Evaluating the multi-functional potential of stormwater ponds: planning support for a Water Sensitive City transition in Cape Town, South Africa

> Jessica Fell, PhD student Professor Neil Armitage & Doctor John Okedi (Supervisors)





"Water Sensitive Cities are sustainable, resilient and liveable through a combination of physical infrastructure, governance arrangements and social engagement."

Why WSCs?

Water resource shortages, urbanisation, deteriorating water infrastructure, declining water quality, climate change, resource and capacity constraints

Current conventional approaches liveable, equitable and resilient water sensitive cities (Wong & Brown, 2009; Savenije et al., 2014; Capps et al., 2016; Hoekstra et al., 2018)



Manifestation

Example

Nelson Mandela Bay Metro



Cape Town Day Zero crisis

Current stormwater systems (Chocat et al., 2007)









Cape Town has 850 monofunctional stormwater ponds which offer a way to achieve a Water Sensitive City through being repurposed to provide multi-functional benefits such as managed aquifer recharge, amenity and biodiversity.

When planning for multi-functional infrastructure, it is important to determine which benefits are most important and to try maximize different benefits given the spatial context and local needs.







Aims & method

"Evaluate the potential of Cape Town's existing 850 stormwater ponds to provide multi-functional benefits as BGI for a WSC transition in a developing country"

Develop relevant evaluation criteria with stakeholder input for a stormwater pond multi-functionality framework and tool, and use to perform a multi-criteria analysis (MCA) to evaluate and visualize the multi-functional potential of stormwater ponds



01 | Criteria selection



7x semistructured expert interviews

5W's of a WSC – Who, What, Where, When, Why (Meerow, 2019)

Stormwater pond multifunctionality framework





7x WSC Planning priorities (green space, climate change, culture, MAR)

01 Results	Water Sensitive City planning priority	Criterion and attributes
	Enhancing cultural and heritage associations with water systems	Pond proximity to culture and heritage resources (City of Cape Town (2019))
23	Increasing water re-use	Managed Aquifer Recharge Potential (Aquifer presence and type, Transmissivity, Soil Type, Geology) (WR2012 (2012), City of Cape Town (2022))
	Reducing the Urban Heat Island effect	Heat Islands Risk at pond (land cover classes, daily normalised, irradiation and windspeed) (City of Cape Town (2022))
	Community services connection with water systems	Pond proximity to schools, community centres and religious institutions (City of Cape Town (2019))
	Increasing access to blue-green space	Recreation potential (Mean population density and park presence in 500m pond radius) (City of Cape Town (2019), StatsSA (2012))
	Incorporating water quality limitations	Pond proximity to Potential Contaminating Activities (informal settlement, industrial, landfill, wastewater treatment works,) (DFFE (2021), City of Cape Town (2019))
	Enhancing biodiversity	Wetland category of pond (Freshwater Consulting, 2009))

02 | Value scaling

0 – 0.1	Low priority/potential
0.1-0.2	
0.2-0.3	
0.3-0.4	
0.4-0.5	
0.5-0.6	
0.6-0.7	
0.7-0.8	
0.8-0.9	
0.9-1	High priority/potential







Trade-offs and synergies



WQ limitations -UHI



Recreation - MAR potential

Recreation – Community services

Recreation - UHI



03 | Stakeholder derived weights

Pairwise comparisons & Point allocation

Workshop with x20 diverse stakeholders



Pairwise Point allocation

Weighted linear combination

$$S_i = w_1 S_{i1} + w_2 S_{i2} + \dots + w_n S_{in} = \sum_{j=1}^n w_j S_{ij}$$
 (Dodgson *et al.*, 2009)

where the preference score for option *i* on criterion *j* is represented by s_{ij} and the weight for each criterion by w_j , with *n* criteria the overall score for each option is S_i .

Stormwater pond priority ranking





Conclusions

Recommendations

- Multi-functional stormwater ponds can provide WSC related benefits in a city e.g. MAR, recreation etc (selected criteria)
- MCA paired with GIS visual capabilities demonstrated a range of low to high potential for benefits across Cape Town
- Important trade-offs exist between prioritizing ponds for MAR, recreation and UHI versus incorporating WQ limitations
- Priority stormwater ponds can simultaneously provide for recreation, MAR, community services and UHI
- Stakeholders considered recreation, biodiversity and MAR as most important benefits
- Provides a transferrable, flexible, participatory and strategic approach to planning and decision making for multi-functional Blue-Green Infrastructure for a Water Sensitive City transition

- Conduct finer scale analyses and detailed suitability assessments on high priority ponds to identify appropriate retrofit designs based on land use, cost and other contextual factors
- Refine and improve criteria by accessing higher quality datasets with spatial and temporal similarities
- Include additional criteria such as cost, green job potential, safety.



Thank you.

fell.jessical@gmail.com



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