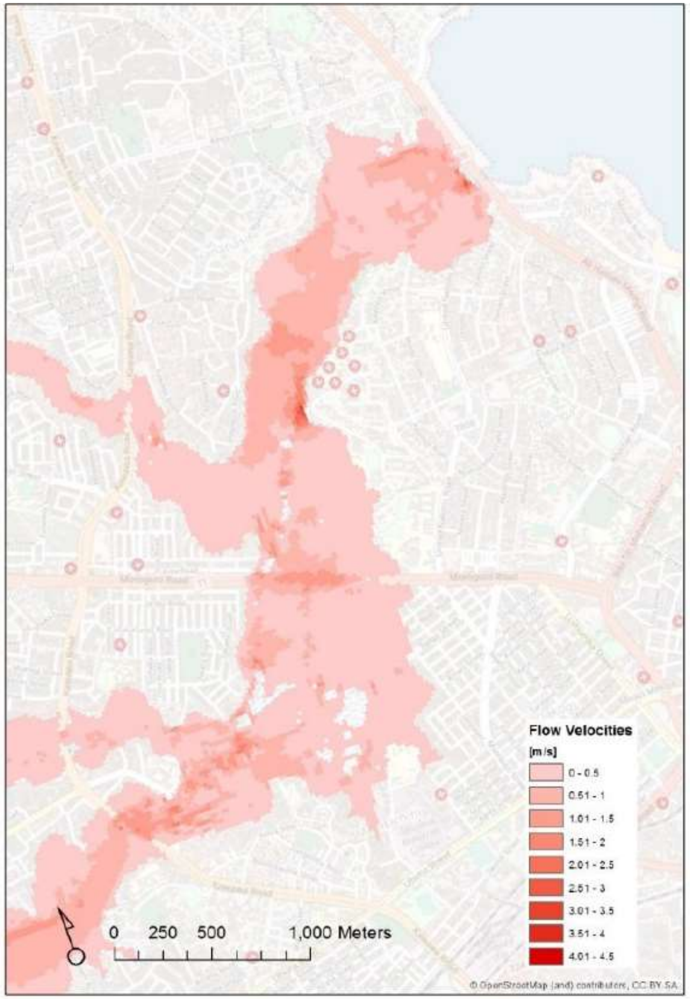
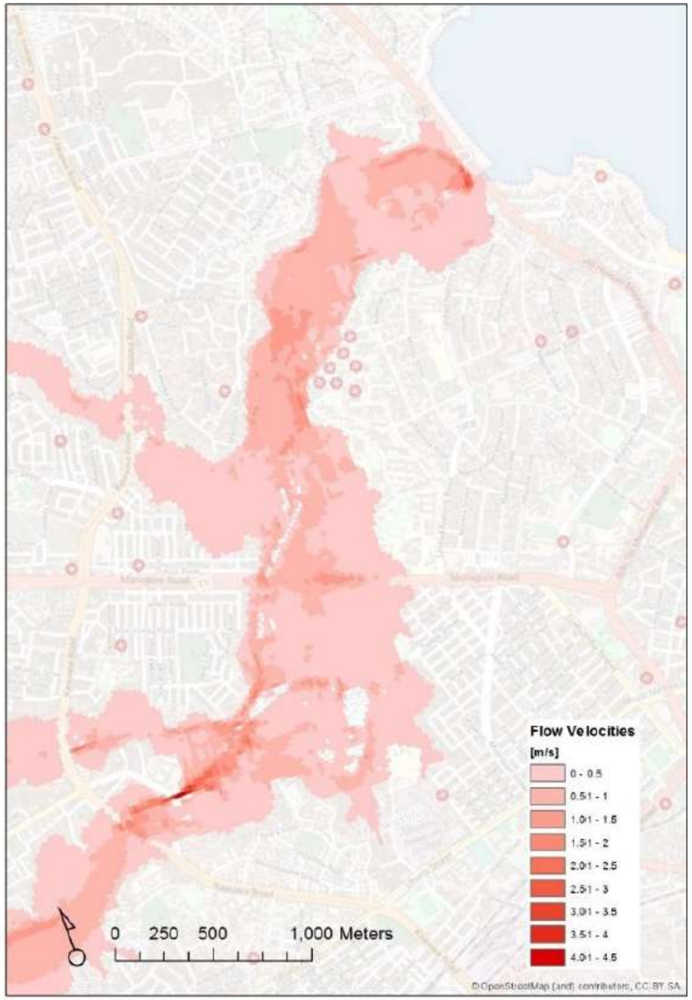
DTM Quality - LiDAR vs Photogrammetry

Msimbazi basin,
Dar es Salam





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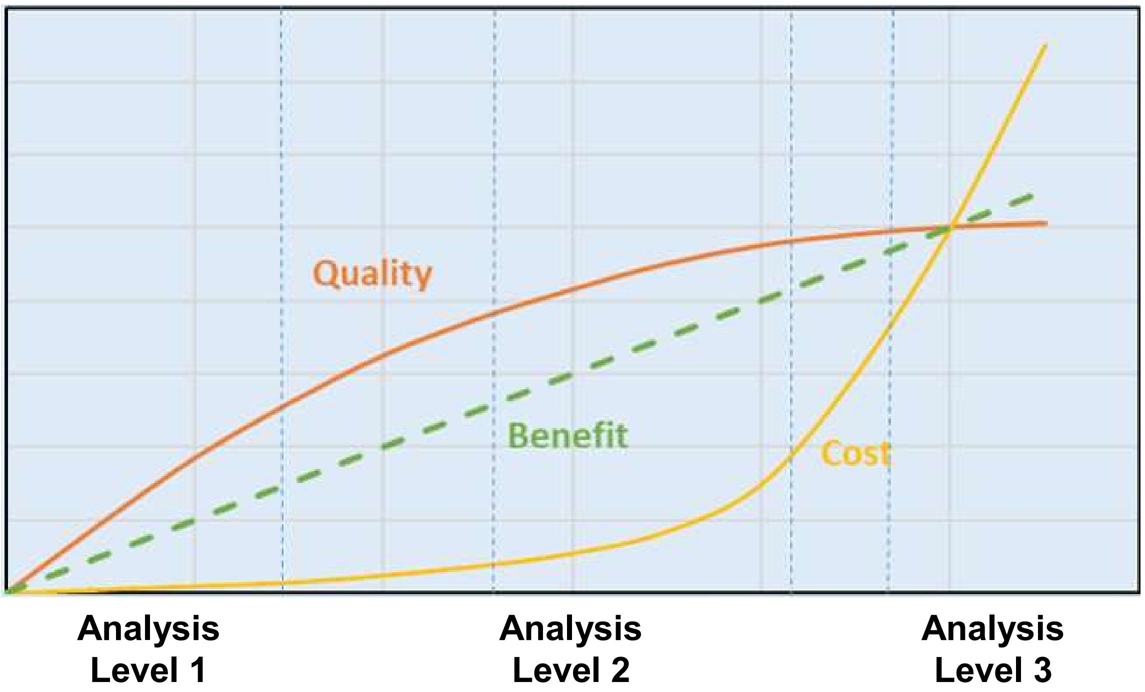
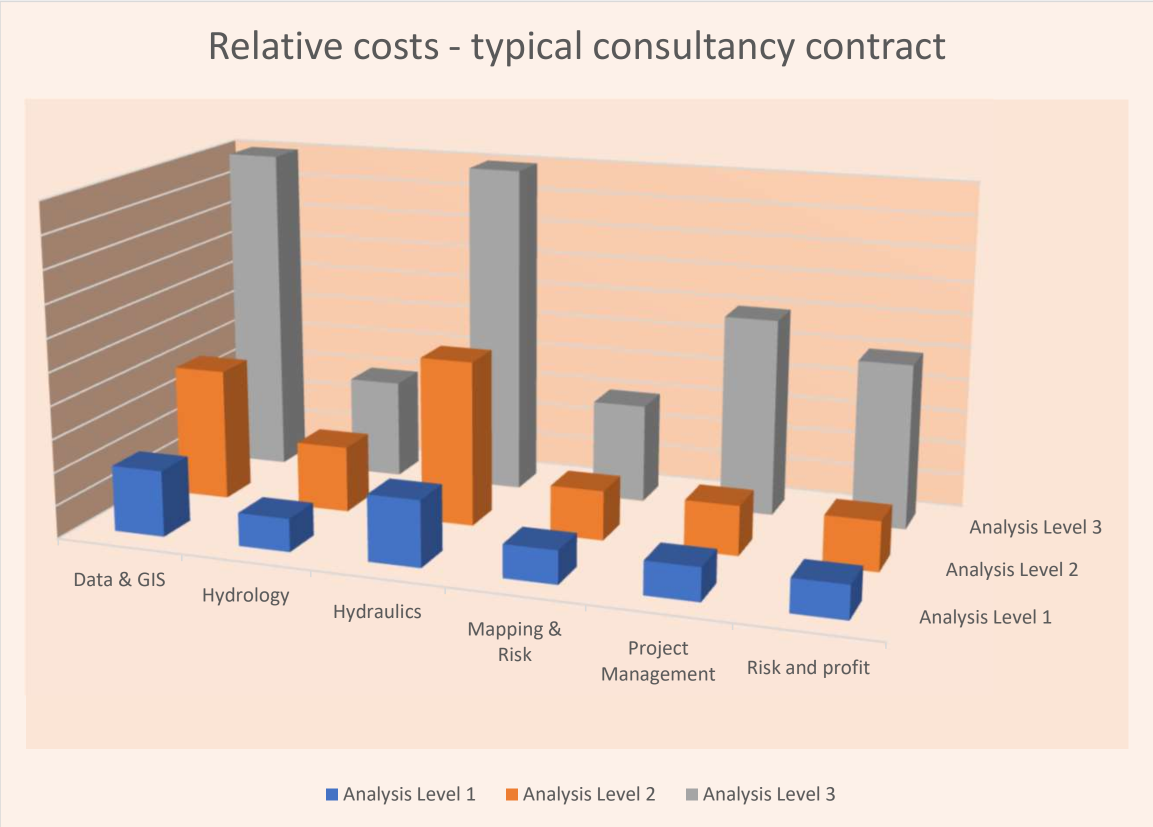
Key Messages in Selecting Modeling Approaches and Options

Modeling Compromises



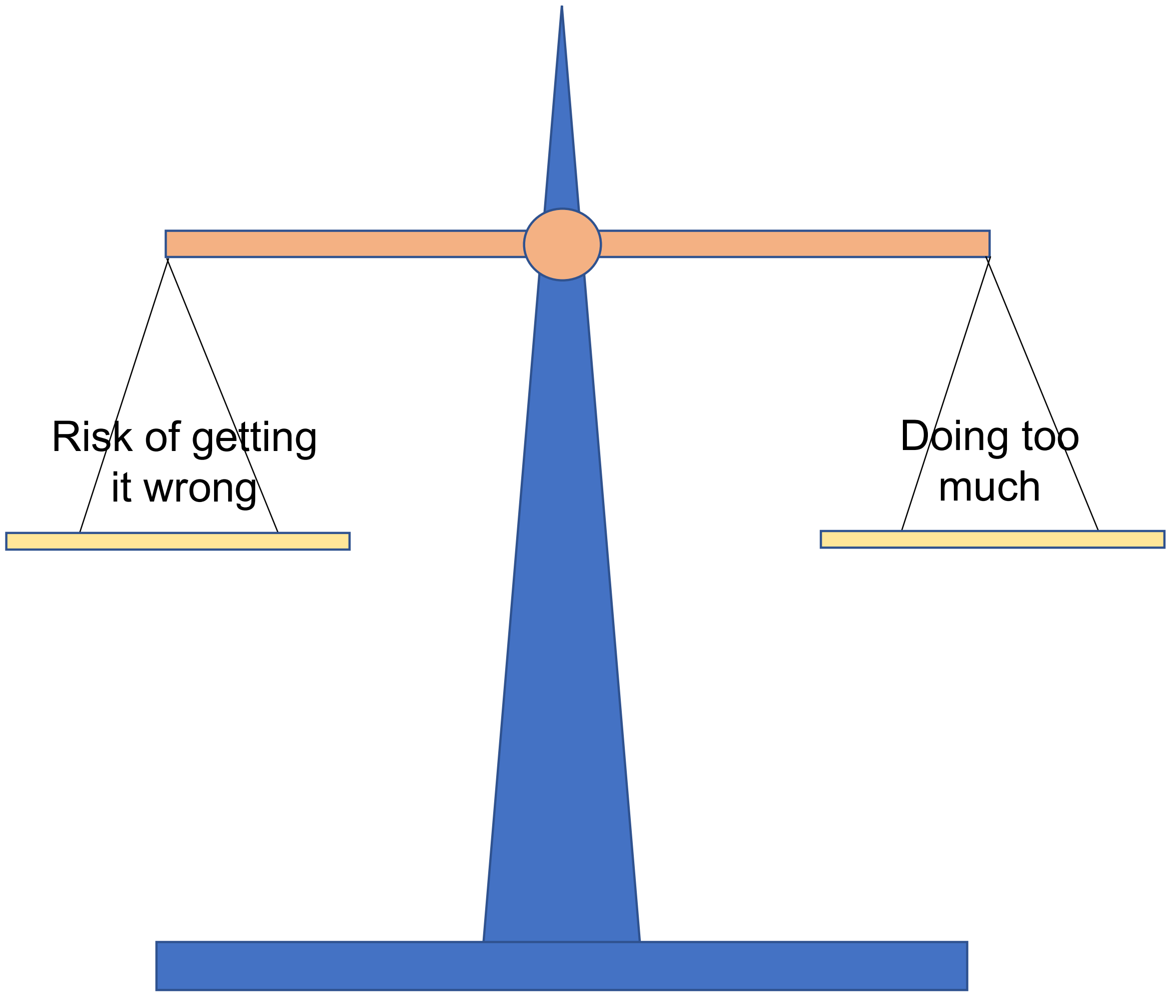
- Modeling analysis for any flood situation process consists of a chain of processes and relies on a range of data types and sources
- The overall quality and usefulness of the modeling results is dependent on the weakest link in that chain
- Every effort should be made to prevent a single aspect of the process from reducing the optimum overall quality

What are you paying for?



How good is "good enough" ?

Remember the **80:20** rule. It is normally possible to produce acceptable strategic level results (i.e. 80% of what might be possible) for comparatively little cost. The remaining 20%, which in many instances may not be needed is where the escalating costs lie.



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