DLGS Dresden Leibniz Graduate School

A Spatiotemporal Indicator-based Method to Assess the

Drought and Heat Risks for Urban Green Infrastructure

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Image Credit: inthenewyork.com

1. Introduction

The intensity, frequency, and concurrence of drought and heat events is expected to increase in many urban areas around the world (IPCC, 2021).

When drought and heat hazards overlap spatially and temporally, impacts can become more severe (e.g. Brune, 2016).

Underestimation of these impacts and lack of intervention may affect human health, water and food security, etc. of urban communities.

Urban Green Infrastructure (UGI)

- Climate adaptation measures
- Contribute to urban sustainability through their **ecosystem services** (ES) (Breuste *et al.*, 2015)
- Receptors of drought and heat impacts (e.g. Kabano *et al.*, 2021)

Research Gap

The spatiotemporal multi-risk assessment for droughts and heat in the context of UGI and its ES is noticeably missing in the literature

Objectives

1. To analyse the interconnected drought and heat situation in the context of UGI
2. To develop an information system based on the (biophysical) risk system
3. To derive an indicator-based method to assess the drought and heat risks for UGI

2. Conceptualisation

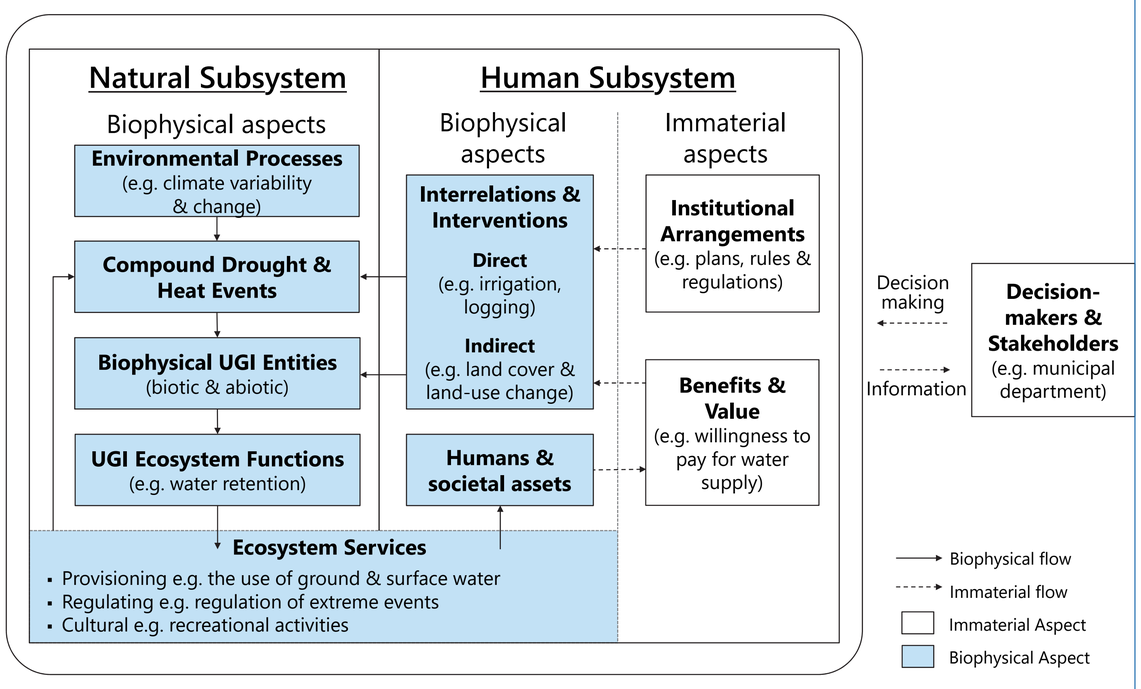


Figure 1. Representation of the UGI under drought and heat conditions as a Coupled Human and Natural System

- The Coupled Human & Natural System shows the interrelations between the diverse aspects of the human and natural subsystems as biophysical and immaterial flows, and their reciprocal relationship with decision-makers
- Ecosystem services are highlighted as the interface between the natural and human subsystems

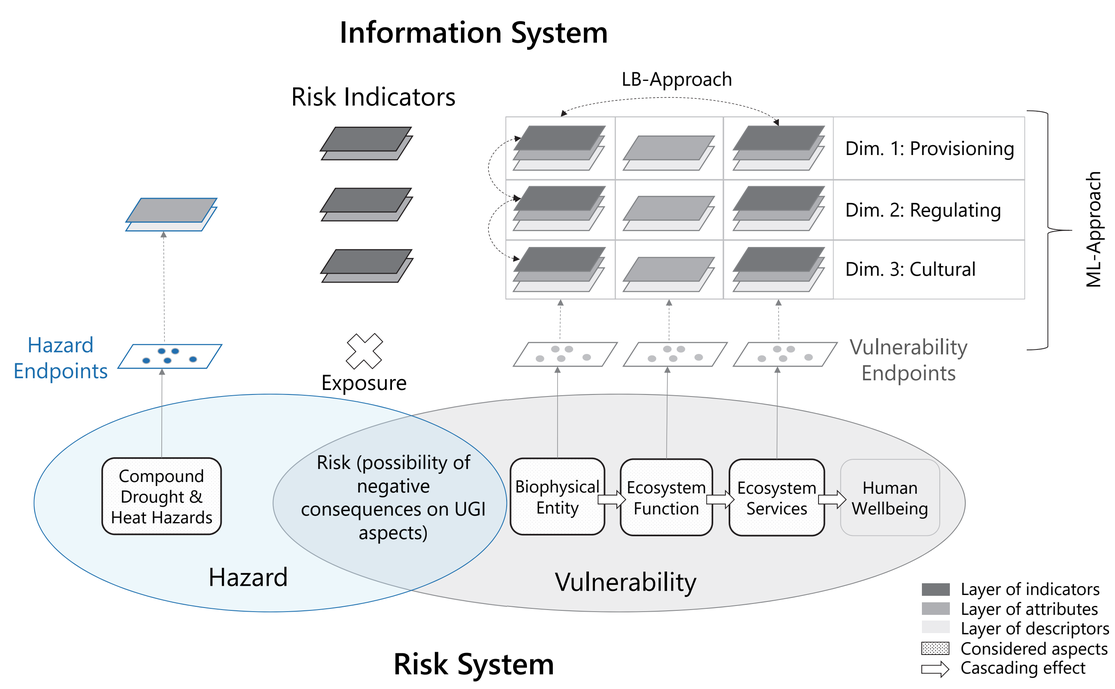
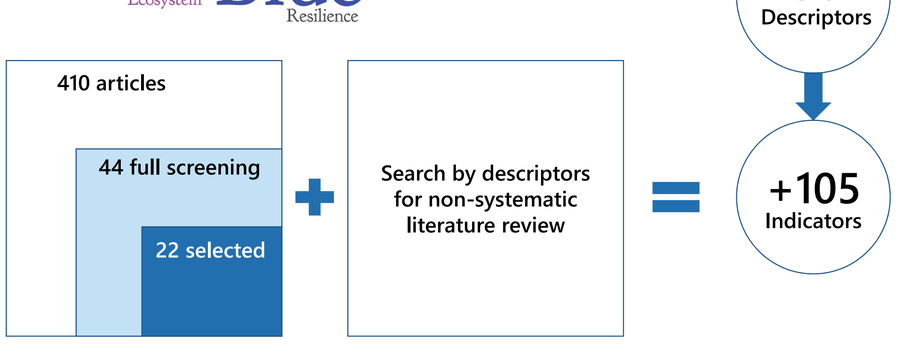


Figure 2. Risk System and its translation into the information system.

- The system is conceptualised as a function of hazard, exposure, and vulnerability
- The vulnerability can be considered over 4 tiers, based on the cascading effect (Potschin & Haines-Young, 2011)
- A multi-layer (ML) approach to translate the risk system into information layers (Müller et al., 2021)
- Lane-based (LB) approach to interconnect indicators (Müller et al., 2021)

3. Operationalisation (Multi-Layer Results)

Systematic and Non-systematic Literature Reviews



Spatial
Measured at minimum mapping units

Temporal
Could be measured at different time instants

Table 1. A sample of translating endpoints into information (P: Provisioning, R: Regulating, C: Cultural)

Tier	Endpoint	Dimension	Descriptor	Attributes	Indicator
UGI Entity	Stressors on vegetation	P, R, C	Pollution stress	Distance to built-up area; degree of human activities	Integrated Disturbance Index
			Insect infestation	Infestations; diseases	Outbreak of pest and diseases
	Soil stressors	P, R, C	Soil erosion	Erosion; time	Erosion rate (mm/year)
ES	The use of surface and ground water	P	Viable extraction of surface water resources	Water volume extracted; renewable water volume	ratio water extracted/ renewable water
	UGI landscape's cultural uses	C	Attractive features of UGI	Water features availability; accessibility	Access to water features

- Based on the different tiers of the risk system, assessment endpoints were selected
- Using the multi-layer approach, endpoints are translated into descriptors with attributes
- Systematic and non-systematic literature reviews are conducted to assign the descriptors with indicators
- Based on the specific case study, selected indicators interconnection between indicators is studied using a lane-based approach

4. Conclusions

- **The study offers a systematic conceptualisation for the drought and heat situation for UGI,** and is based on a strong foundation of risk assessment concepts.
- The multi-layer approach resulted in a generic set of indicators over the three dimensions of ES.
- The indicator method with spatiotemporal aspects operationalises the assessment and its testing could make it viable for researchers, consultants, or local actors to adopt.

This presentation participates in OSPP
EGU
Outstanding Student & PhD candidate Presentation contest

Abstract & References

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Leibniz Association
DRESDEN concept

DLGS is a joint interdisciplinary facility of IOER and TU Dresden.

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Supplementary Material A

Systematic Literature Review Protocol:

Systematic Literature Review for Indicator development

Type: Describe – Textual narrative synthesis

Question: What are the indicators available to measure the vulnerability of UGI components and its ES to drought and heat hazards? Into what dimensions are they categorized?

Data sources

Web of Science – Scopus

Search strategy (Inc. search string)

Drought and heat hazards are the two considered hazards of the study, however, in some cases hydro-meteorological hazards can be inclusive of drought and heat, and hence has been added to the search string. The vulnerability concept and its components are chosen to be the main bounding conditions for the search. Additionally, the urban context was necessary since urban ecosystems have their own conditions that might not apply to other contexts. Therefore the search string is as follows:

1. TITLE-ABS-KEY (Urban AND (drought* OR heat OR "hydro-meteorological") AND (risk OR vulnerability OR susceptibility OR resilience OR "coping capacity" Or "adapt*") AND (indicator* OR index OR indices) AND ("ecosystem*" OR "green space*" OR "blue space*" OR "green infrastructure" OR "blue infrastructure" OR "nature based solution*"))

Note: Run-2: add “adapt*”; Run-3: added “hydro-meteorological”; Run-4: add “index” “indices”

+ snowballing and reverse snowballing

Inclusion criteria

Published/ Peer reviewed (Article, Book Chapter, Series, Conference Proceeding)

English publications

Exclusion criteria

Only social or economic vulnerability, qualitative vulnerability analysis, mapping of ES, performance or benefits evaluation of ES, impacts of hazards, monitoring of ecosystem’s health, other unrelated outcomes

Extract Data

Remove data duplicates

Analyze

Results Run-1:

25.06.22

Total articles: 125 (52 Scopus and 71 WoS)

Using Rayyan Web-software (https://www.rayyan.ai/)

After deleting duplicates: 79

After reviewing title/abstracts: Included: 17 – Maybe: 13 – Excluded: 49

After skimming full papers of the "Maybe" category: Included: 18 – Excluded: 61

Screening full text: 1 excluded due to context (focus no fish communities)

Results Run-2 (with Adapt*):

01.06.22

Total articles: 186 (80 Scopus and 106 WoS)

Results Run-3 (with Adapt* and "hydro-meteorological"):

02.06.22

Total articles: 193 (83 Scopus and 110 WoS)

Using Rayyan Web-software (https://www.rayyan.ai/)

After deleting duplicates: 134

After reviewing title/abstracts: Included: 24 – Excluded: 110

After screening full paper: Included: 10 – Excluded: 14

Snowballing: 1

Results Run-4 Only additional articles to Run-3 (with Adapt* and "hydro-meteorological" and "index" and "indices"):

08.06.22

Total articles: 217 (90 Scopus and 127 WoS)

Using Rayyan Web-software (https://www.rayyan.ai/)

After deleting duplicates: 154

After reviewing title/abstracts: Included: 17 – Excluded: 137

After screening full paper: Included: 10 – Excluded: 7

Snowballing: 1

Results total (Run-3+Run-4) to be reviewed:

22 articles

Supplementary Material B

Poster's List of References

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* Icons were collected from flaticon.com: Affian Afif (time graph); map freepik (map); Inkubators (increase sign); Gregor Cresnar (warning sign); Kiranshastri (overlap).*