Climate Resilient Decision Making

ACity-Centric Approach to Water Security

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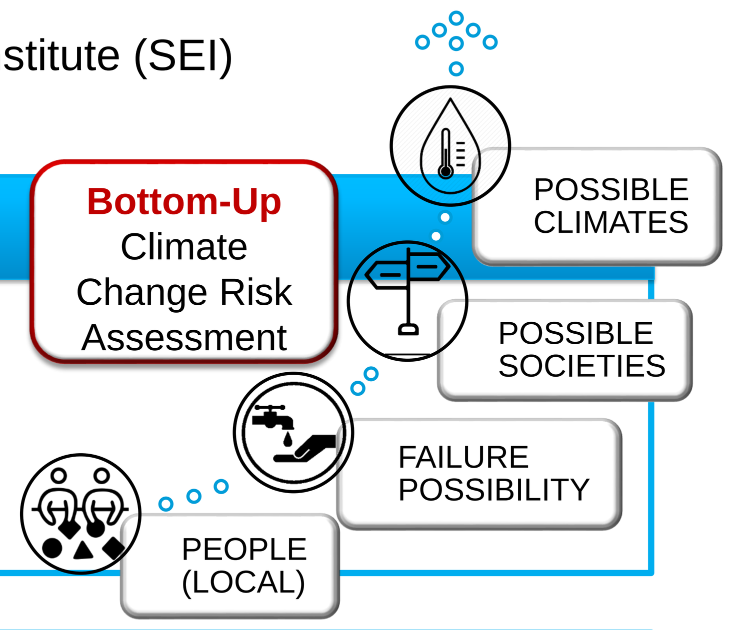
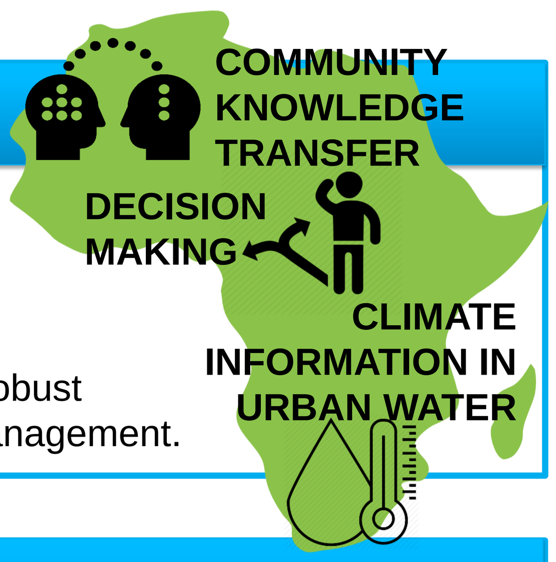
INTRODUCTION

Water managers are accustomed to changing circumstances and adapting to them; however, climate change is an additional layer of complexity with its own uncertainties. While our understanding of the drivers of African climate change and urbanization is improving, there exists relatively little work on the links between climate change risks and urban development. The growth of cities includes the development of formal and informal water resources, which are exposed to changing climates, environments, economies and demographics. This study investigates a bottom-up city-centric approach to water resource decision making under uncertainty; finding the vulnerabilities in a system and evaluating solutions that perform robustly for a range of future scenarios.



OBJECTIVES

1. Integrate decision-making silos to facilitate knowledge transfer, capacity building and co-discovery of resilient solutions;
2. Improve our understanding of the decision making uncertainty in developing climate resilient African cities; and
3. Identify critical climate change information necessary to support robust decision making for future urban water resources planning and management.



METHOD

The **decision-scaling** framework, a bottom-up stakeholder-defined climate adaptation approach, was used to identify the climate robustness of the water supply in the city of Lusaka, Zambia. The method aims to identify the performance thresholds of a system and proposes adaptation solutions that perform robustly in an **acceptable "safe space"** for a range of climate and non-climate related future scenarios. The four steps of the method were adapted from Poff et al. (2015) **(Figure 1)**.

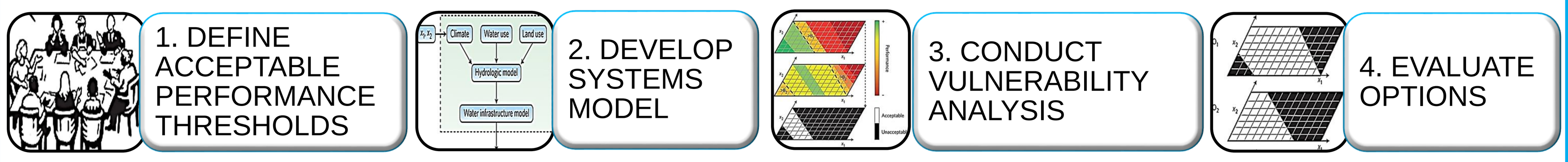


Figure 1- Water supply stress test method adapted from eco-engineering decision scaling framework by Poff et al. (2015)

STEP 1: DEFINE ACCEPTABLE PERFORMANCE THRESHOLDS

The system performance thresholds **(θ_1, θ_2)** were defined through a series of **Lusaka City Learning Labs (Figure 2a)** with decision makers. The first learning lab co-explored **critical issues** for the city. The second learning lab, including a site visit to a peri-urban area **(Figure 2b & 2c),** developed the water system diagram **(Figure 2d)** to determine the **performance thresholds**.
This participatory approach fostered a knowledge transfer for African climate information and water related decision making for Lusaka. **Water supply** was the chosen focus critical issue for this study.

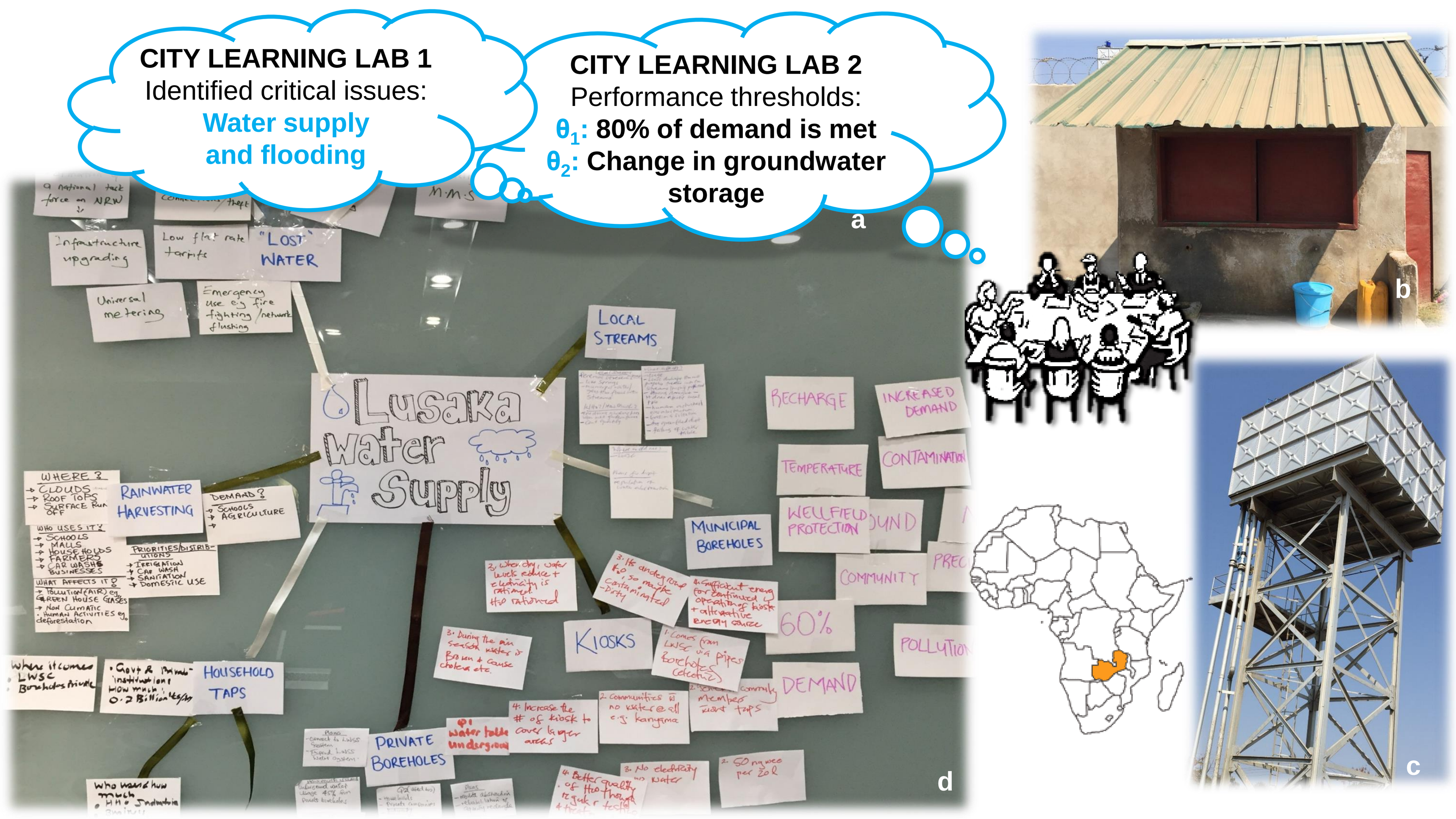


Figure 2 (clockwise)– a. City learning labs outcomes; b. Water kiosk; c. Groundwater tank from a site visit to Kanyama, a Lusaka peri-urban settlement and d. Lusaka water supply system diagram co-exploration using mind-mapping

STEP 2: DEVELOP A SYSTEMS MODEL

Water Evaluation And Planning system (WEAP), an integrated water resource planning **tool** by SEI, was used to develop a simplified hydrological model of the Lusaka City water system. This was based on the systems diagram and the performance thresholds outcomes of Step 1. climate, demographic and water use inputs. The developed system model includes supply and demand for both **formal and informal water options** on a city-centric scale **(Figure 3)**.

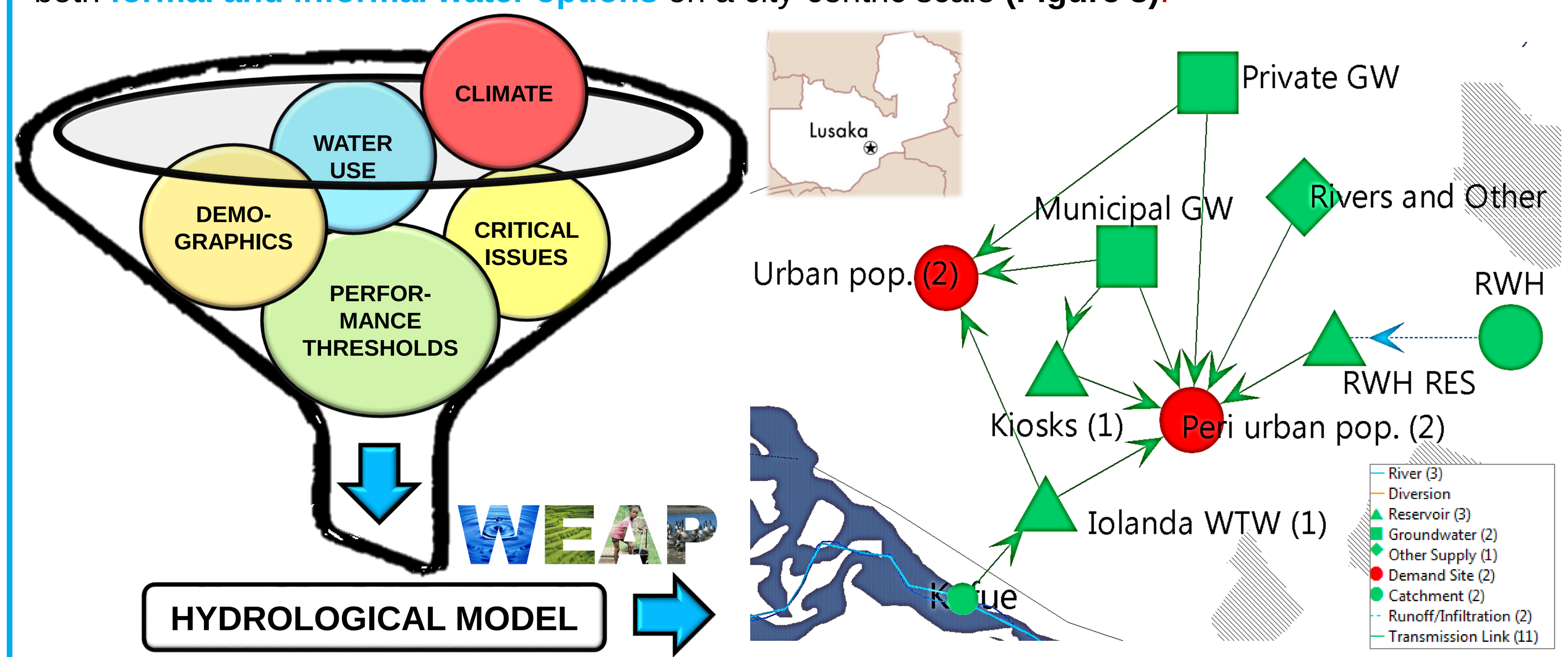


Figure 3– Systems model inputs (left) and Lusaka City WEAP schematic showing formal and informal water supply options for urban and peri-urban Lusaka(right)

RESULTS AND DISCUSSION

STEP 3: CONDUCT A VULNERABILITY ANALYSIS

The WEAP model (Step 2) was repeatedly run for multiple **potential system stressors**, outlined as **climate change** stressors **(x_1, x_2), demographic** (e.g. population changes) and **water use change stressors (Figure 4)**. The output data simulated by WEAP was used to evaluate the performance thresholds (Step 1). The results of the stress tested formal and informal water supply systems were plotted against the range of system stressors to create a **climate response map (Table 1).**

	Climate Stressors	Range
Local (City scale)	X_1 ΔMAP	-50% to +50%
Basin (Kafue scale)	X_2 ΔMAR	-25% to +25%

Demographic water use changes
POPULATION
NON-REVENUE WATER
PERI-URBAN POPULATION

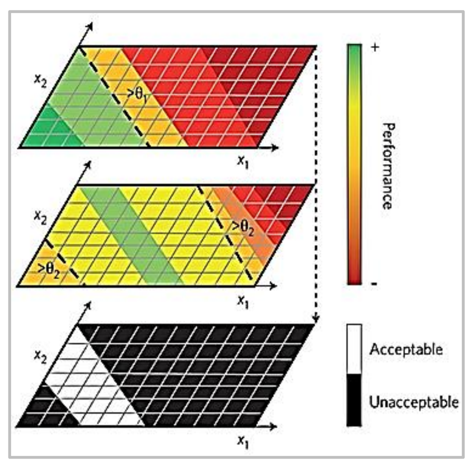


Figure 4- Vulnerability analysis inputs i.e. climate system stressors (left), demographic water use changes (centre); and example outputs i.e. climate response map from Poff et al. (2015) (right)

Table 1- Climate response map for performance thresholds θ_1 and θ_2 for climate stress variations (X_1 and X_2)

θ_1: Met demand (%)		x_1:ΔPRECIPITATION (%) +50	0	-50
x_2:ΔRUNOFF (%)	+25	61%	61%	61%
	0	61%	61%	61%
	-25	61%	61%	61%

θ_2:ΔGroundwater storage ('billion m^3/a)		x_1:ΔPRECIPITATION (%) +50	0	-50
x_2:ΔRUNOFF (%)	+25	+12	0	-12
	0	+12	0	-12
	-25	+12	0	-12

- Variations in runoff (from the Kafue river basin) show no changes in performance thresholds due to the negligible requirements for the City of Lusaka **(Figure 5).**
- Changes in groundwater was taken as a measure of sustainability as there is limited data availability for the current status of the Lusaka aquifers and the number of private boreholes.
- The performance of the Lusaka City water supply system with no changes in climates stressors **(Table 2)**; shows trade-offs between demographic and water use stressors, formal and informal water supply & per capita demand assumptions.

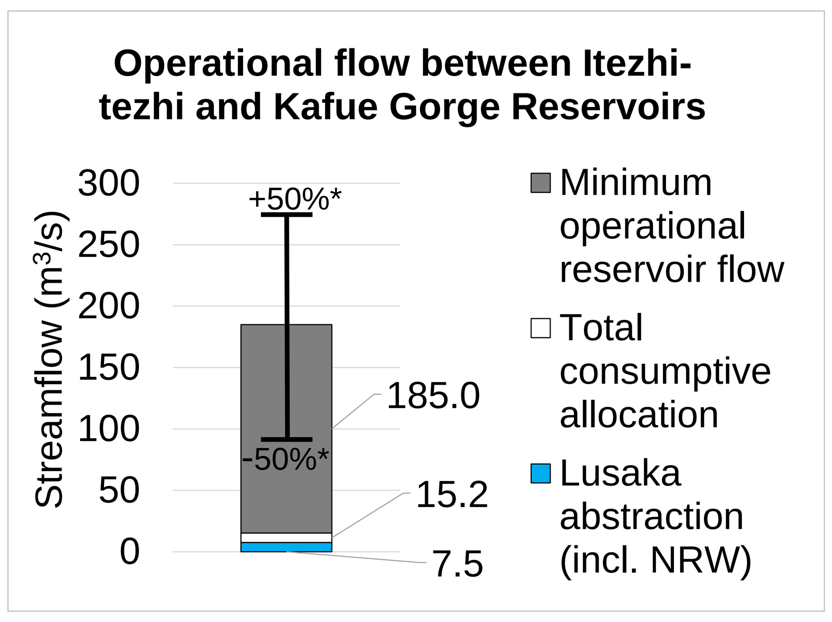


Figure 5- Operational flow between Kafue reservoirs showing consumptive allocation, Lusaka abstraction & *Predicted range of changes in runoff for the Kafue River (Fant et al. 2013, p.16)

Table 2-Lusaka City water supply system WEAP outputs under specified exploratory management actions (Baseline, 2020 and 2035) with no climate changes

	Baseline	2020	2035
Population (million)	2.43	2.80	4.36
% Peri Urban	70	50	25
NRW (%)	45	30	15
Demand (Mm^3/a)	128	184	359
Demand incl. NRW (Mm^3/a)	232	263	422
Planned supply (Mm^3/a)	182	263	364
Met demand (%)	61%	100%	84%

LESSONS LEARNED SO FAR…

- Role and representation of decision makers in co-exploration
- Infrastructure constraints and their climate sensitivity
- Value of the decision scaling process for climate change risks

FUTURE WORK: EVALUATE OPTIONS TO INFORM DECISIONS

Future learning labs will be used to **explore alternative adaptation solutions,** such as:
- Investigating Lusaka-relevant elements of the **Kafue basin (e.g. hydropower energy)** that affect the city supply and are vulnerable to changing climate.
- Overlaying **climate states** to determine their plausibility and to inform climate robust solutions.

REFERENCES: Poff, N.L., Brown, C.M., Grantham, T.E., Matthews, I.H., Palmer, m. A., Spence, C.M., Wilby, R.L., Haasnoot, M., Mendoza, G.F., Dominique, K.C. And BAEZA, A. , 2015. Sustainable water management under future uncertainty with eco-engineering decision scaling. Nature Climate Change. (September)
Fant, C.,Gebretsadik, Y. and Strzepek, K. 2013. Impact of Climate Change on Crops, irrigation and Hydropower in the Zambezi River Basin. WIDER Working Paper, No. 2013/039, p. 16.

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