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2nd African Forum On Urban Forests

Green Horizons: Shaping the Future Resilience of African Cities through Urban Forests

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Urban land surface cover dynamics and its impact on land surface temperature between 2011-2021 in Hawassa City, Ethiopia

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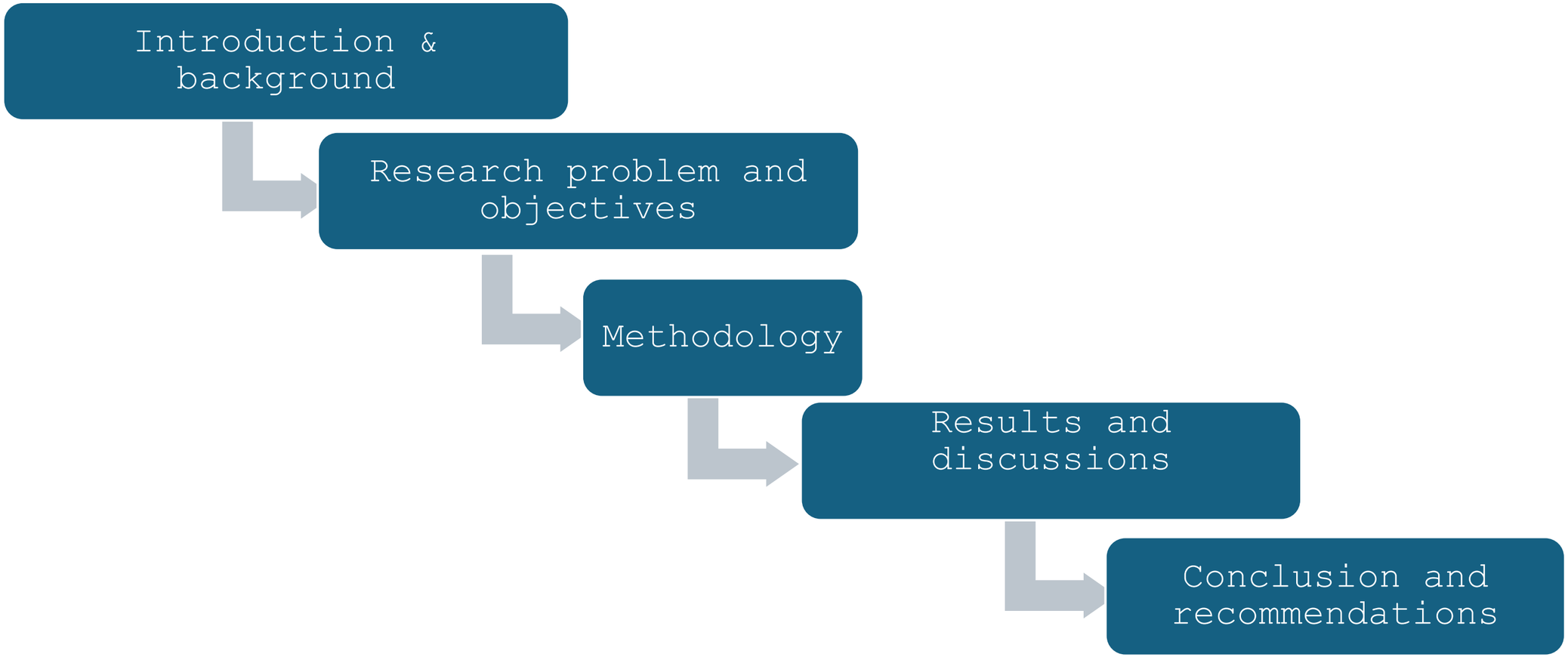
Outline of the presentation



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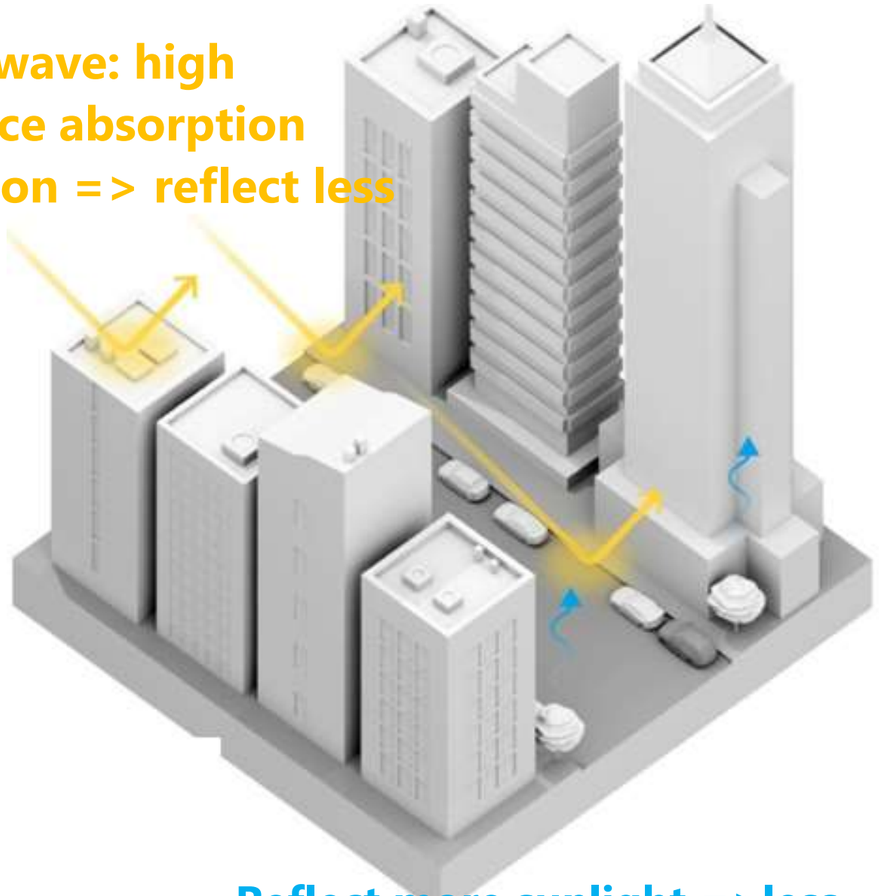
Introduction

- **Urban sprawl** ↑ ~ 95% globally (1990 & 2014)
- **Built-up surface expansion** ~ 2786 km^2/day (Behnisch et al., 2022)
- **Less compacted growth** → inefficient land use and widespread impervious cover
- **Why are urban areas hotter?**
  - Materials with high thermal conductivity trap more heat
  - Greater absorption of solar radiation compared to rural areas
  - Urban centers are 1–6°C hotter than surrounding rural areas



Short wave: high radiance absorption radiation => reflect less

Reflect more sunlight =>less heat absorption, more evapotranspiration

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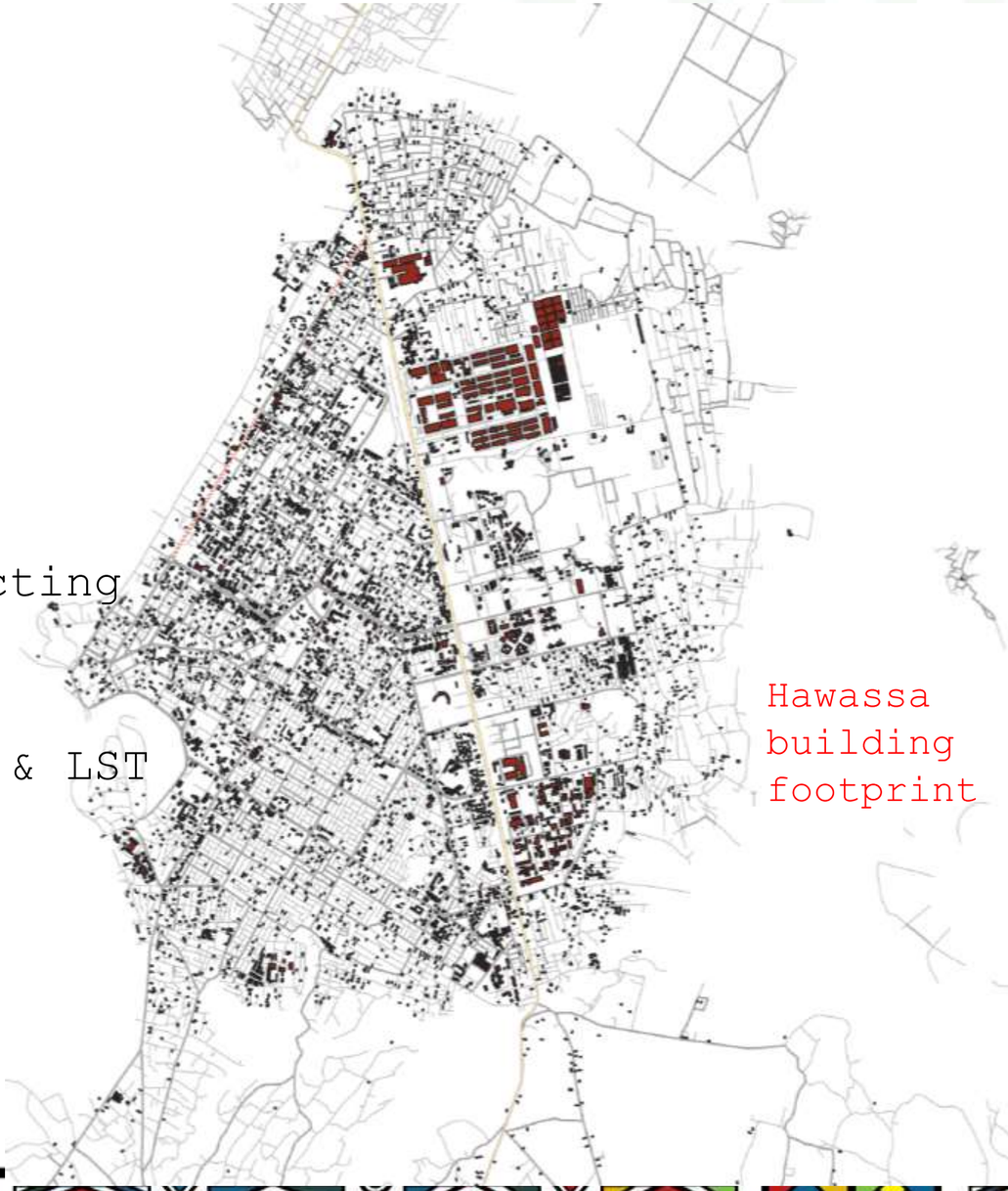
Introduction

Existing studies in Ethiopia:

- ✓ focus on broad-scale land cover change using satellite image
- ✓ overlook fine-scale surface cover types affecting LST
- ✓ limited information on surface cover changes & LST impact



Hawassa building footprint

This study, **using i-Tree canopy** with high-resolution imagery,

- ✓ provides essential baseline data for urban development
- ✓ guides policy decisions → **urban sustainability.**

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Aims and objectives

This study examines the impact of urbanization on land surface cover change and its role in triggering climate change impacts in Hawassa, Ethiopia.

- **Specific objectives:**
  - ✓ **Assess the proportional trend between grey and green coverage in Hawassa City.**
  - ✓ **Detect temporal changes in ground surface cover over the past decade**
  - ✓ **Analyze the impact of land surface cover changes on land surface temperature (2011–2021)**

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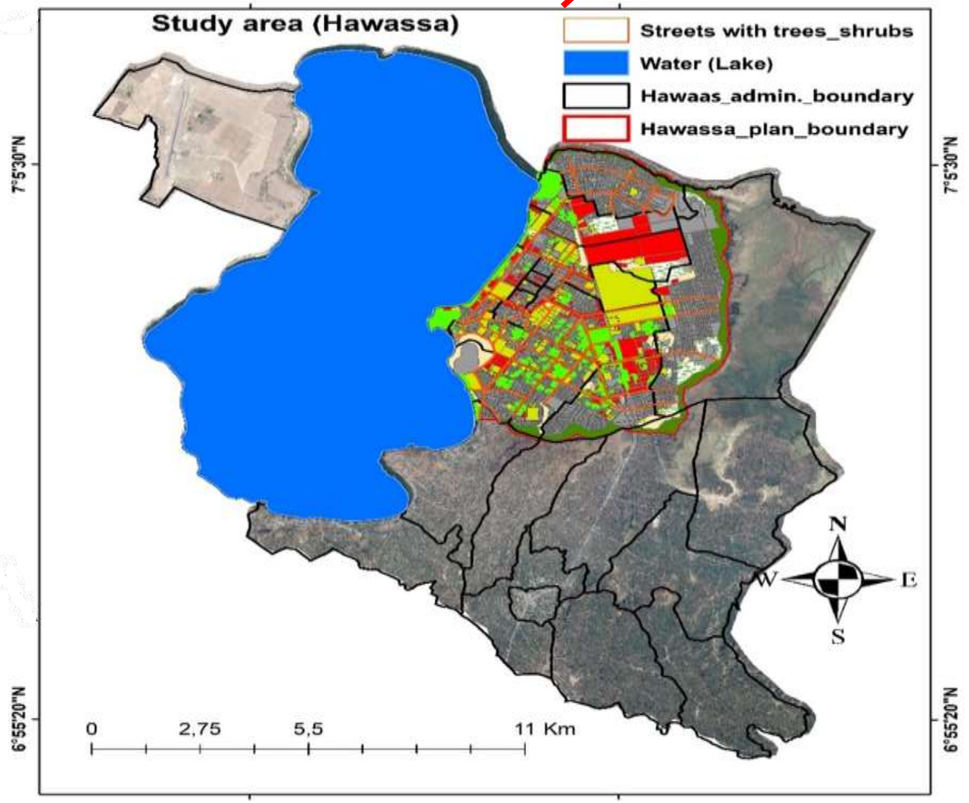
Study area

Hawassa city, Southern Ethiopia

- Medium sized ~ 387K pop., 4% growth/yr)

- Tropical climate with bimodal rainfall pattern
  - Avg. rainfall: ~1,013 mm
  - Temp.: 6–34°C (Avg. 23.75°C)
  - Wind speed: Peaks mid-June–Aug, lowest Sept–June

- UGI elements ~ lack strategic planning



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Methods

Application of i-Tree canopy tool - land surface cover

i-Tree canopy (high resolution aerial image)

Defining study area using boundary shapefile

Predefining cover classes (9 classes)

Classification of random points: Tree/shrub or Non-Tree/shrub (500 points)

Cover change detection

Transferring to Google Earth image 2021

Reclassifying in Google Earth image 2011

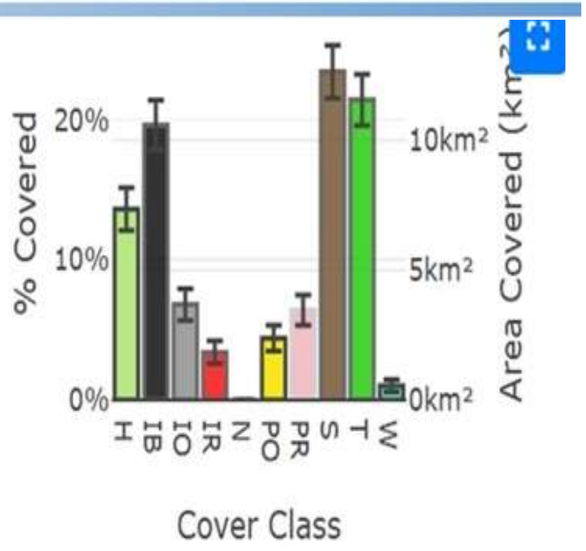
Cover change detection

Sample points from the 2021 aerial image (i-Tree Canopy tool)

Reclassified points overlaid on the 2011 Google Earth image

Canopy
i-Tree. A tree canopy assessment tool

Partial view of identifying ground cover types using i-Tree canopy tool



Buildings: 19.6%±1.78 Impervious Other: 6.8%±

View Results

Report

ID	Cover Class	Latitude	Longitude
1	Pervious Roads	7.04967	38.47351
2	Impervious Buildings	7.02600	38.47177
3	Impervious Buildings	7.03523	38.50630

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Method: Land surface temperature

Remote sensing application (Landsat 5 and 8 images):

- **Image preprocessing:** radiometric calibration → atmospheric correction → NDVI-based emissivity estimation

- **Land Surface Temperature:** Landsat 5 and 8 thermal infrared (TIR)
  - ✓ TIR (band 6) → Landsat 5 for 2011
  - ✓ TIR (band 10) → Landsat 8 for 2021

- **Normalized Difference Vegetation Index (NDVI):**
  - ✓ **Red (**bands 3) and NIR (band 4) = Landsat 5 for 2011
  - ✓ **Red (**bands 4) and NIR (band 5) = Landsat 8 for 2021

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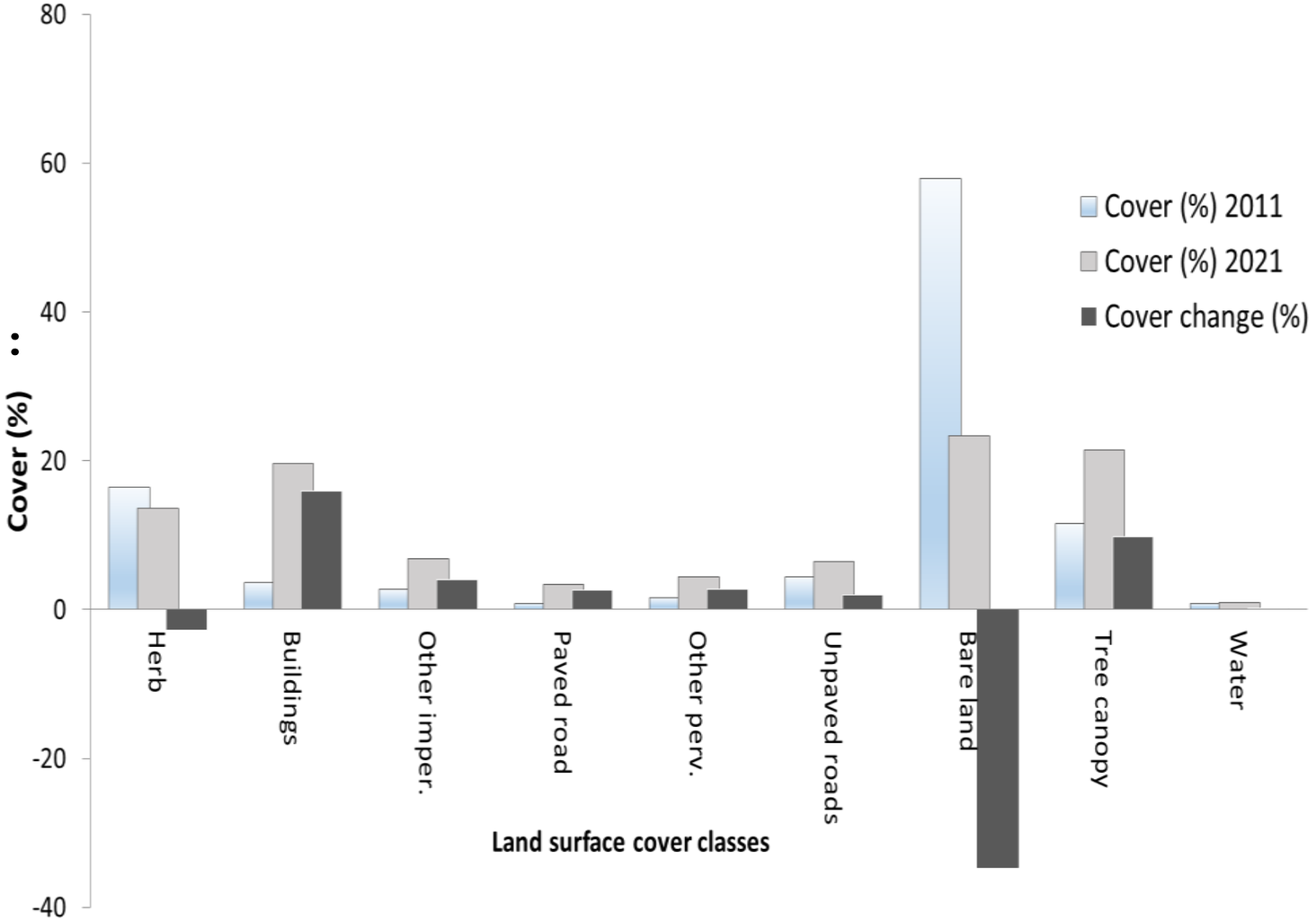
Results and discussions

- Dominant covers in 2021:
  - Barren land: 23.4%,
  - Tree canopy Cover: 21.4%
  - Building Cover: 19.6%

- Land surface cover changes:
  - Open land type ↓ **34.6%**
  - Tree canopy cover ↑ **9.8%**
  - Impervious surfaces ↑ **24%**



✓ Barren land declining was due to rapid urbanization.

✓ TCC raising with ↑housing and other infrastructure

✓ Impervious surfaces ↑heat island risk.

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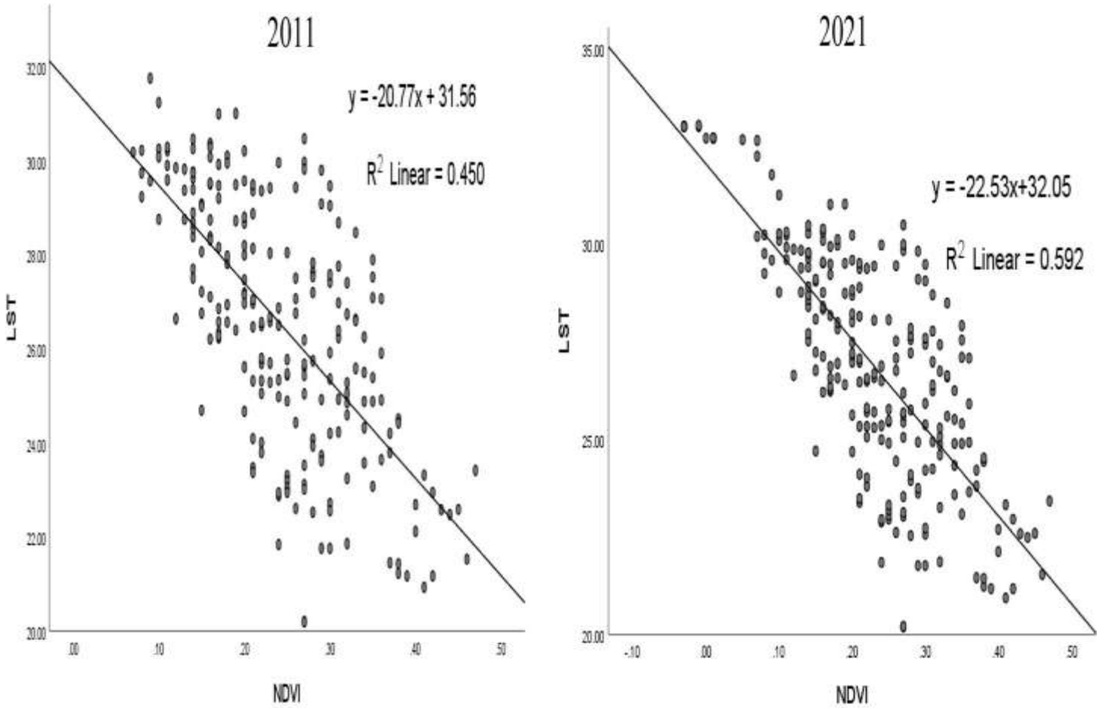
Results and discussions

LST and land surface cover dynamics

Cover (%)/Temp (°C)	2011	2021	Change
Green cover	**28.8**	**36**	**7.2**
Grey cover	**13.2**	**40.6**	**27.4**
Bare land cover	**58**	**23.4**	**-34.6**
Min Temp.	**18.38**	**18.97**	**0.59**
Max Temp.	**35.65**	**33.48**	**-2.17**
Aver. Tem.	**27.71**	**26.04**	**-1.67**

LST and NDVI



- Higher NDVI value → more tree cover → cool the city
- Lower NDVI → more built-up areas → increase LST in the city.

Weaker negative correlation in 2011:

- ✓ Less green space coverage
- ✓ none vegetation (e.g., water) may also contribute to lower LST

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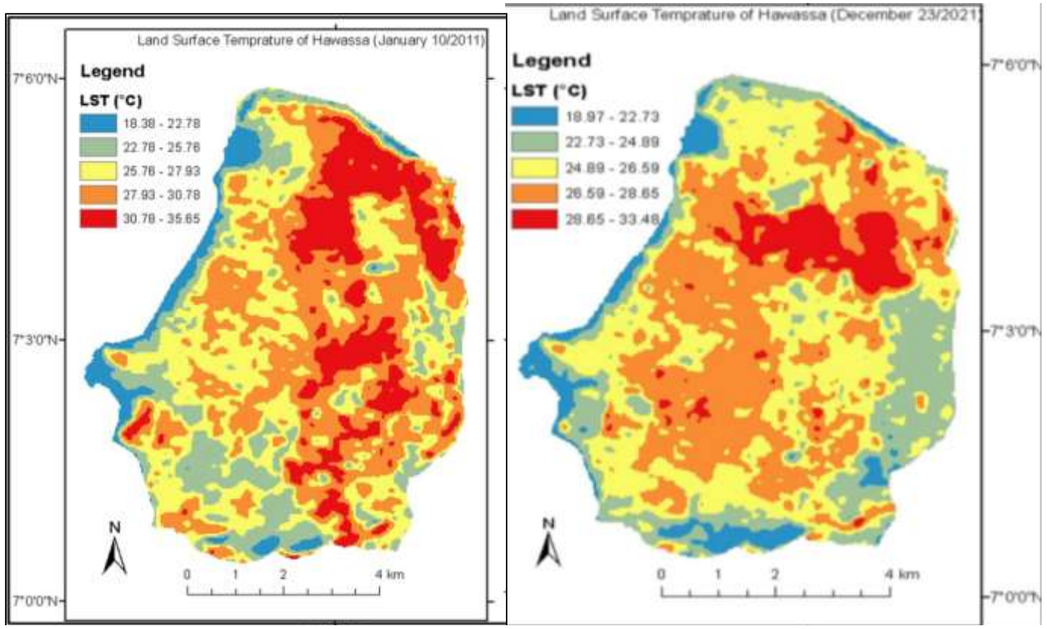
Results and discussions

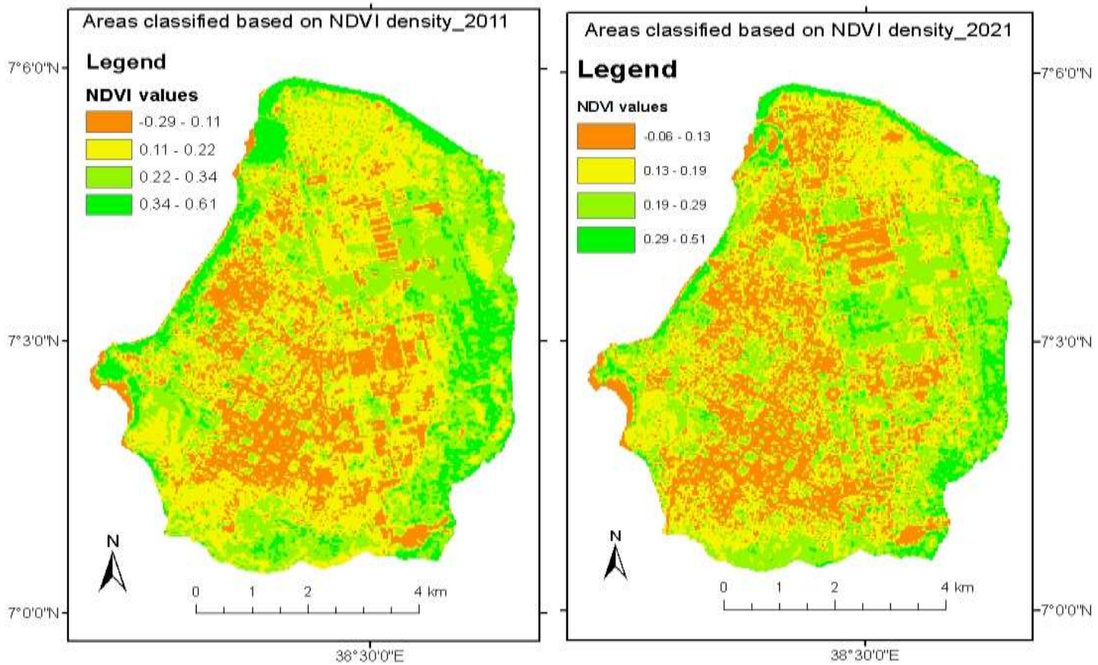
LST vs NDVI spatial/temporal variation

- **Vegetation index:** NDVI↑ from 0.17 (2011) to 0.23 (2021)

- **Hottest Zones (>30°C):**
  - recorded in industrial areas, residential, and CBD zones.

- **Moderate temperature (27–30°C): o**ldest neighborhood of the city





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Conclusion and recommendations

Urban green spaces & cooling effect

- ✓ Urban tree cover increased between 2011 and 2021 despite rapid urbanization
- ✓ A rise in NDVI and TCC → LST decreased, showing the cooling effect of urban green spaces.

Integration of green and built environments

- Increasing TCC in Hawassa, even amidst urban growth:
  - ✓ New green spaces emerged alongside infrastructure development.
  - ✓ Urban growth can integrate both built-up areas & vegetation, fostering a balanced environment.

Spatial variation of LST

- **LST is highest** in concrete-dominated areas
  - ✓ **Industrial zones**, **CBD**, and **residential areas** recorded **LST > 30°C**.
  - ✓ This emphasizes the **urban heat island effect.**

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Policy & Future Planning

- ✓ Balance green and grey by revisiting the existing structural plan to enhance the city's climate resilience
- ✓ The minimum standard for TCC should be adopted to maintain climate-resilient cities
- ✓ Enhance TCC by integrating trees in all planning stages
- ✓ Use TCC & NDVI as UHI indicators for long-term monitoring
- ✓ The findings can serve as baseline information to set TCC goals and sustainability strategies

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Thank You.

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