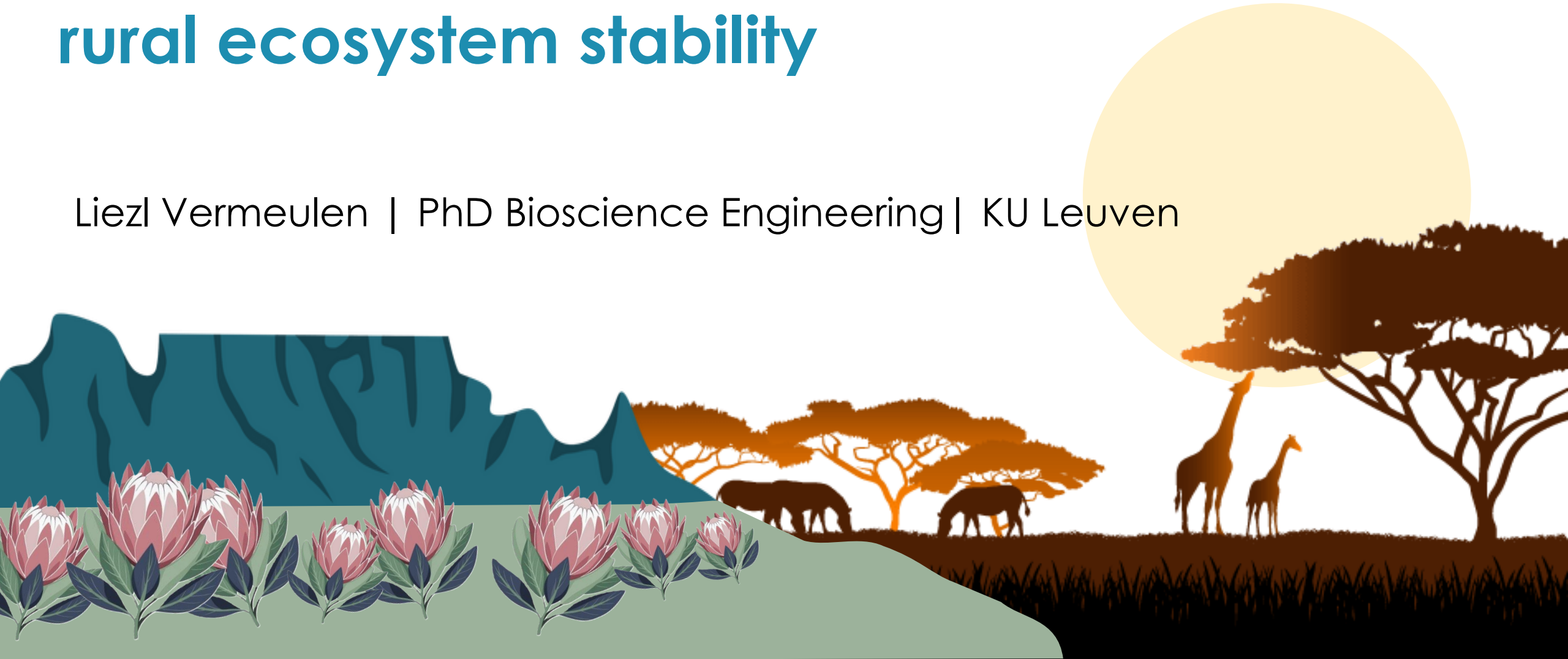


Climate change, local anthropogenic degradation and **rural ecosystem stability**

Liezl Vermeulen | PhD Bioscience Engineering | KU Leuven



Ecosystem stability

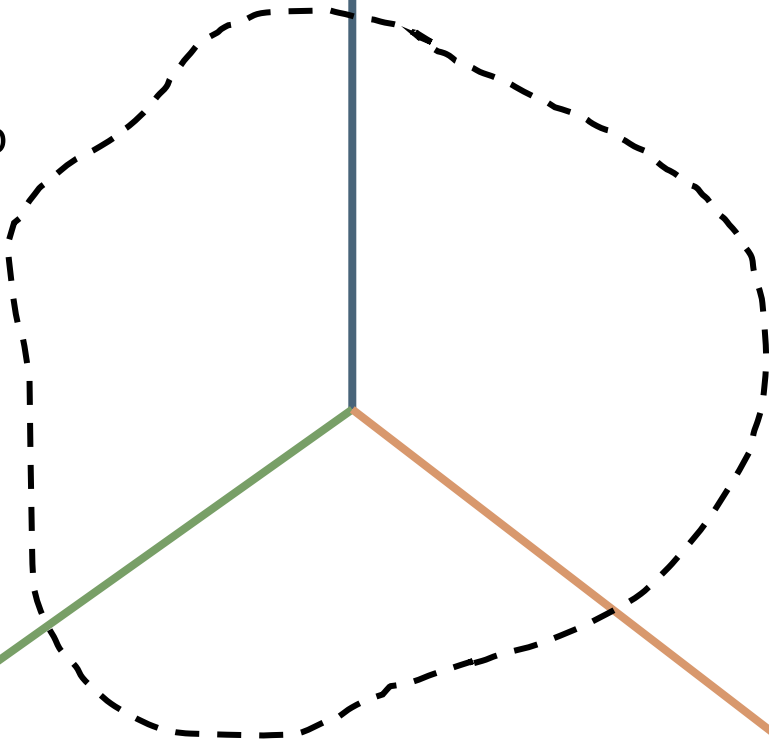


Change drivers

- Climate change
- Anthropogenic activities

Stability

- Ecosystem response to change



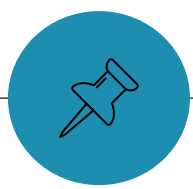
Ecosystem characteristics

- Soil
- Terrain
- Vegetation type



Natural disturbance cycles

- Fire history
- Elephants



Study Areas



Savanna



Fynbos

1 Abrupt shifts in arid African savannas



What are abrupt shifts?



What are abrupt shifts?

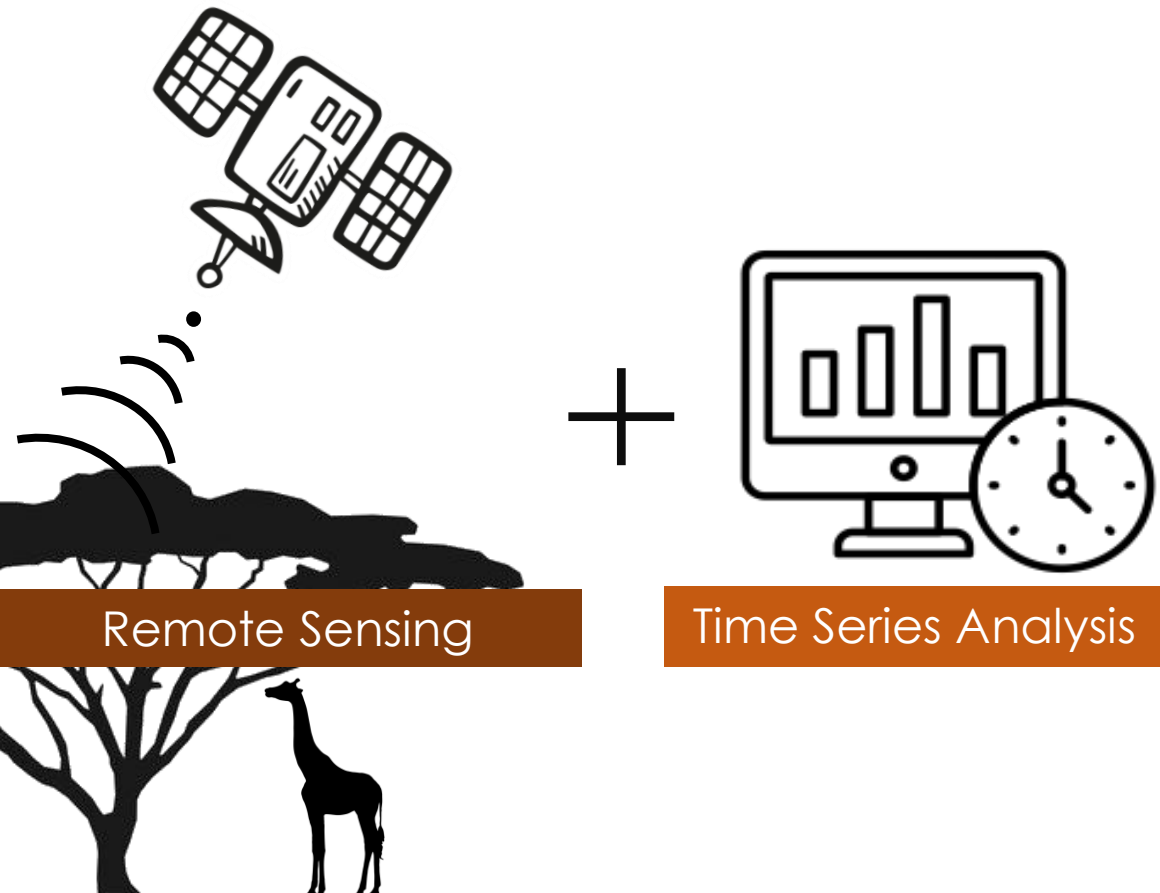


What are abrupt shifts?

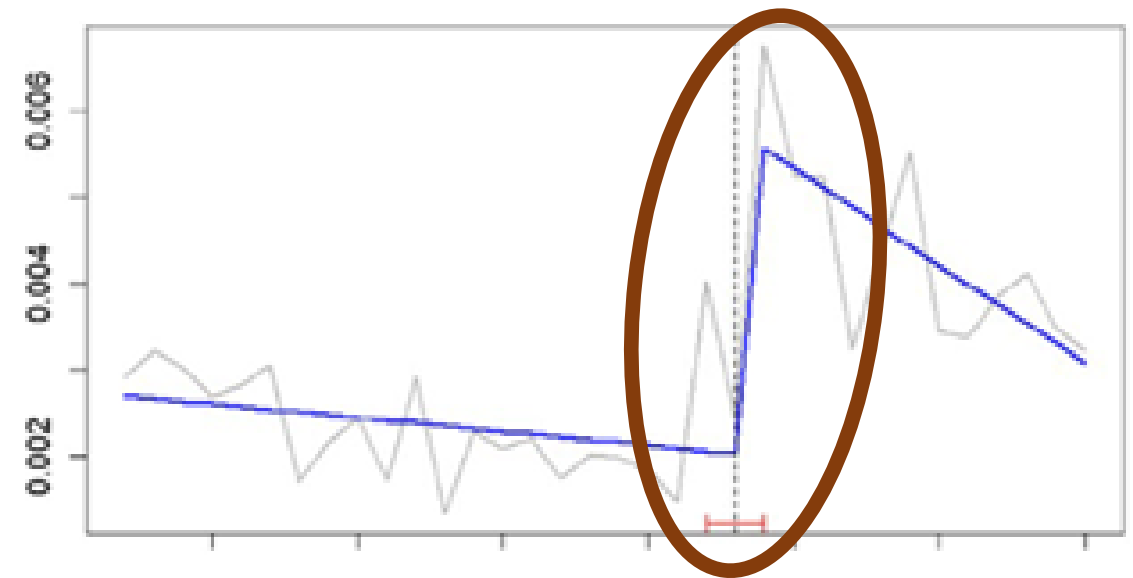


- 1 **Where** are they?
- 2 **Why** are they there?
- 3 **What** do they look like?

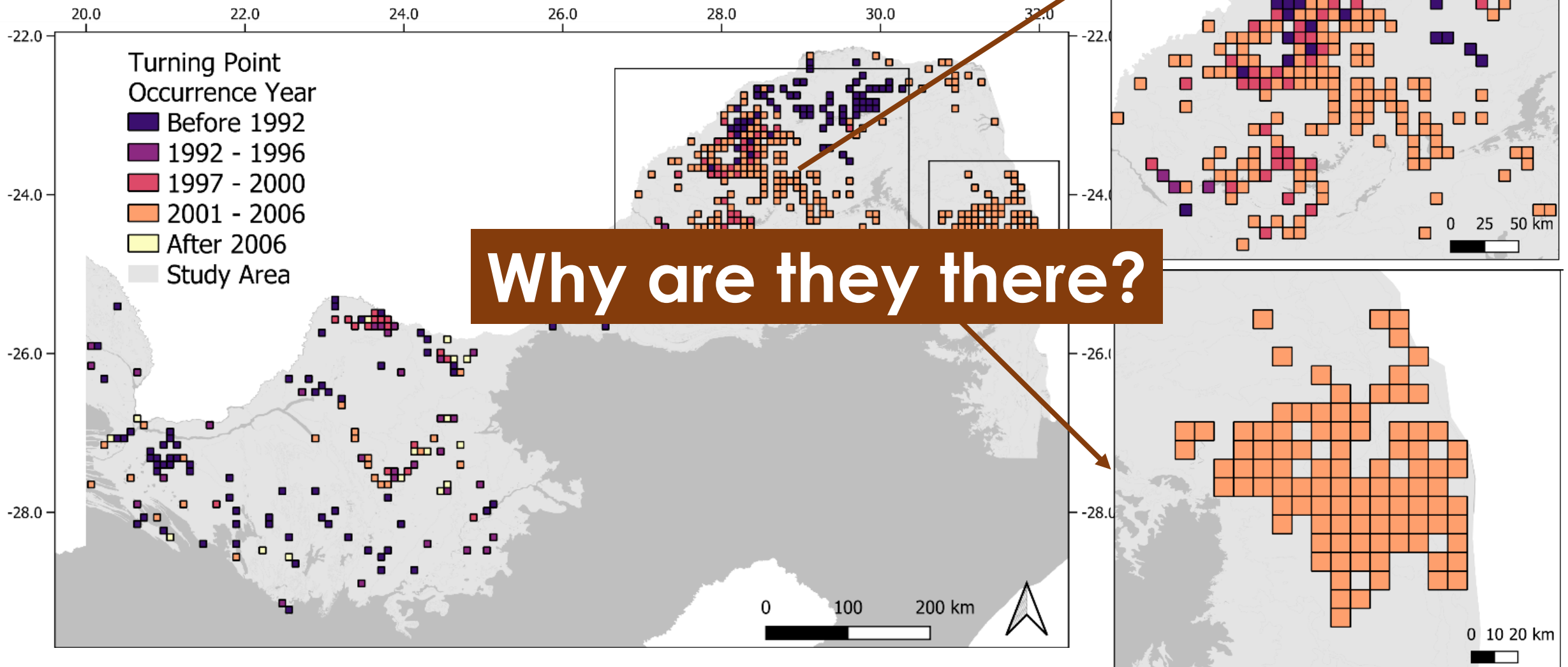
Where?



- Measure vegetation using satellite imagery
- Create a time series
- Identify breaks in the time series

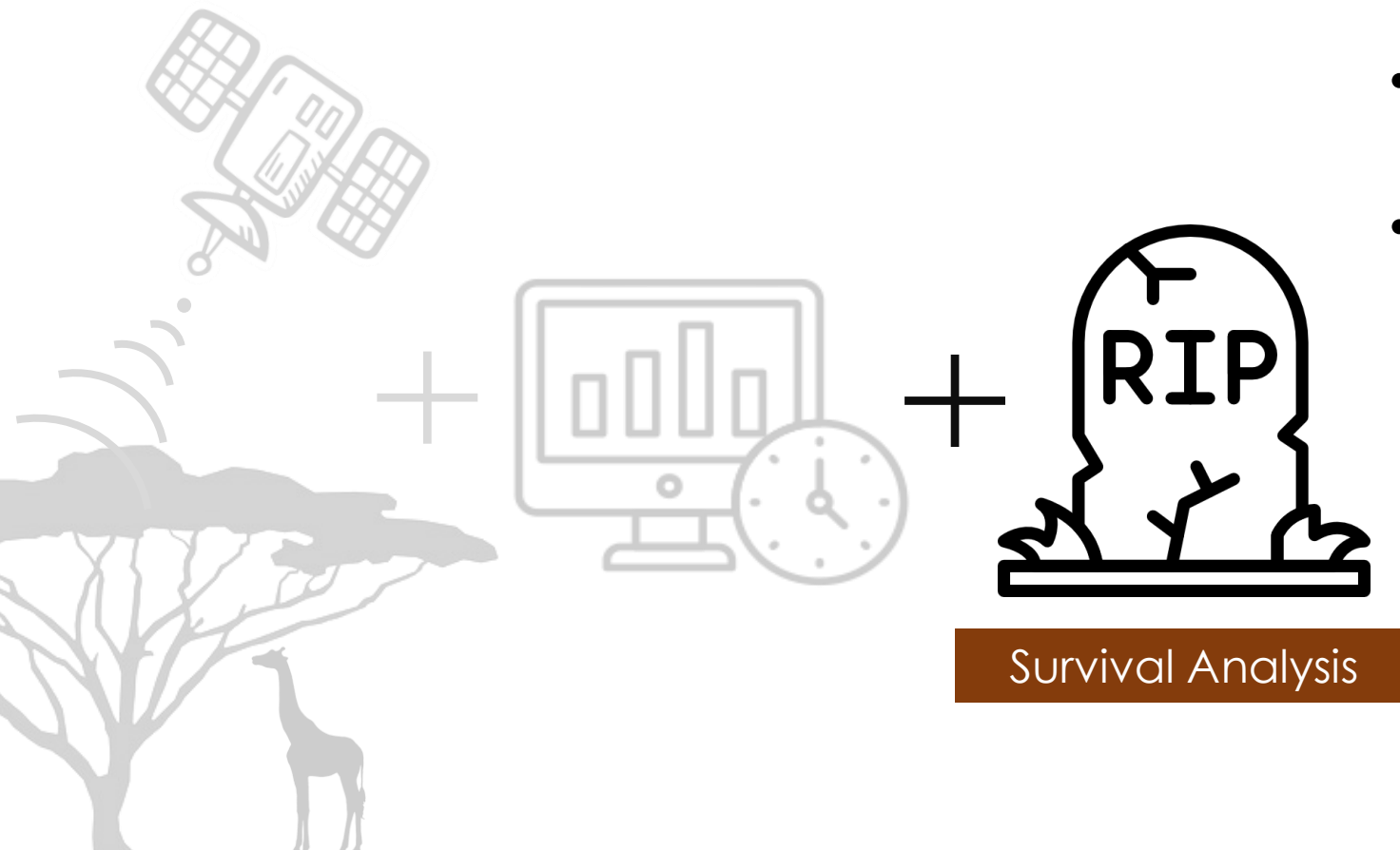


Where?

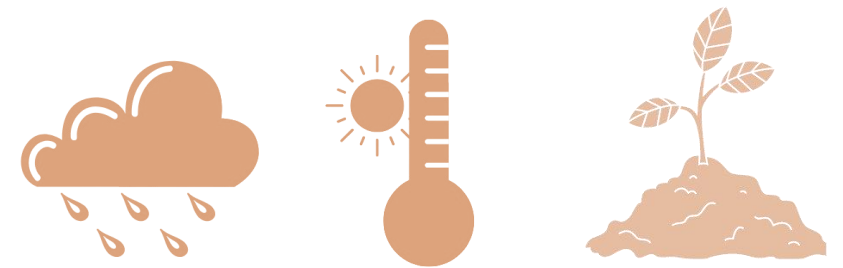




Why?



- **“Death” = shift in ecosystem functioning**
- Covariates: ecosystem characteristics + climate legacy



Why?

↑ 25%



Flat slopes

↑ 25%



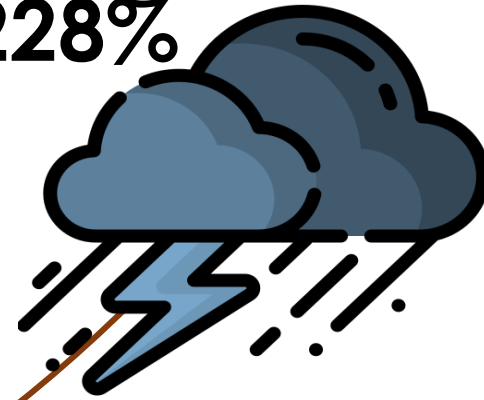
Colder summer temps.

↑ 26%



Sandier soils

↑ 228%



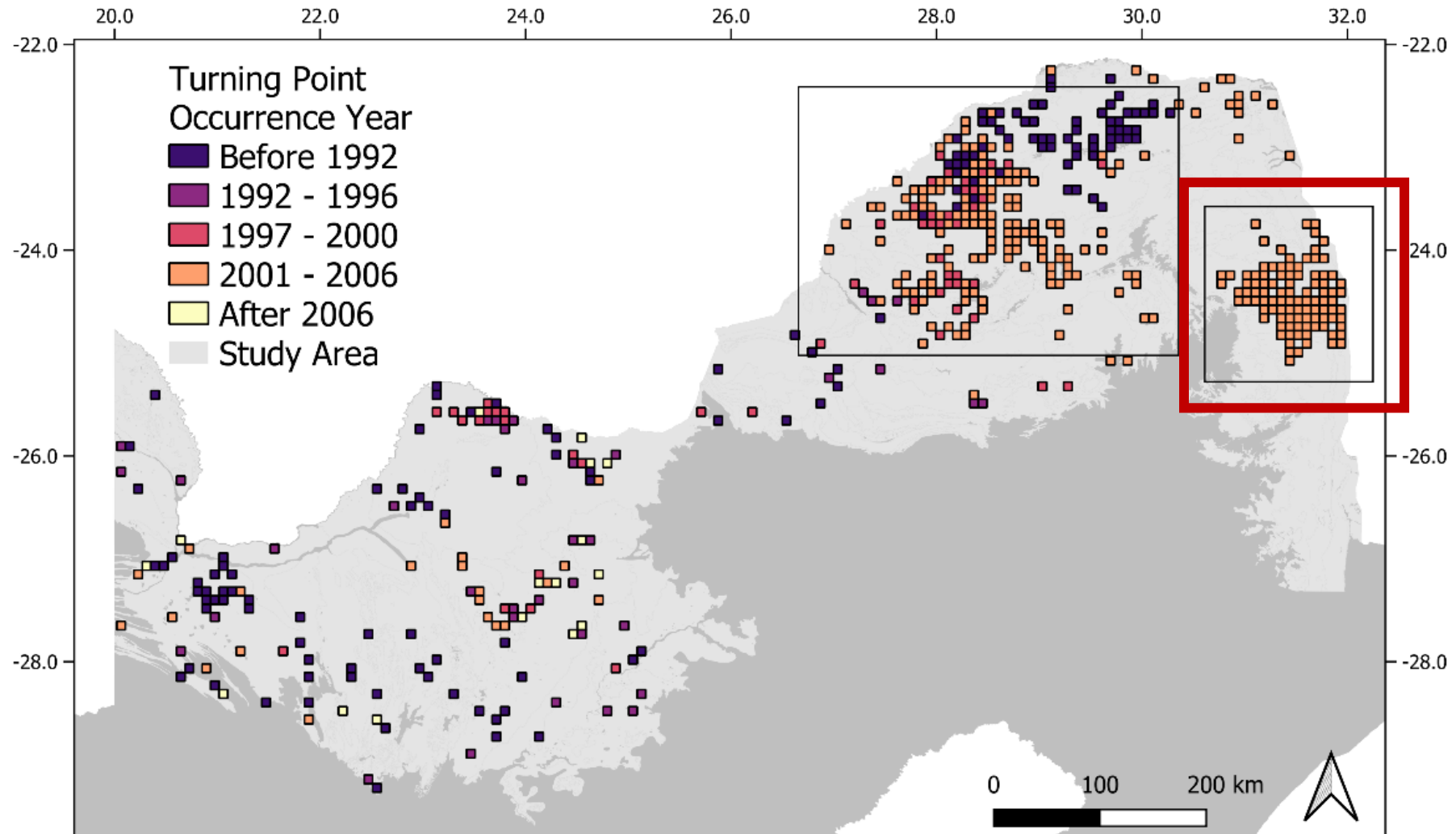
Severe rainfall events



What?

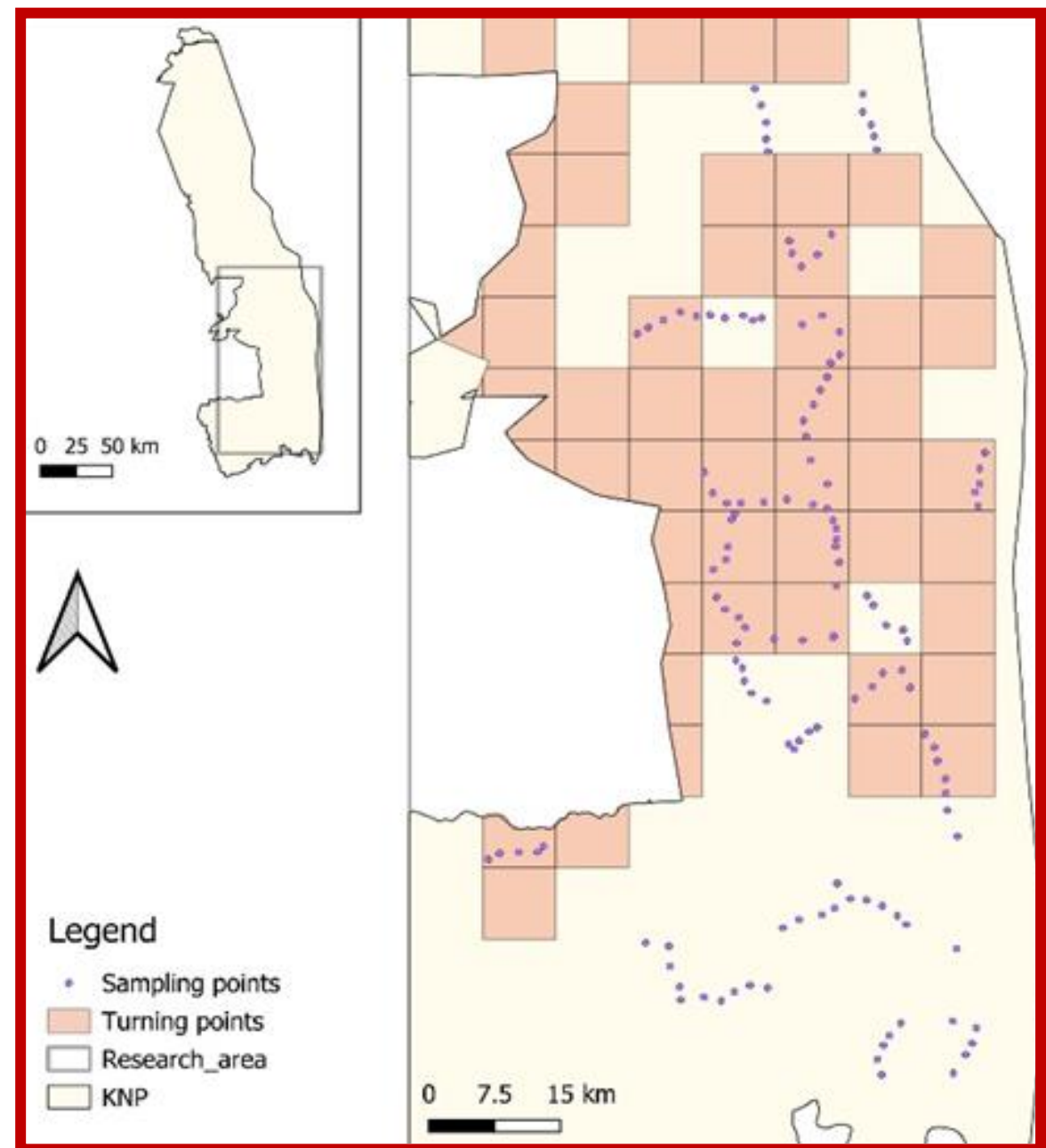


- Combine RS and field data

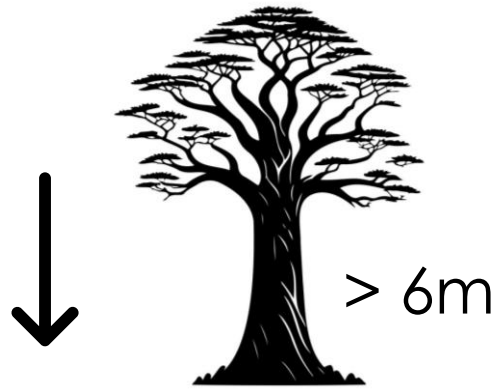


Remote sensing vs Field data

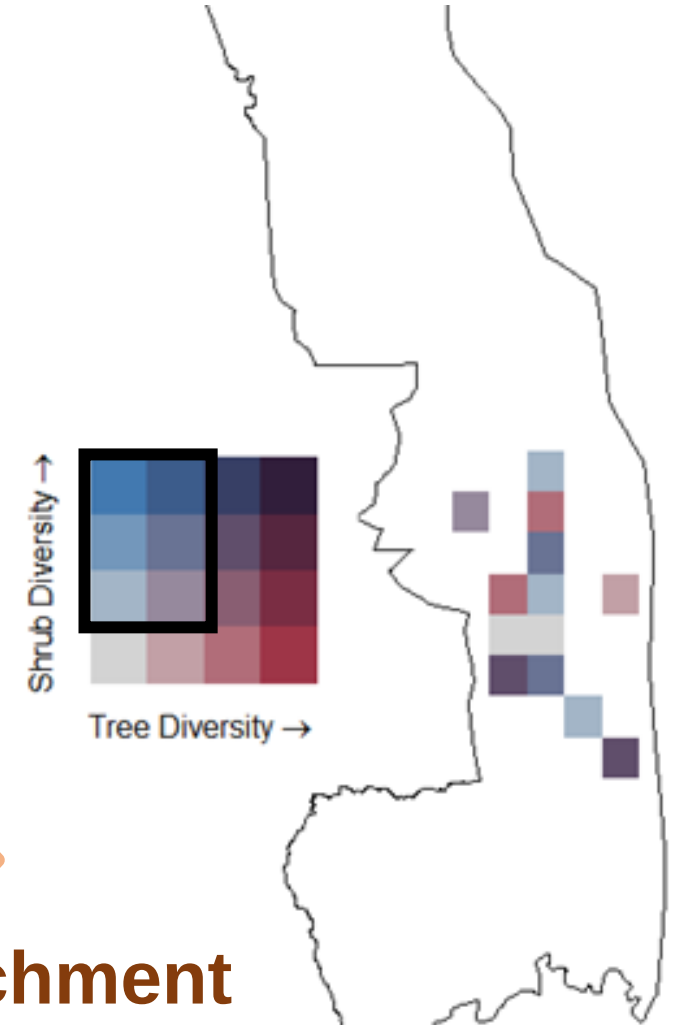
- Compare:
 - changed vs unchanged areas
 - field surveys of **species diversity**



What?



shrub encroachment



2

Degradation legacies, **drought** and **ecosystem stability** in the Fynbos





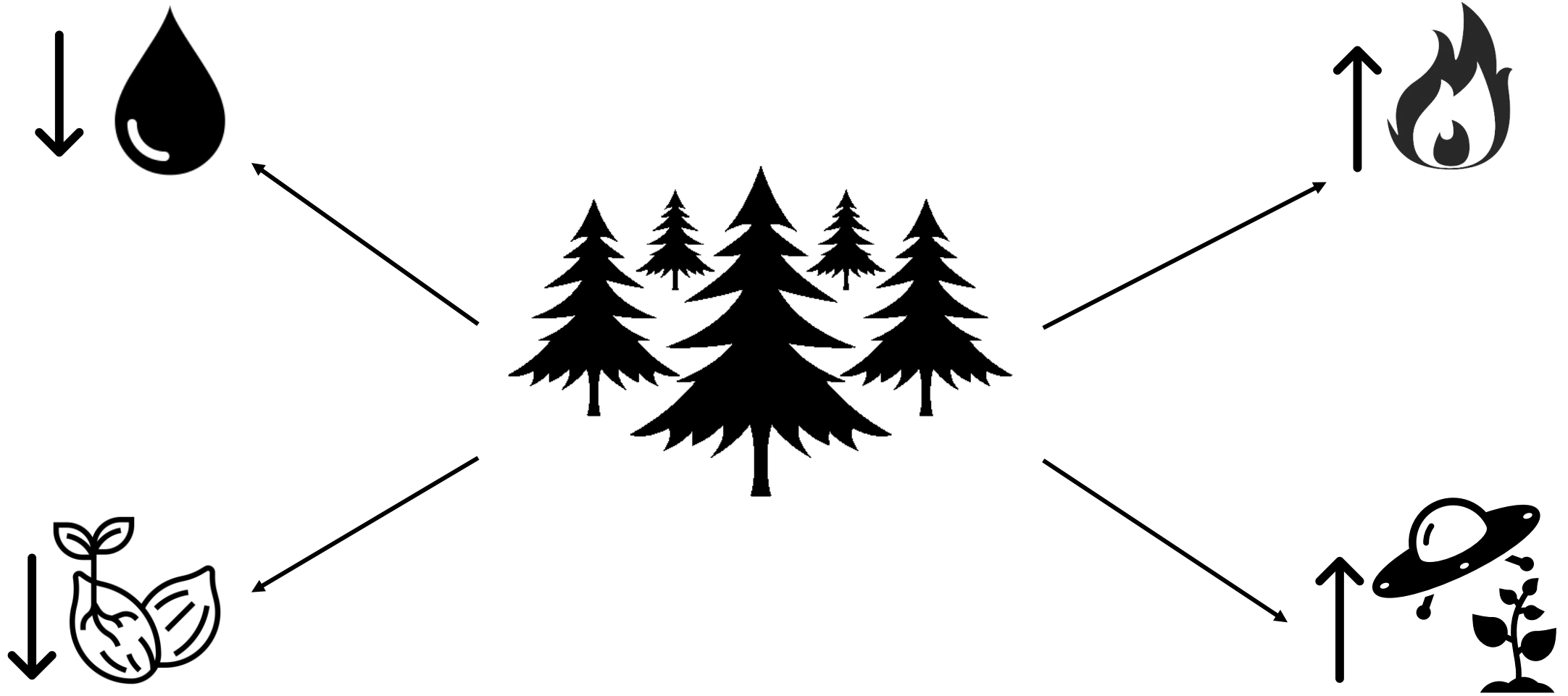
The hyperdiverse Fynbos

Fynbos ecosystem

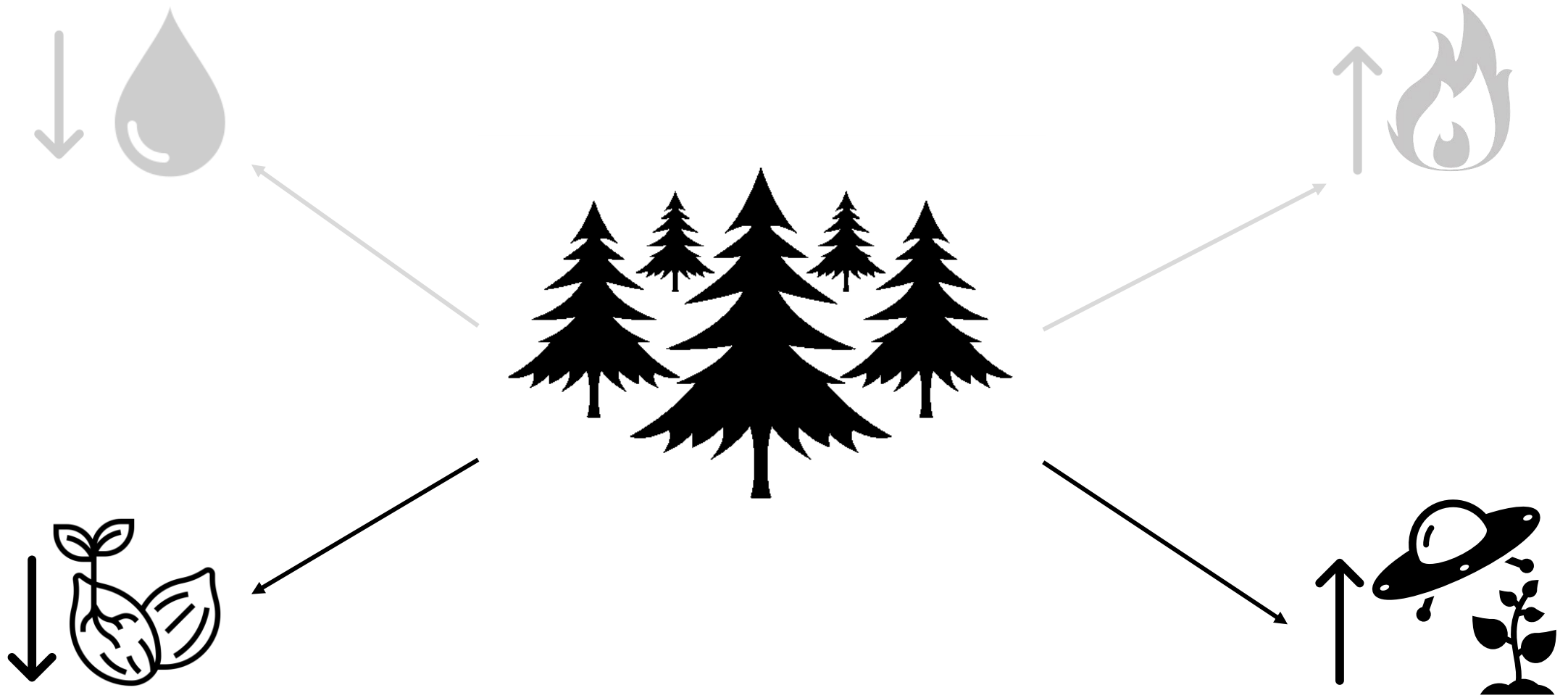
- Cape Floral kingdom
 - Southern tip of South Africa
- Fire-dependent
- **Biodiversity hotspot**
 - +9000 species
 - 6200 endemic
 - 3% of the world's plants in less than 0.05% of the Earth's surface
- **Fire-dependent**



Challenges: plantations

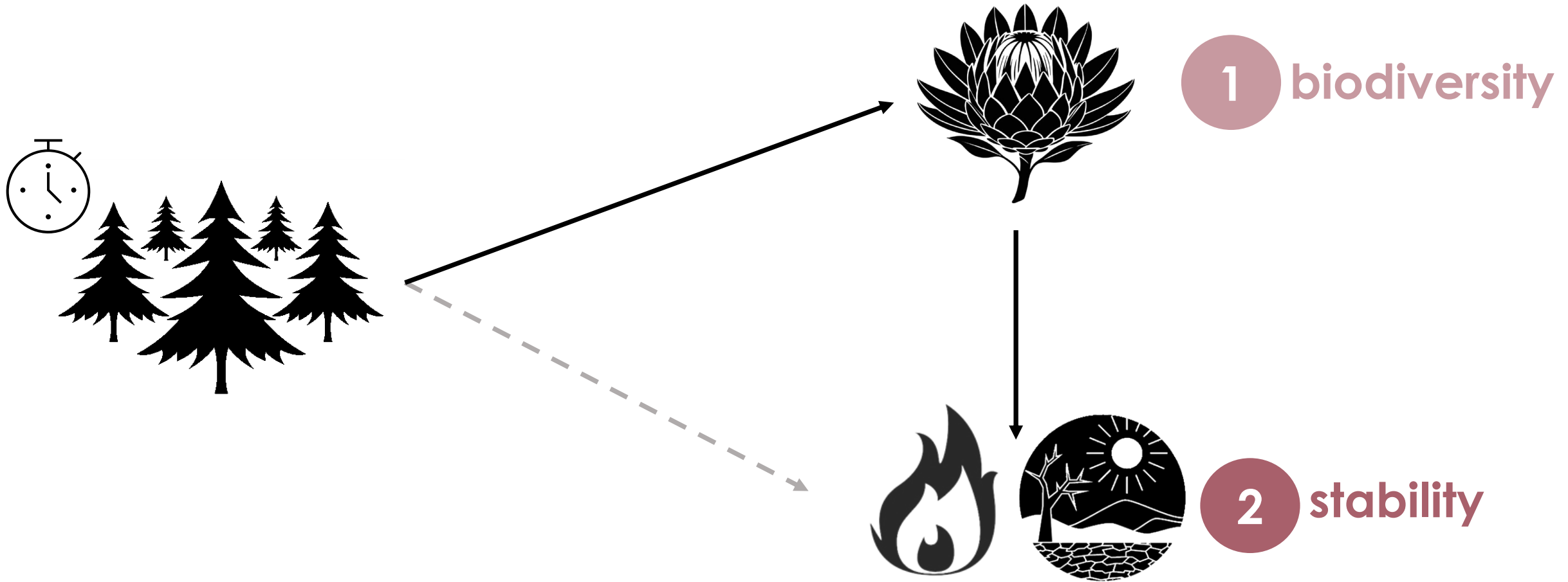


Challenges: exotic plantations



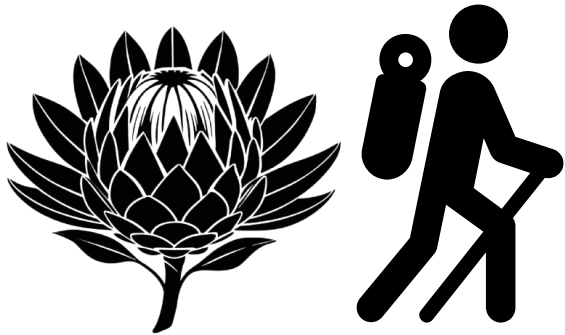
Legacy effects: long-lasting impacts of past disturbances/activities

Legacy effects & Fynbos stability



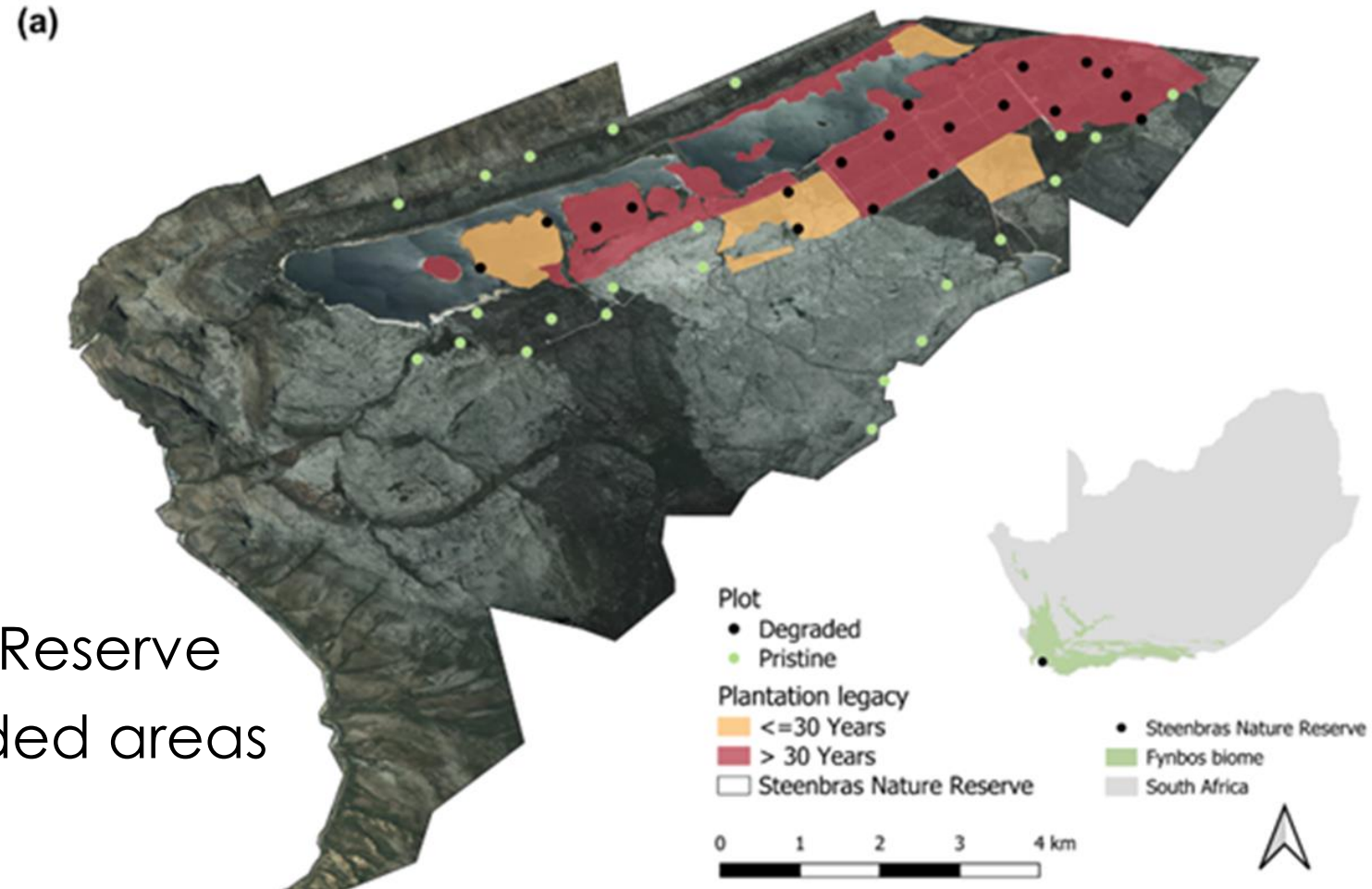


Biodiversity



Biodiversity Analysis

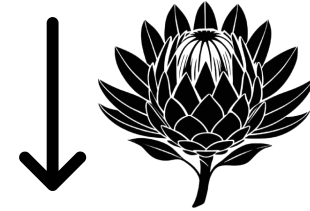
- Field work: Steenbras Nature Reserve
- Compared natural vs degraded areas



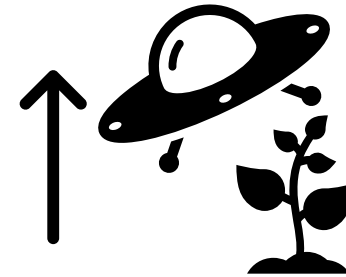
natural



degraded



species diversity



weedy, alien species

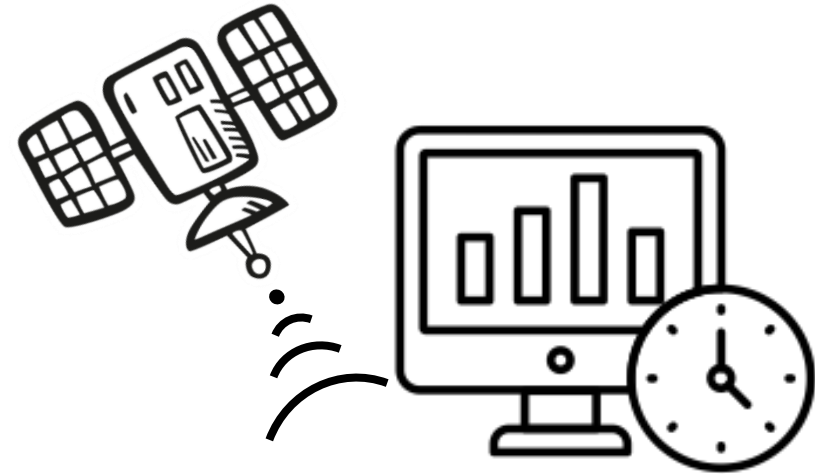
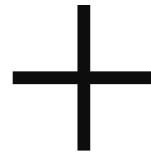
longer plantation = **stronger** effects



Stability



Biodiversity Analysis



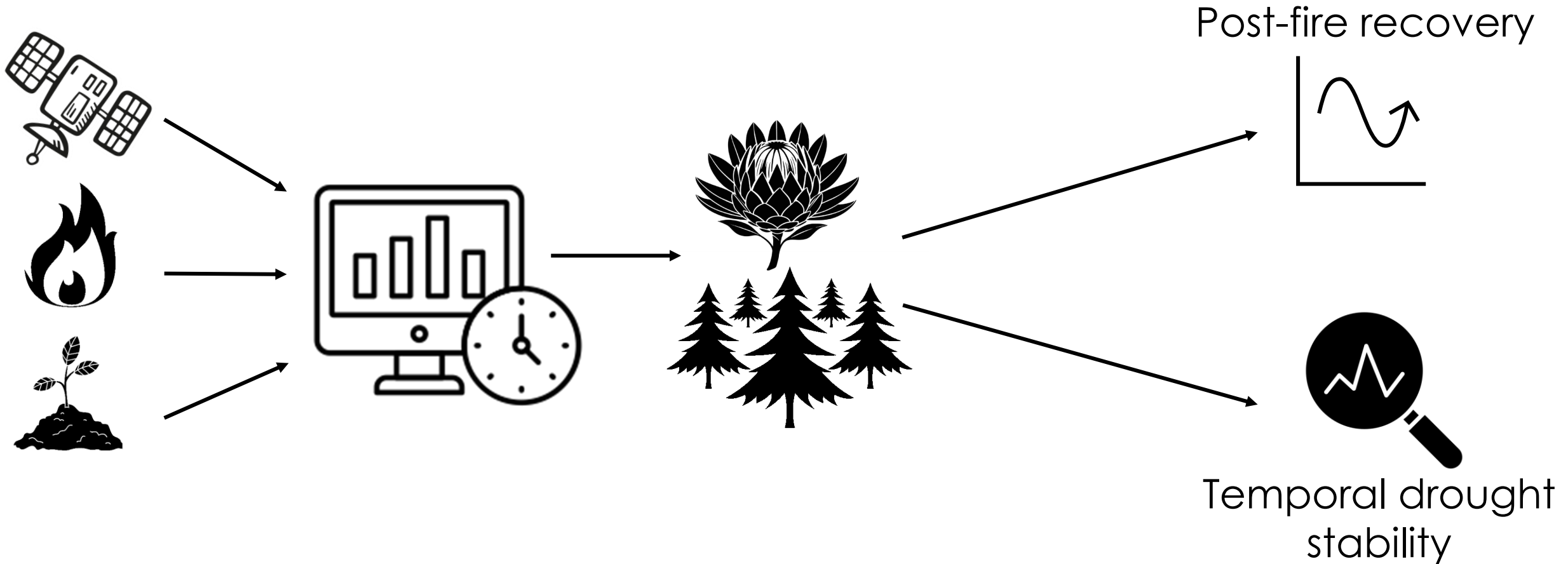
Remote Sensing
Stability Analysis

- Remote sensing time series
- Spatiotemporal hierarchical Bayesian model



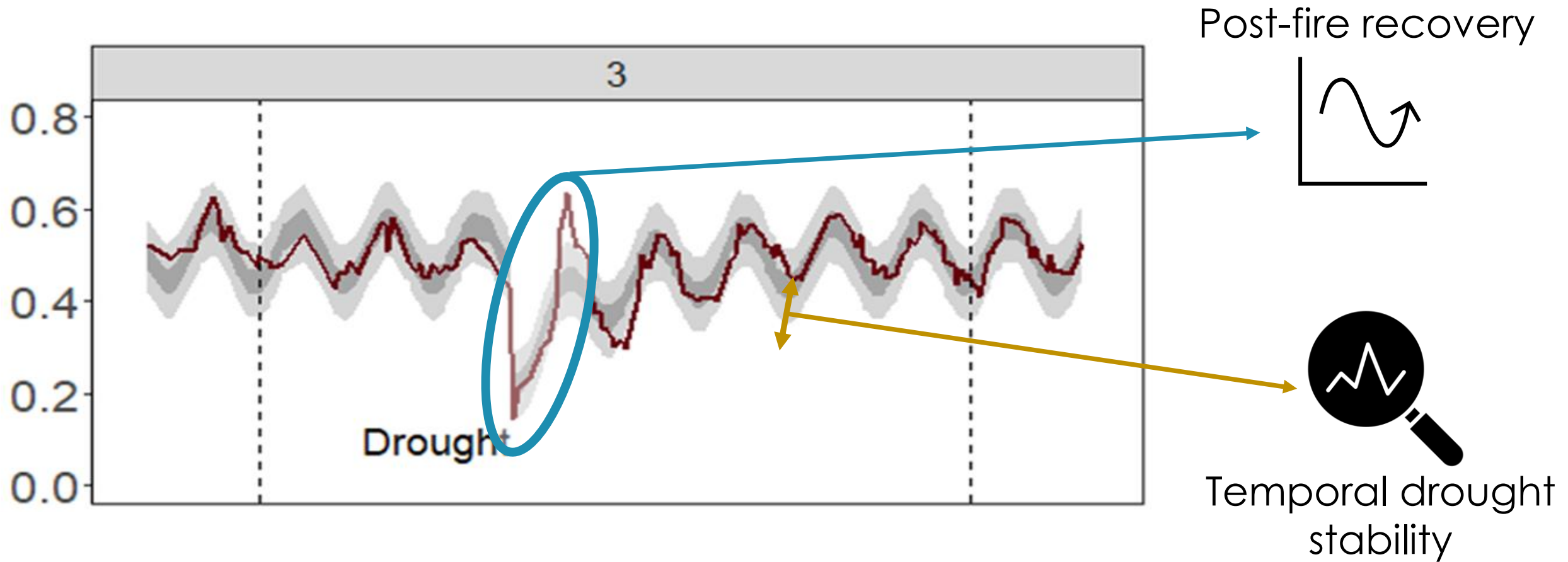
Stability

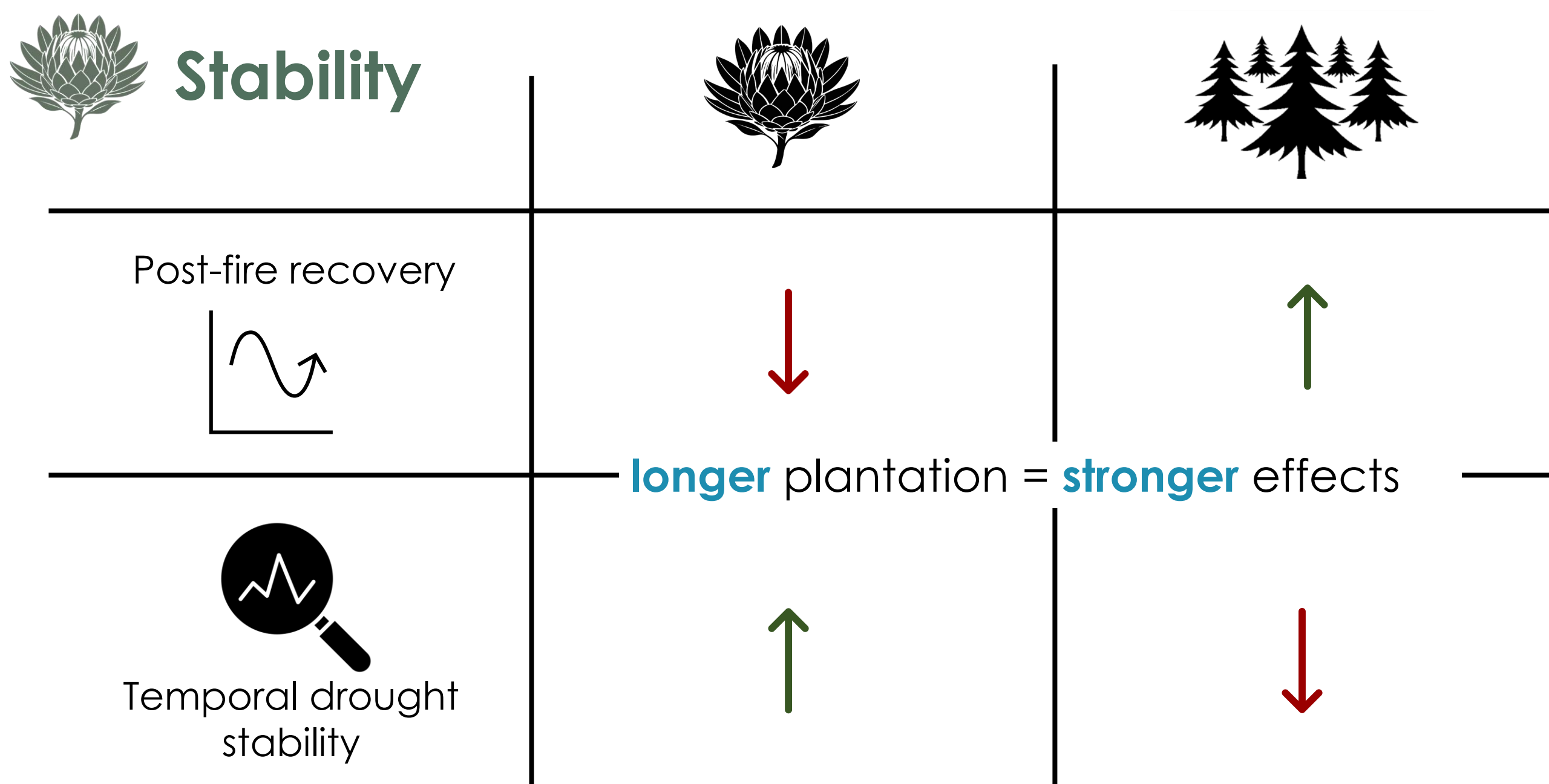
Models how we expect healthy fynbos vegetation would respond **to a fire and during a drought**





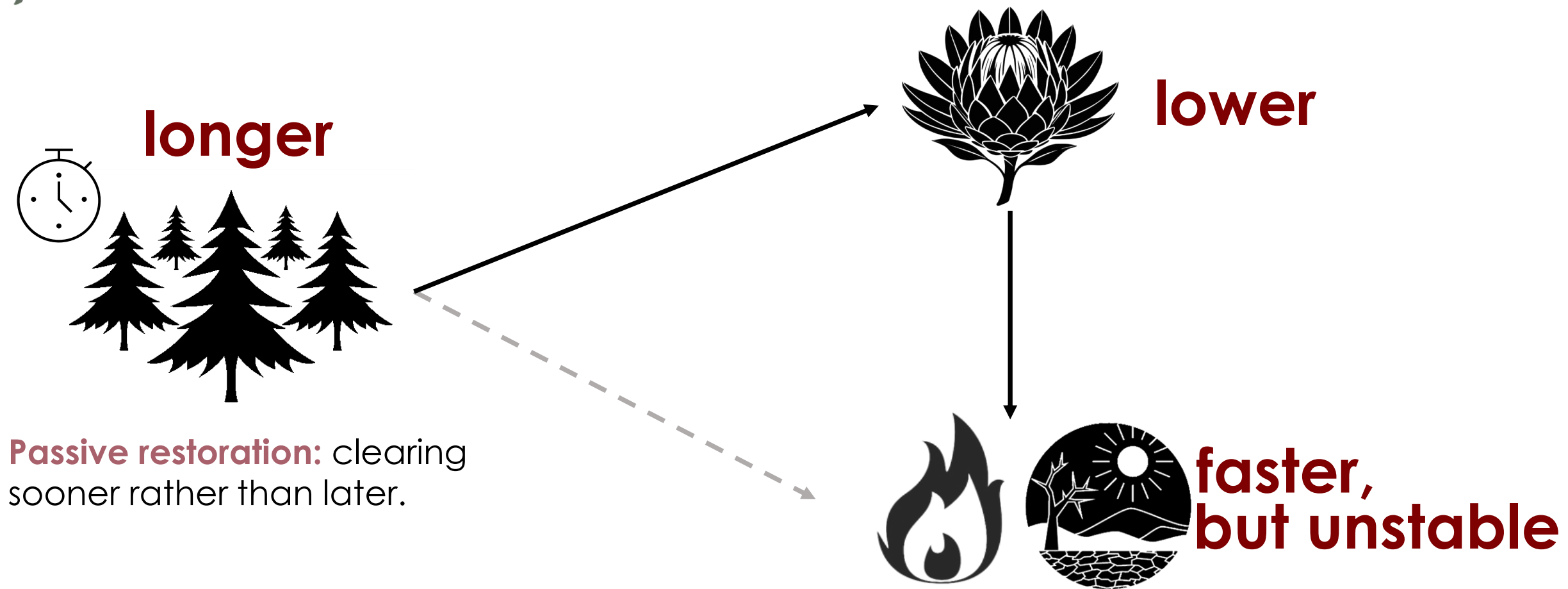
Stability







Take away message



Conclusion

From **fynbos** to **savanna**:
remote sensing is a robust, vital tool for
monitoring and management of rural
ecosystems.



Optimizing local climate zones through clustering for Surface Urban Heat Island Analysis: A Case of Cape Town, South Africa.

T.C. Manyanya
(Doctoral Researcher KU Leuven)

26 February 2025

Promoter: Prof. Ben Somers

Co-Promoters: Dr Bruno Verbist

Co-Promoter: Prof N.S. Nethengwe

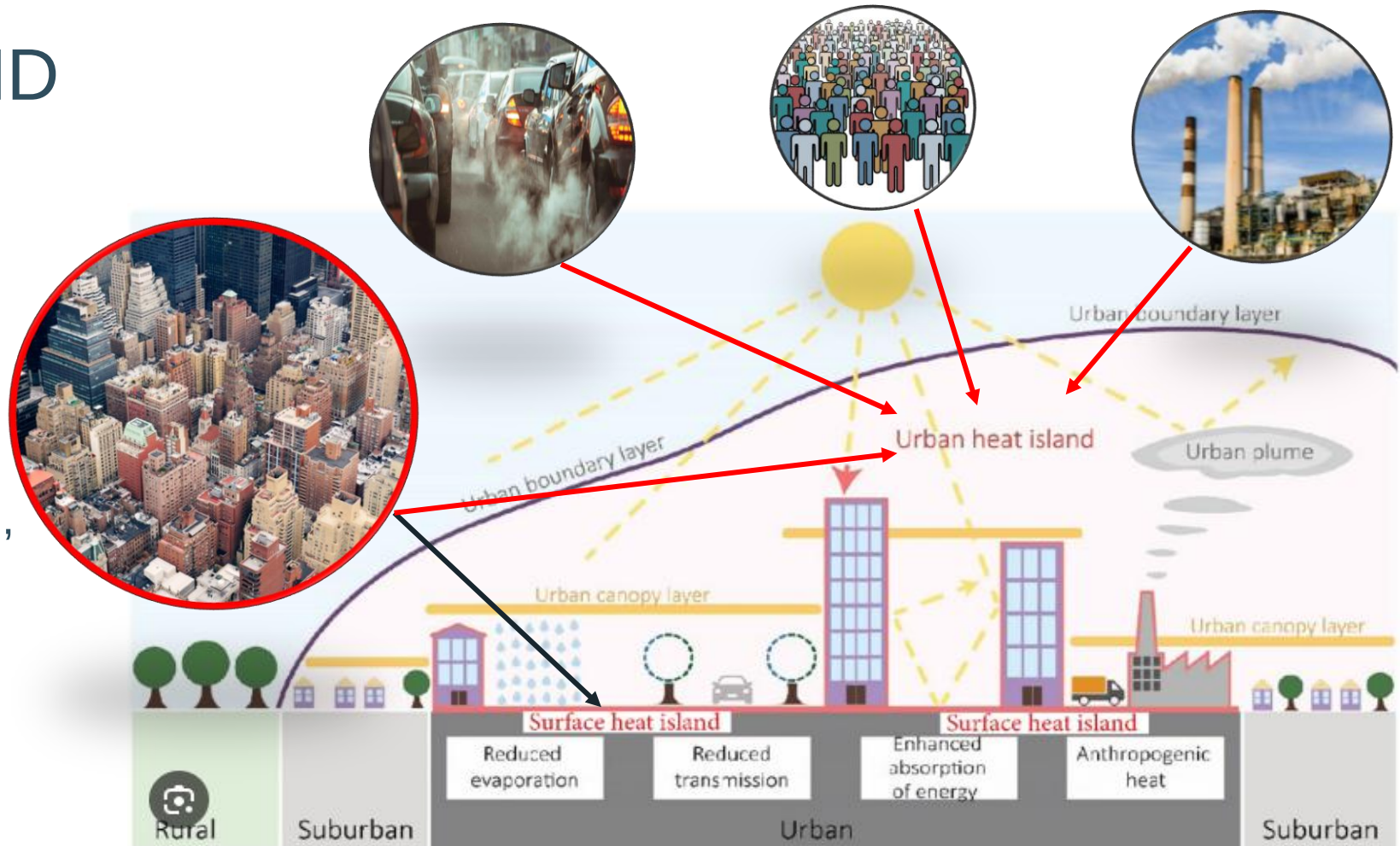


URBAN HEAT ISLAND

- Phenomenon where Urban Areas experience higher temperatures compared to the surrounding rural areas
- Caused by urban activities and landscape (artificial surfaces and infrastructure).
- Results in environmental, social, health and economic distress.
- **TWO COMPONENTS**

Atmospheric Component (AUHI):
Affected by more variables and harder to study

Surface Component (SUHI)
(Study focus): Primarily affected by Land cover and can be accurately assessed through LST



Local Climate Zones and UHI

- Universal framework developed to study UHI – Consisting of 10 Built and 7 Natural classes.
- The LCZ framework is built on the premise that all these classes are thermally distinct universally for both AUHI and SUHI.

PROBLEM

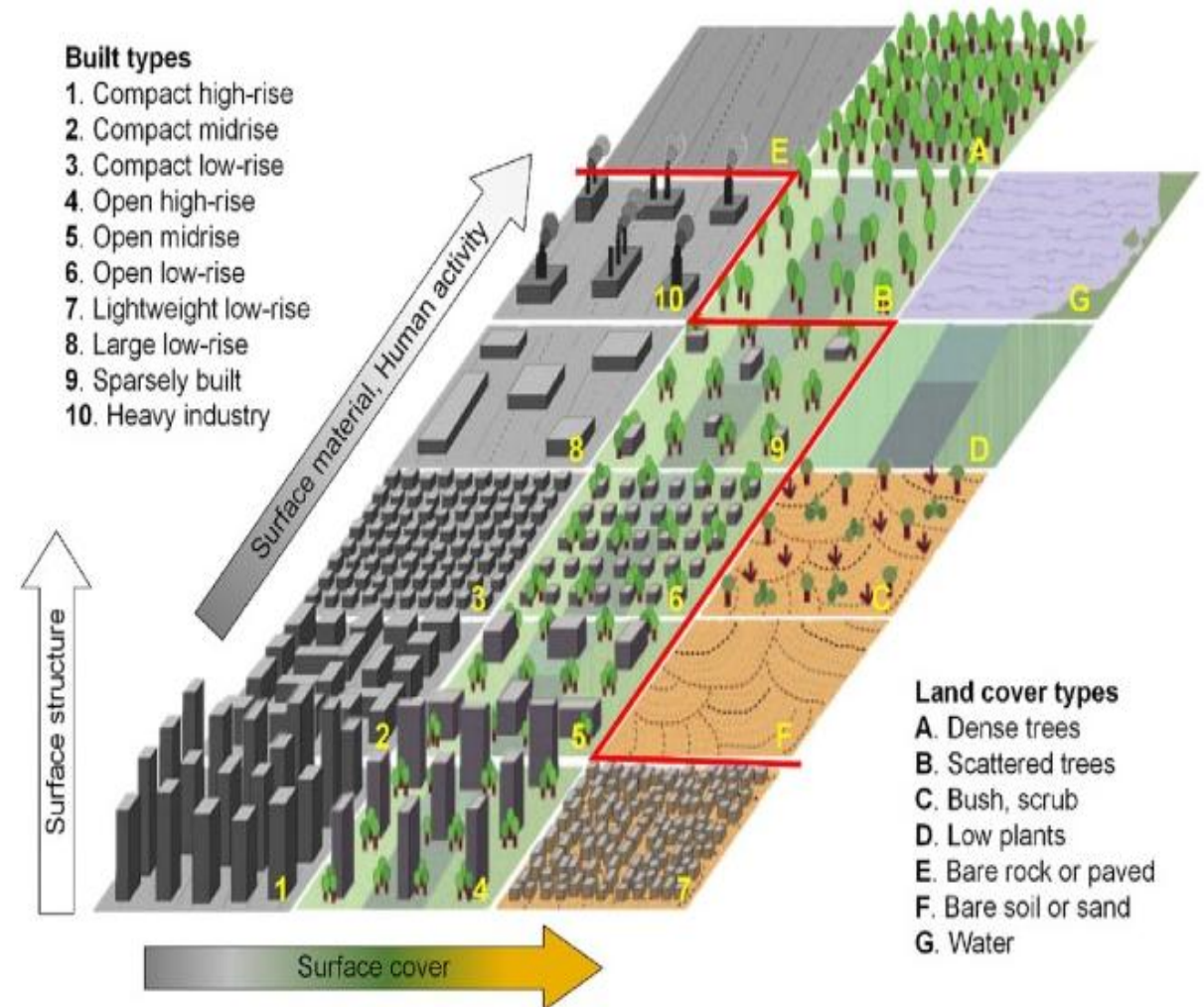
- Some of the classes share great similarities in physical characteristics which the typology does not account for
- Urban areas have different morphologies.

RESEARCH QUESTIONS

- To what extent are these similarities propagated onto the Surface temperature patterns?
- Are the individual LCZ classes thermally distinct enough for practical applications?
- Can the framework be optimized (clustered) for practical applications ?

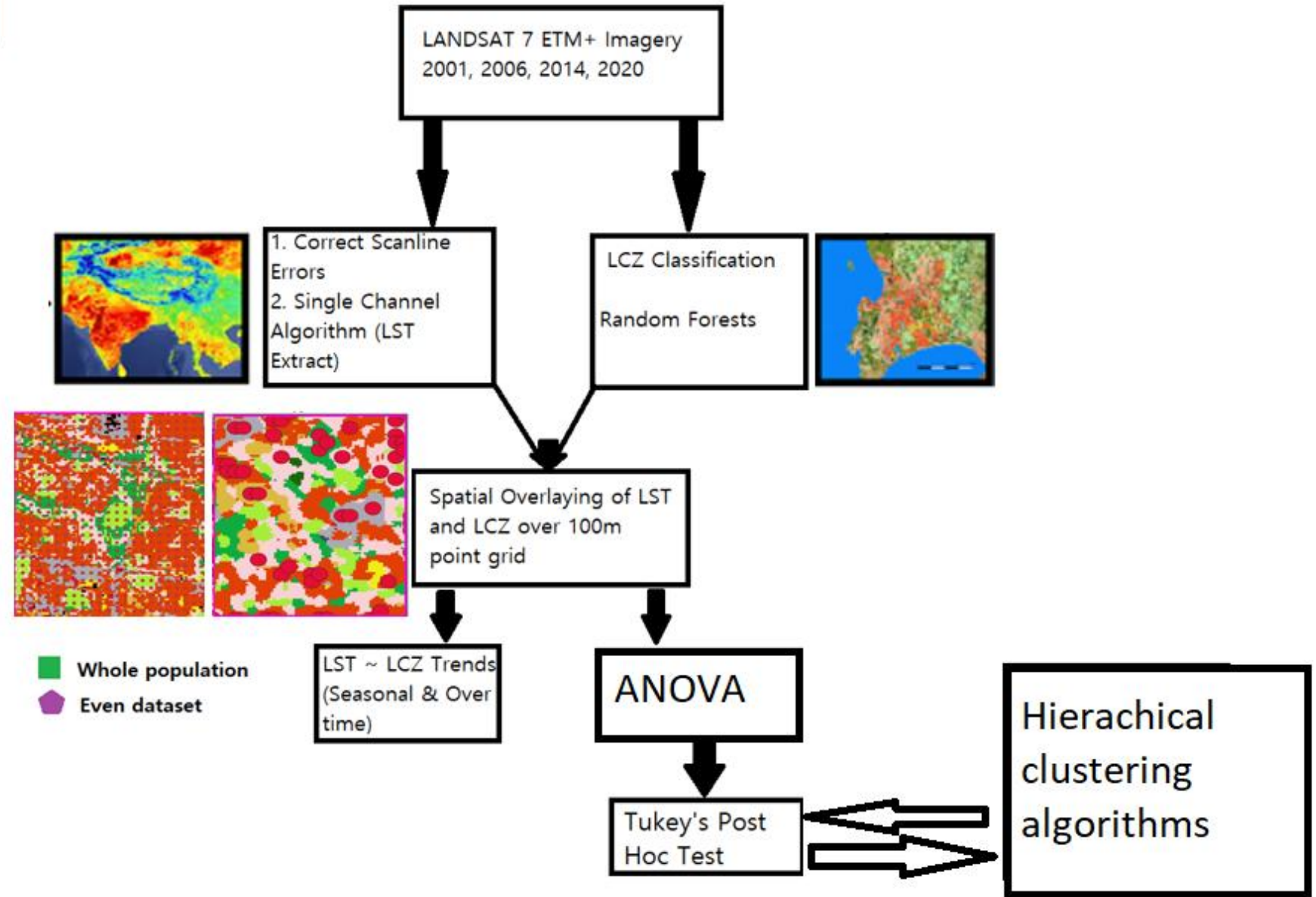
STUDY AIM:

- Develop a SUHI optimized version of the LCZ framework for practical applications.

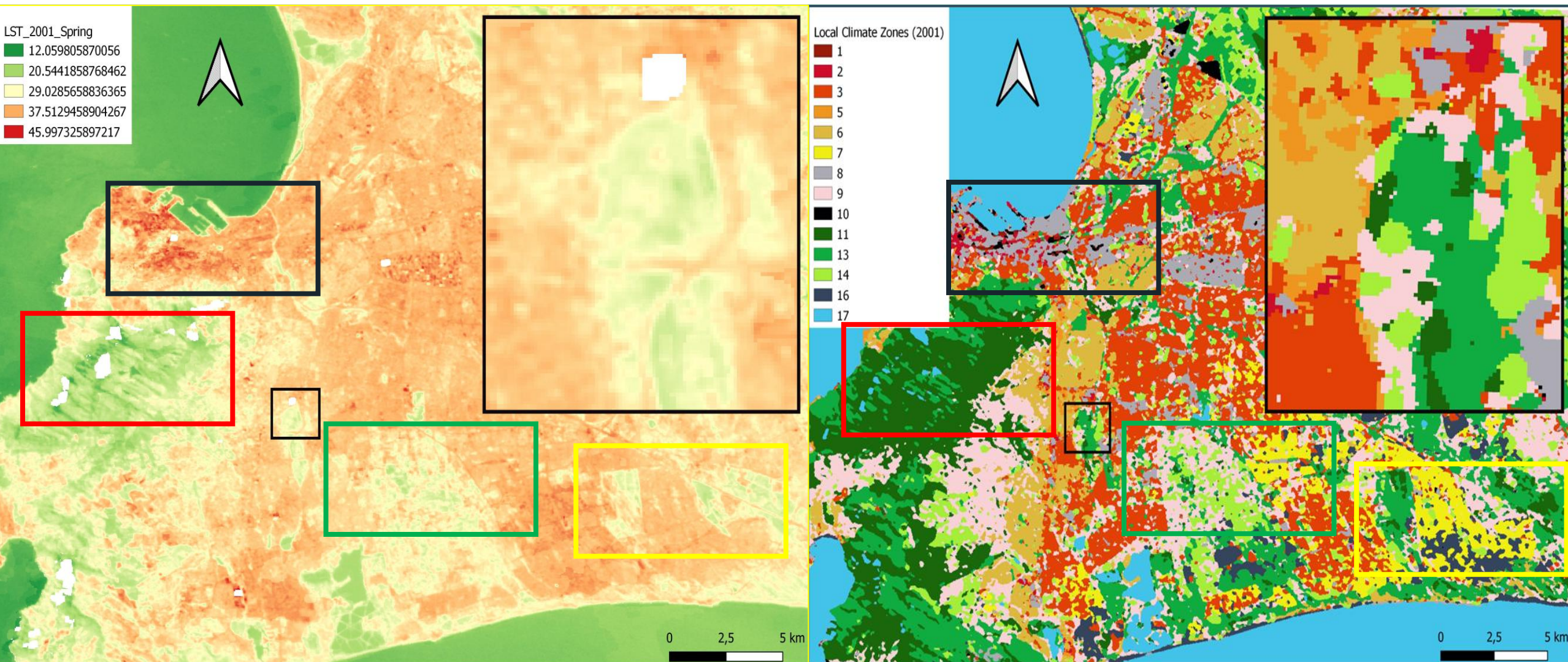


Methodological Flowchart

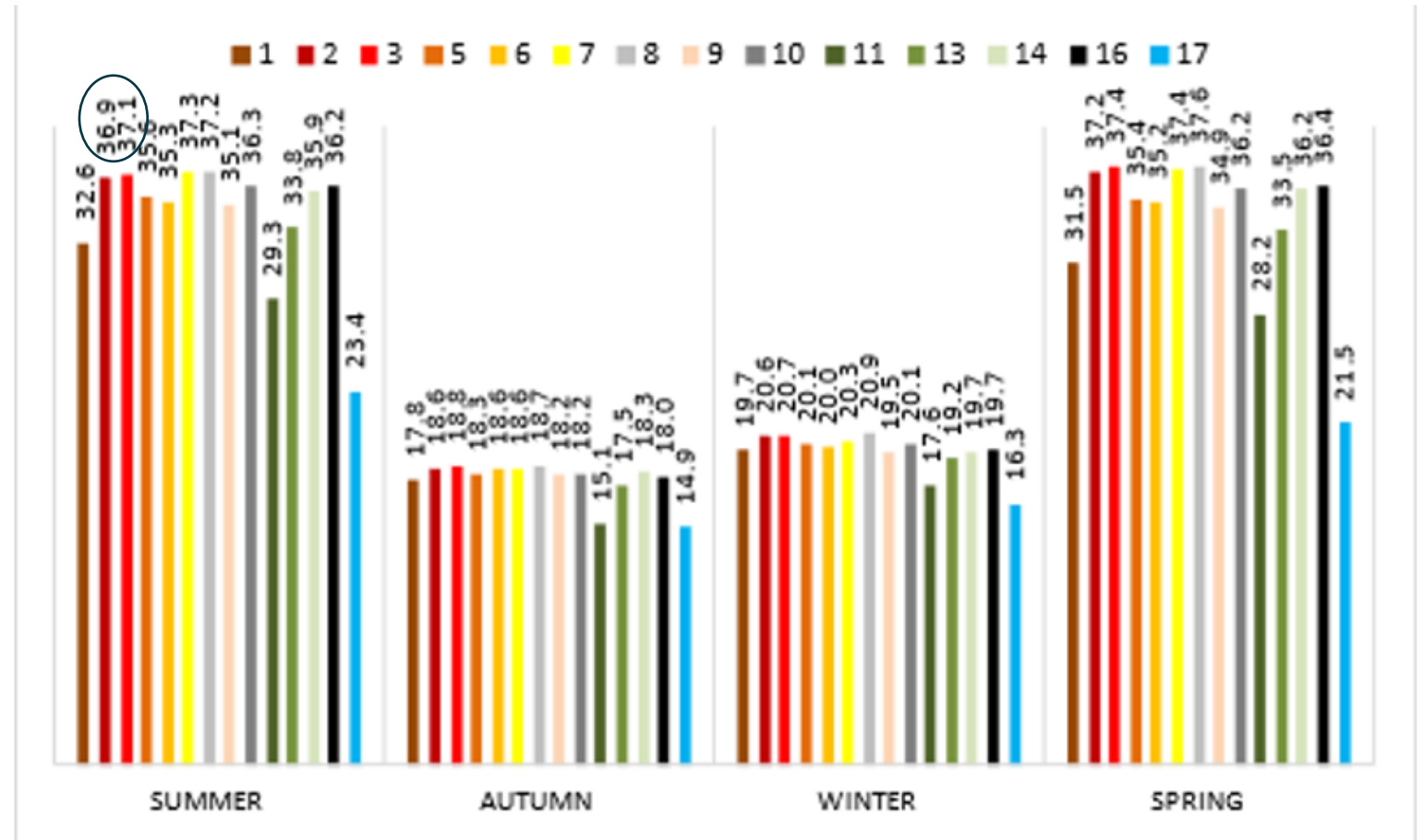
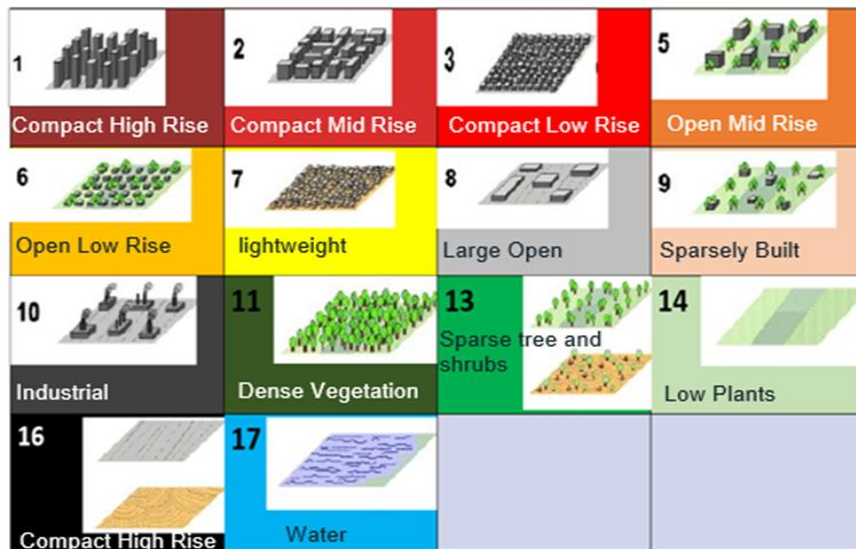
LCZ	Number of Points	
9	15479	
13	14540	
14	11968	
3	11205	
11	8941	
6	7959	
8	3936	
7	3874	
16	3291	
5	1932	
17	1466	
2	1107	
10	650	
1	126	



Results: LST vs LCZ visual analysis



Mean LST per LCZ



Statistical analysis of Mean LST differences between LCZs

Statistical significance: A difference did not occur by chance

Challenge: The problem is that this difference can be astronomically small, too small to have a real-life effect.

Solution.

Practical Significance:

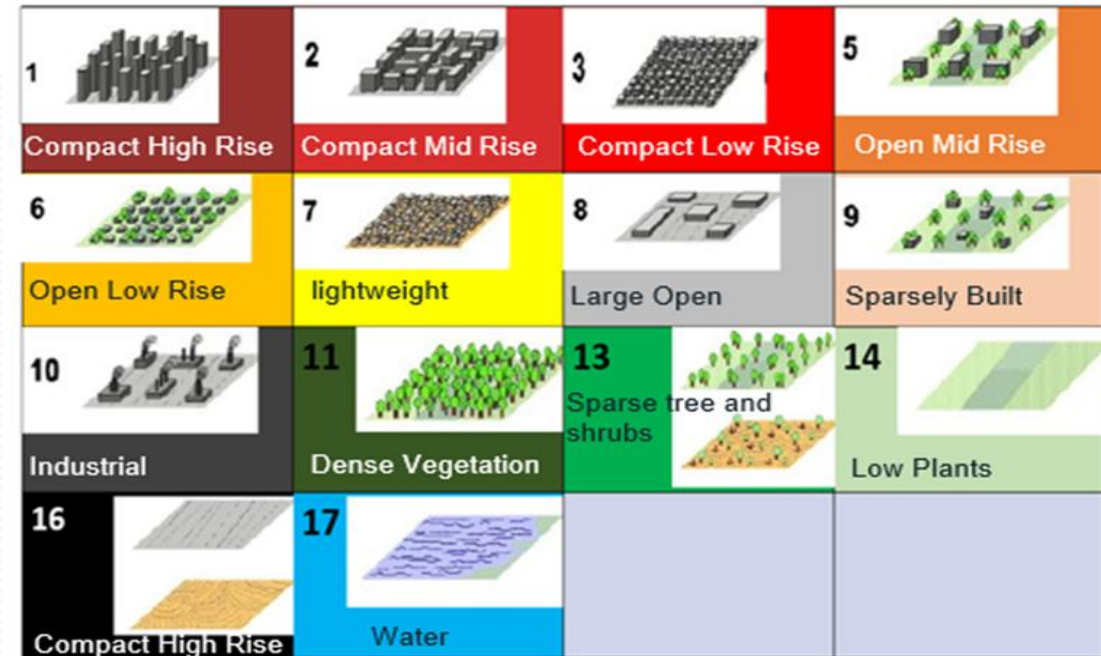
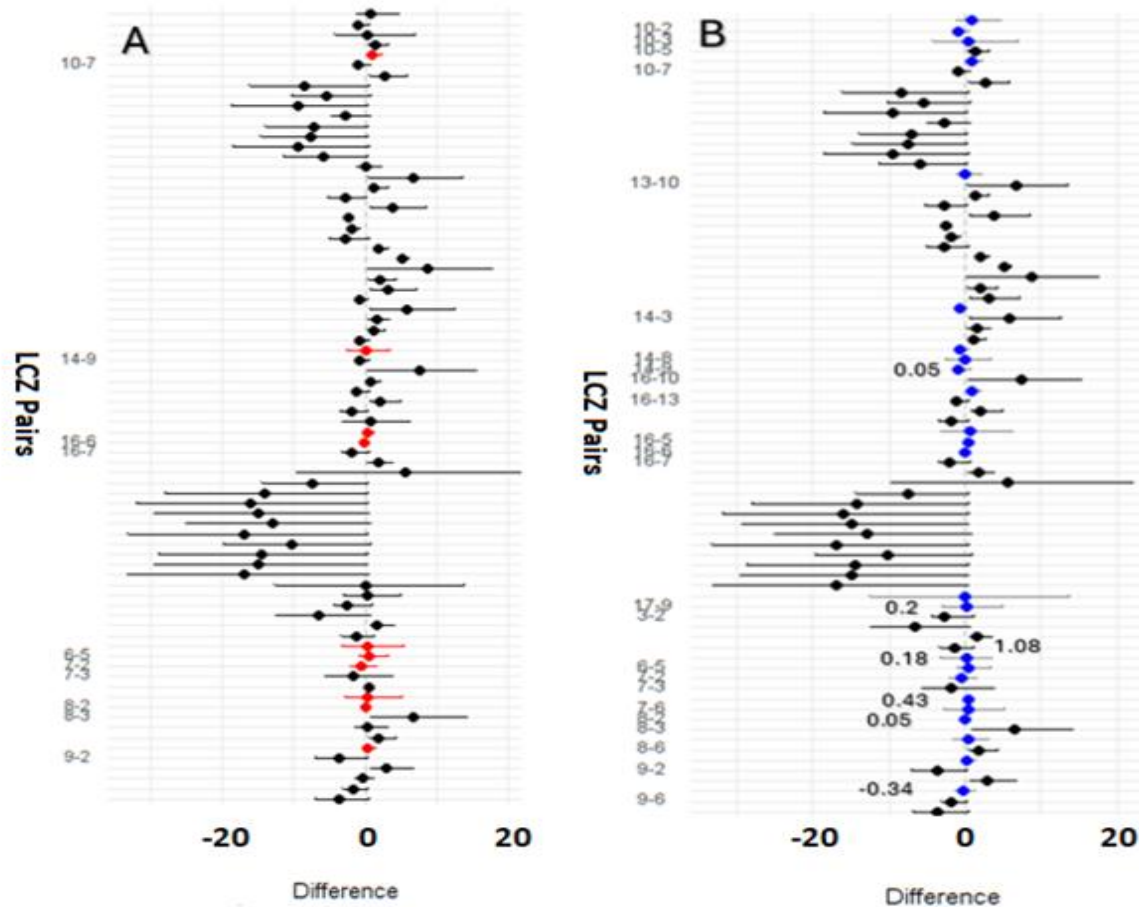
- Practical significance threshold of 1°C
(based on ecological processes and previous research)



ANOVA and Post Hoc Test (Tukey's HSD)

Red = Pairs not statistically significant

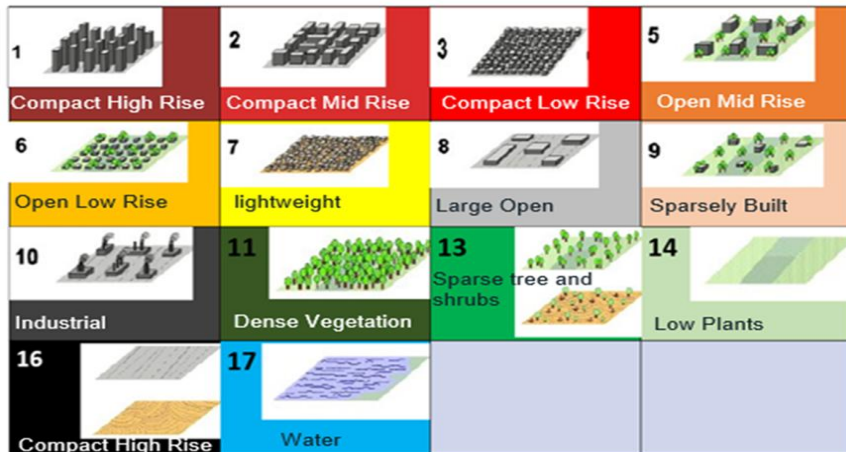
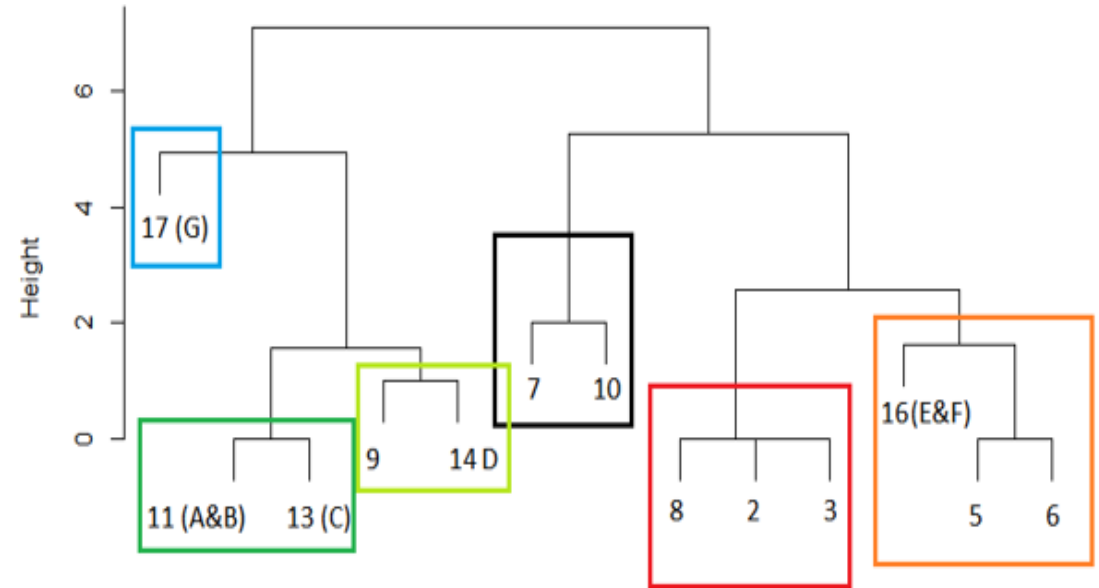
Blue = Pairs not practically significant



LCZ Clustering Algorithm1: Semi Automated algorithm

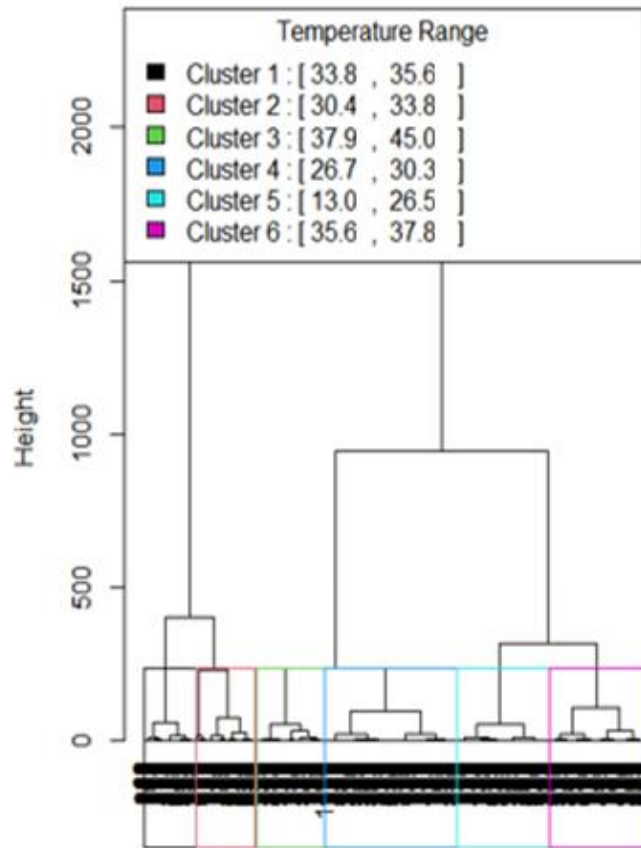
- Agglomerative Clustering
- Spectral Approach.
- Groups LCZs based on similarities in physical characteristics alone.
- Relies on an input matrix.

• RESULTS



Cluster	Semi-Automated (SAAC)
1	LCZ 9 and 14 (low Veg and Sparsely Built)
2	LCZ 7 and 10 (Industrial looking)
3	LCZ 2,3 and 8 (Impervious)
4	LCZ 11 and 13 (highly vegetated)
5	LCZ 17 (Water Bodies)
6	LCZ 5,6 and 16 (Open)

Clustering Algorithm 2: Fully Automated



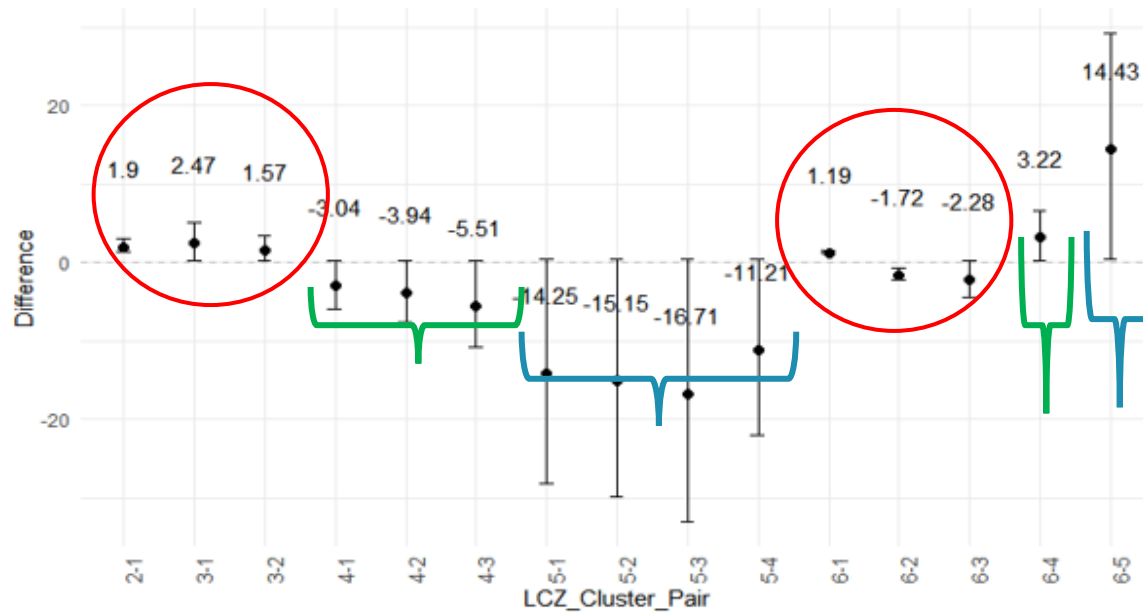
	Local Climate Zones												
Cluster	2	3	5	6	7	8	9	10	11	13	14	16	17
1	1	45	1	15	3	8	42	2	3	42	22	5	0
2	11	4	0	21	12	1	30	4	20	63	8	4	1
3	50	109	0	7	23	11	19	13	3	38	12	9	0
4	0	0	2	5	2	1	16	0	68	34	5	4	2
5	1	0	2	0	0	0	3	1	25	5	0	0	40
6	12	35	17	44	23	3	20	4	6	32	10	12	0

Cluster	Automated (ADC)
1	LCZ 9 and 14 (low Veg and Sparsely Built)
2	LCZ 13 (Shrub-lands)
3	LCZ 2,3,8,10 (Impervious)
4	LCZ 11 (Densely Vegetated)
5	LCZ 17 (Water Bodies)
6	LCZ 5,6,7,16 (Open)

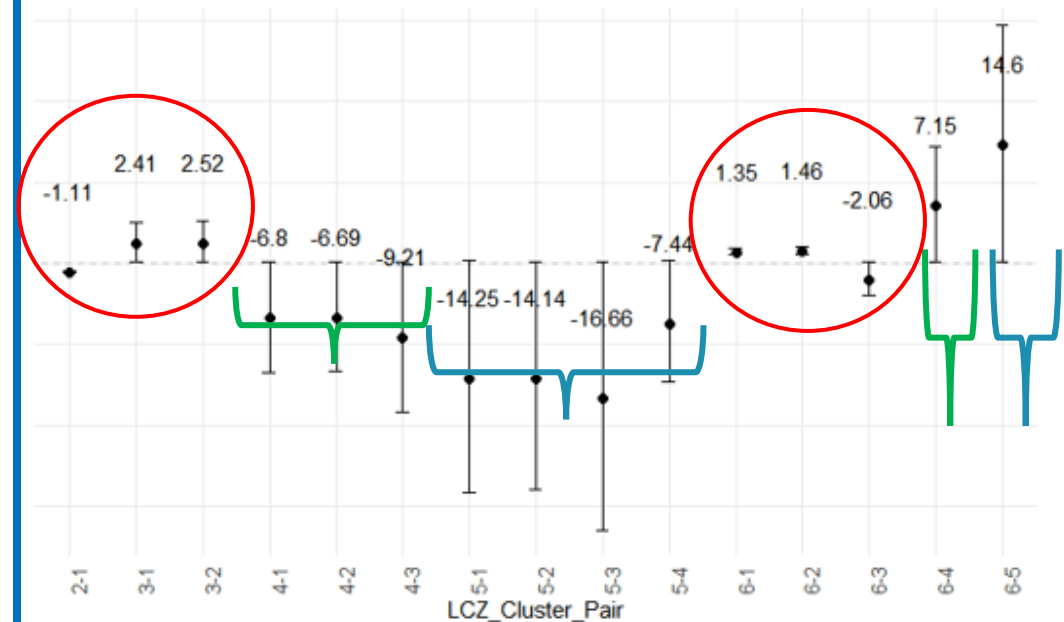
Cluster	Semi-Automated (SAAC)
1	LCZ 9 and 14 (low Veg and Sparsely Built)
2	LCZ 7 and 10 (Industrial looking)
3	LCZ 2,3 and 8 (Impervious)
4	LCZ 11 and 13 (highly vegetated)
5	LCZ 17 (Water Bodies)
6	LCZ 5,6 and 16 (Open)

Clusters practical Significance (Tukey)

Cluster	Automated (ADC)
1	LCZ 9 and 14 (low Veg and Sparsely Built)
2	LCZ 13 (Shrub-lands)
3	LCZ 2,3,8,10 (Impervious)
4	LCZ 11 (Densely Vegetated)
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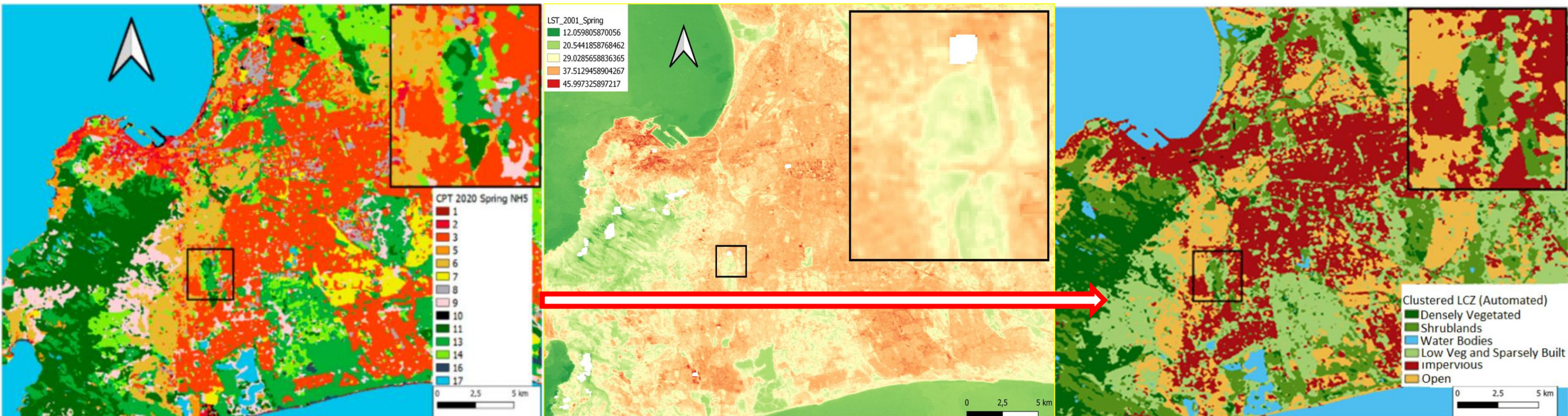
Semi Automated



Fully Automated

Conclusions:

- _ The similarities in LCZ physical characteristics are propagated onto the LST patterns.
- A clustered typology is the only way to achieve practically distinct thermal environments.



Thank you



Open Access Article

Optimizing Local Climate Zones through Clustering for Surface Urban Heat Island Analysis in Building Height-Scarce Cities: A Cape Town Case Study

by Tshilidzi Manyanya ^{1,*} ✉, Nthaduleni Samuel Nethengwe ² ✉, Bruno Verbist ¹ ✉ and Ben Somers ^{1,3} ✉

¹ Division of Forest, Nature and Landscape, Department of Earth & Environmental Sciences, KU Leuven, Celestijnenlaan 200E, 3001 Leuven, Belgium

² Geography and Geo-Information Sciences, Faculty of Science, Engineering and Agriculture, University of Venda, Thohoyandou 0950, South Africa

³ KU Leuven Urban Studies Institute, KU Leuven, Parkstraat 45-3609, 3000 Leuven, Belgium

* Author to whom correspondence should be addressed.

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Submission received: 2 July 2024 / Revised: 15 August 2024 / Accepted: 4 September 2024 /
Published: 10 September 2024

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Versions Notes



VLIR-UOS TEAM project

Remote sensing for Urban and Rural Development & Resilience (Resider)

Liezl Vermeulen, KU Leuven
Tshilidzi Manyanya, KU Leuven
Bruno Verbist, KU Leuven-KLIMOS

VLIR-UOS Community talk , 26 February 2025

4 partner universities

- UCT – ACDI Prof. Mark New
- UNIVEN – Dr. Nthaduleni “Sam” Nethengwe
- Fort Hare - Dr. Leocadia Zhou
- KU Leuven - Prof. Ben Somers – Dr. Bruno Verbist



University of Venda
Creating Future Leaders



University of Fort Hare
Together in Excellence

Close collaboration with

- The South Africa / Flanders Climate Adaptation Research and Training Partnership
<https://saf-adapt.org/>
- RVSC (Risk & Vulnerability Science Centres) at UCT, UNIVEN & Fort Hare
- Policy makers
 - Department of Forestry, Fisheries & the environment
 - Adaptation network
- // VVOB – Climate education for secondary schools in South-Africa (KIC)



KU Leuven students: Resider – SAF-ADAPT

	Name	Degree	Status	Research Title
1	Tshilidzi Manyanya	PhD	ongoing	Application of Local Climate Zones in urban regions of different function and size to study urban heat islands in South Africa.
2	Liezl Vermeulen	PhD	ongoing	Modelling the effect of climate change and anthropogenic factors on southern African ecosystem functioning, stability and integrity using remote sensing
3	Massimula Ntandokazi	MSc	ongoing at UCT	Impact of land-use and climate change on invasive alien plant species in South-Africa
4	Ariana Bravo	MSc	completed	Assessing the training and teaching materials used for the professional development of school teachers to implement climate change education and set up projects in South Africa
5	Jonas Simons	MSc	completed	The impact of drought of drought stress in the fynbos ecosystem via remote sensing
6	Anna Van Eyck	MSc	completed	Multitemporal assessment of local climate zones in Cape Town, South Africa, using LANDSAT imagery
7	Jutta Meylemans	MSc	completed	An investigation of sustainable urban drainage systems to mitigate urban heat case of Cape Town, South Africa
8	Senne Spreij	MSc	completed	Identifying invasive plant species in fynbos vegetation with multispectral drone imagery
9	Queenny Lopez	MSc	completed	Determining local ecosystem-driver dynamics of turning points in arid South-African savannas
10	Francisco Ramirez Castro	MSc	completed	Monitoring Invasive Alien Plant Species Using Drone and Sentinel-2 Imagery in Tembe Elephant Park, S-Africa
11	Hubert Claes	MSc	completed	Wildlife monitoring through remote sensing in Tembe Elephant Park
12	Paul Jhon Diezon	MSc	completed	Assessment of Climate Change and Tree Growth using Tree-Ring Analysis in Northern Kwazulu-Natal, S-Africa
13	Caroll Mewa Fotso	MSc	ongoing	Exploring the relationship between local climate zones and human health in South African towns and cities

Thank you!!

More info:

- <https://saf-adapt.org/>
- <https://ees.kuleuven.be/en/fnl>