Household-Based Contributing Factors to Heat, Air Pollution, and Flooding Stressors in Dar es Salaam, Tanzania

Tandale and Kigogo

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- Objectives
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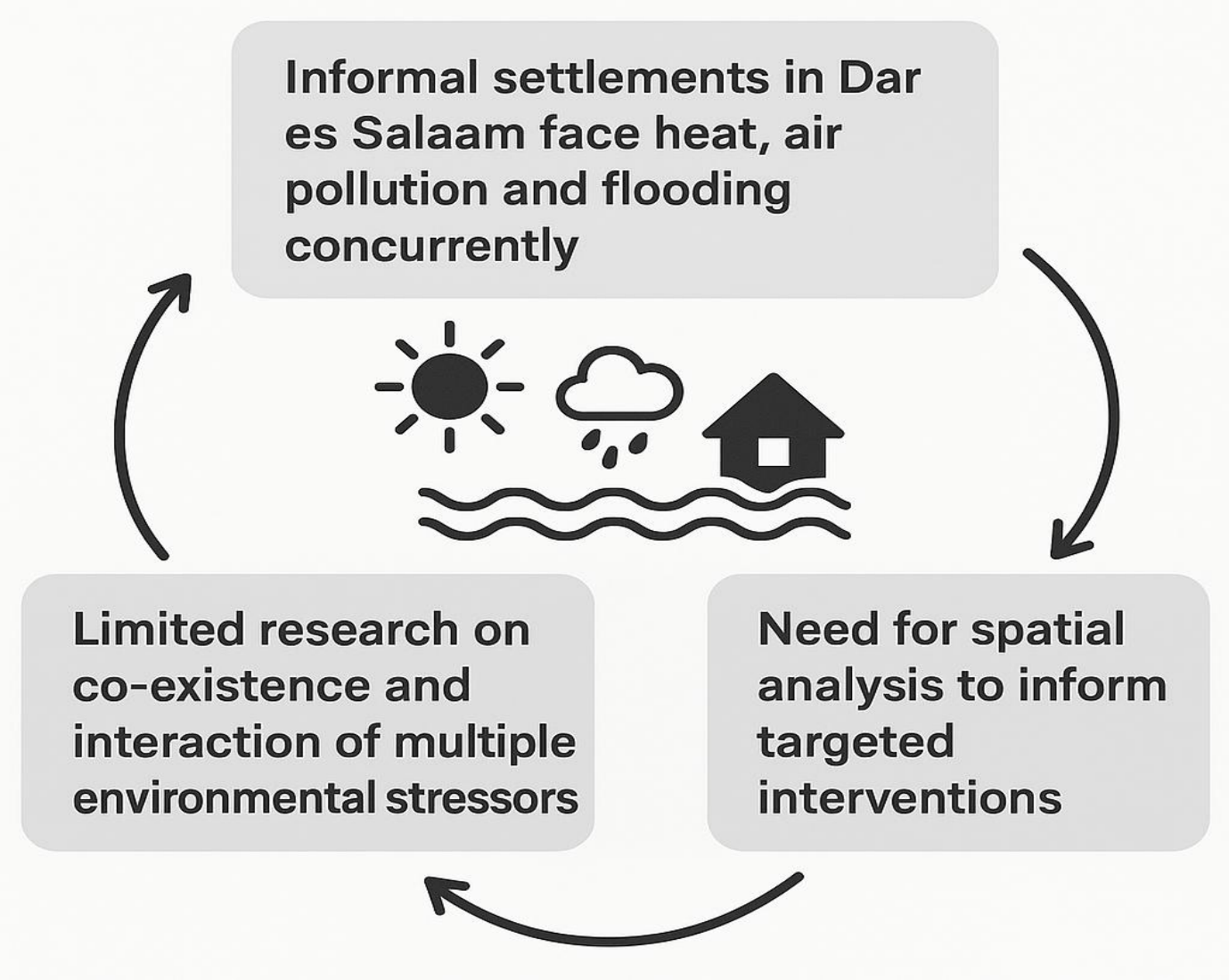
Background

- Climate change is expected to escalate and intensify the environmental stressors: heat, air pollution, flooding.
- Scientists have set 1.5^0C as the maximum bearable average global temperature (AGT) increase
- However, the AGT is increasing at alarming rate
- The IPCC has warned the increase is likely to surpass 1.5^0C
- The heat accumulated in the atm. from GHG emmissions is equivalent to 500,000 hiroshima bombs exploding every year
- This increases the frequence of heat waves, causes significant evaporation and downpours, and shifts the concentration and distribution of air pollutants
- Developing countries are highly affected due to low adaptive capacity contributed by limited resources.
- Rapid population growth, urbanization, poor planning, and poor waste management aggrevate the heat, air pollution, and flooding stressors and their impacts

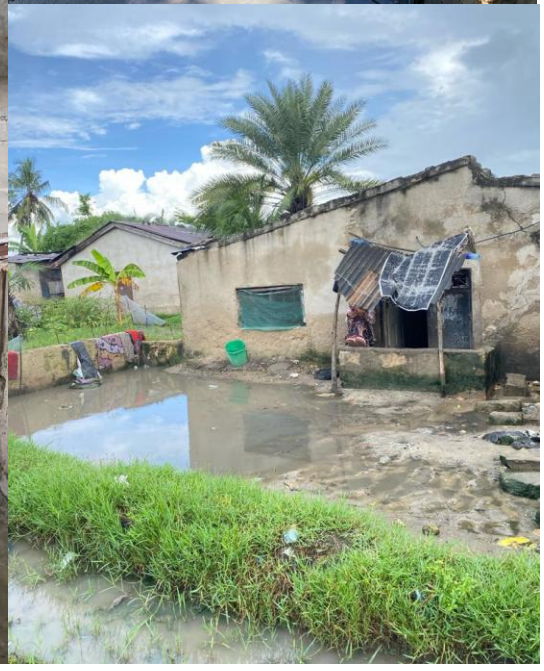
Problem Statement



Problem Statement





Study Objectives

- Assess household-level contributions to heat, air pollution, and flooding.
- Develop Environmental stressors indiced and the Comprehensive Environmental Pollution Index (CEPI).
- Map spatial distribution of the environmental stressors indices.

Study Area

- Dar es Salaam: economic hub of Tanzania with ~6 million residents.
- Case studies: Tandale and Kigogo wards in Kinondoni Municipality.
- Areas were selected because of their pronness to floods, air pollution, and heat stress.

Study Area

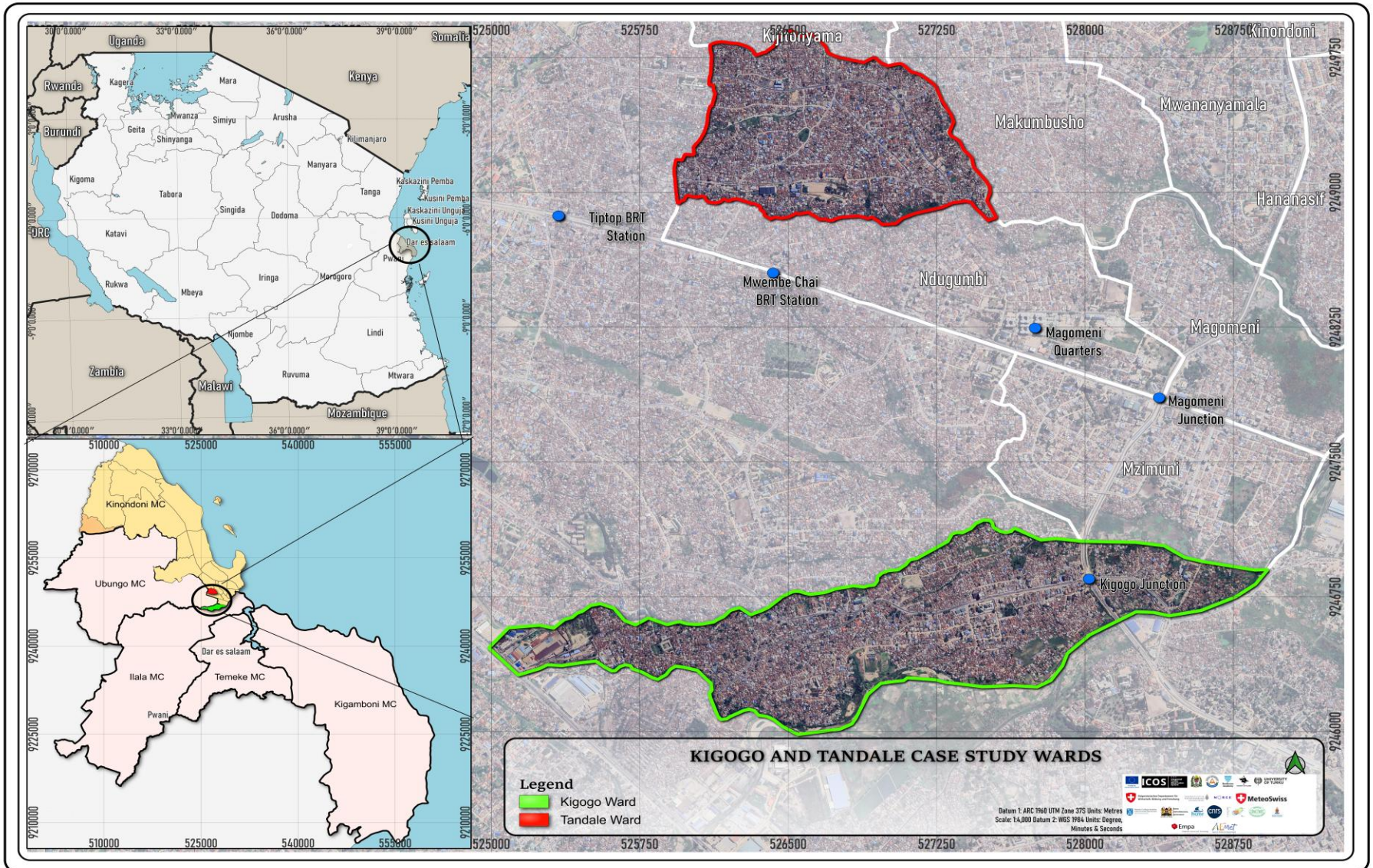
Tandale

- A ward in Kinondoni Municipality, Dar es Salaam
- Bordered by Makumbusho, Ndugumbi, Kijitonyama, and Manzese wards
- The name Tandale originated from the Lake Tandale
- Characterised by unplanned high density housing with narrow pathways and limited access
- Population is 43,374
- It has six Subwards (Tumbo, Sokoni, Mtogole, Mkunduge, Pakacha, Muhalitani)
- Prone to flooding especially along the Ng'ombe river - although current construction of the river has lessened the problem
- Lack of proper sanitation systems and the overflow of water streams contribute to sanitation challenges
- Tandale is recognized as the birthplace of Singeli, a popula Tanzanian music, particularly withini the Zaramo community in the Mtogole neighbourhood

Kigogo

- A ward in Kinondoni, Dar es salaam
- The origin of its name was a large wooden log (gogo in Swahili) that was once a landmark- the area is currently a bar called Randa bar
- Shares borders with Mburahati and Mabibo (North and West), Ilala, Buguruni and Tabata to the South
- Has three subwards, Kigogo Mbuyuni, Kigogo Mkwajuni, and Kigogo Kati
- A densely populated ward with 45,291 people
- Faces environmental challenges especially flooding. River valleys surrounding the ward are becoming increasingly prone to flooding exacerbated by poor solid waste amangement

Study Area


Uganda
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Malawi
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Geita
Shinyanga
Kilimanjaro
Manyara
Kigoma
Tabora
Tanga
Kaskazini Pemba
Kusini Pemba
Kaskazini Unguja
Kusini Unguja
Singida
Dodoma
Katavi
Dar es salaam
Pwani
Rukwa
Iringa
Morogoro
Mbeya
Njombe
Lindi
Ruvuma
Mtwara
Kinondoni MC
Ubungo MC
Ilala MC
Temeke MC
Kigamboni MC
Kijitonyama
Kinondoni
Mwananyamala
Makumbusho
Hananasif
Tiptop BRT Station
Mwembe Chai BRT Station
Ndugumbi
Magomeni Quarters
Magomeni
Magomeni Junction
Mzimuni
Kigogo Junction
KIGOGO AND TANDALE CASE STUDY WARDS
Legend
Kigogo Ward
Tandale Ward
MeteoSwiss
Empa

Methodology

- Case study approach with mixed methods (quantitative and semi-qualitative).
- 458 households were surveyed using semi-structured questionnaires.
- Descriptive analysis was adopter using SPSS and Microsoft Excel tools
- Pollution indices were calculated for heat, air, and flooding. Followed by the CEPI to evaluate the co-existence contribution of the stressors

Methodology

- ✓ $PI = \frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i}$
- ✓ $CEPI = I_{max} + \left[(100 - I_{max}) x \left(\frac{I_2}{100} x \frac{I_3}{100}\right)\right]$

Quality index	Grading	Quality status
0 - 25	A	Excellent
26 - 50	B	Good quality
51 - 75	C	Poor quality
76 - 100	D	Very poor quality
Above 100	E	Unfit for consumption

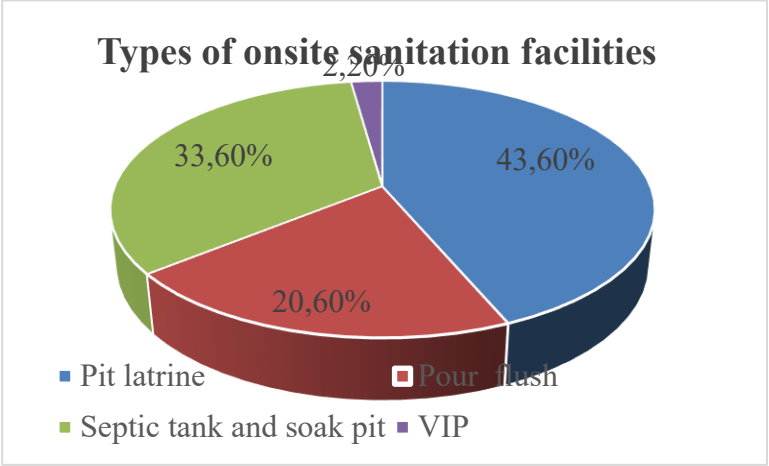
- GIS for spatial mapping.

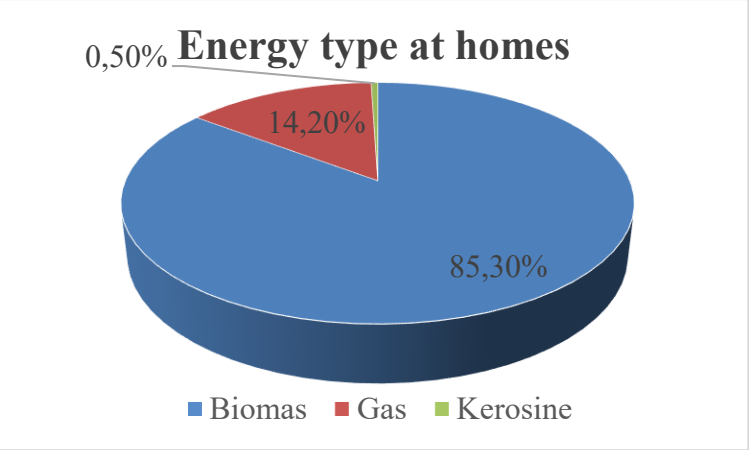
Results – Heat Stress Contributors

- 96% of buildings are low-rise, with mainly cement, iron sheets, timber construction material (high heat retention).
- 71% of plots have no green spaces; <10% greenery in most cases.
- Urban heating effect prevalent in densely built-up areas.

Results – Air Pollution Contributors

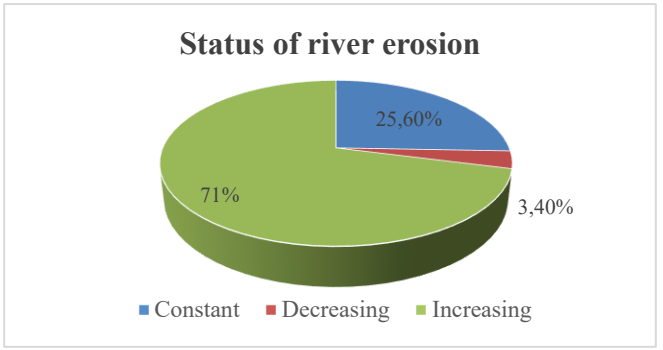
- Poor solid waste management: 90% waste remains >1 week at collection points.
- 99.8% use onsite sanitation; 43.6% pit latrines (GHG sources).
- 85% use biomass fuels for cooking; some kerosene/gas usage.
- Limited automobile/generator ownership but 2-stroke engines emit pollutants.

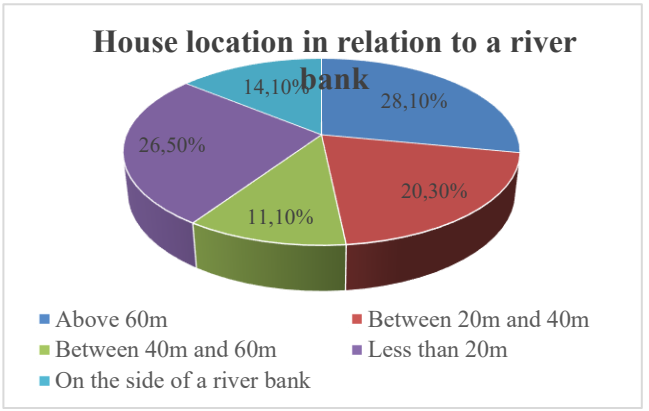


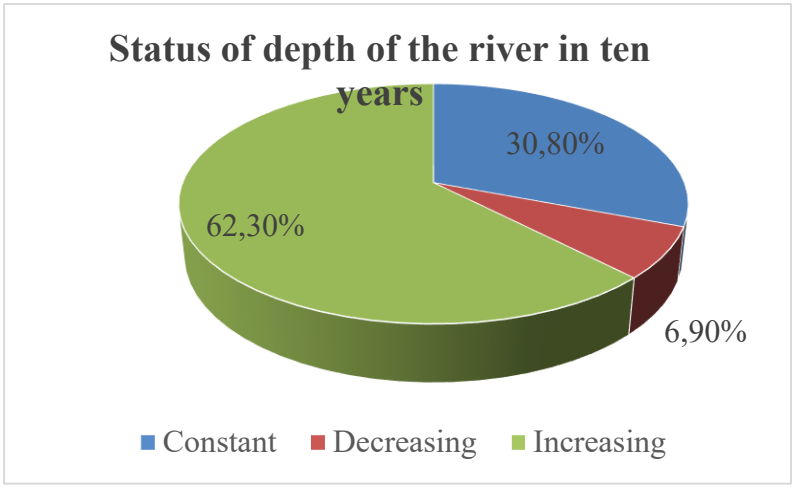


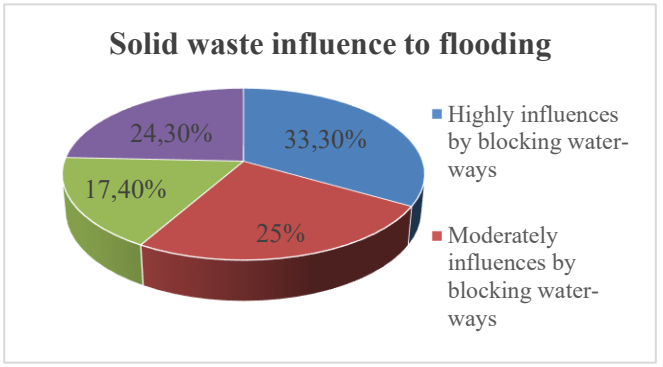
Results – Flooding Contributors

- Increased river depths due to erosion; overflow risk.
- 72% of houses within restricted 60m river buffer.
- 82% believe poor waste disposal worsens flooding.
- 75% do not harvest rainwater, increasing runoff.









Pollution Indices and Spatial Distribution

Heat Pollution Index (HPI):

- The average HPI was 53.75 indicating poor environmental quality.
- This is aggrevated by Use of onsite sanitation system, inadequate and/ delayed solid waste collection, inadequate green spaces, and use of building material that retain heat

Air Pollution Index (API):

- The average API is 44.5 indicating good environmental quality
- However, the use of biomass as major source of energy for cooking, and the dominance of onsite sanitation facilities contributes to air pollution in the area

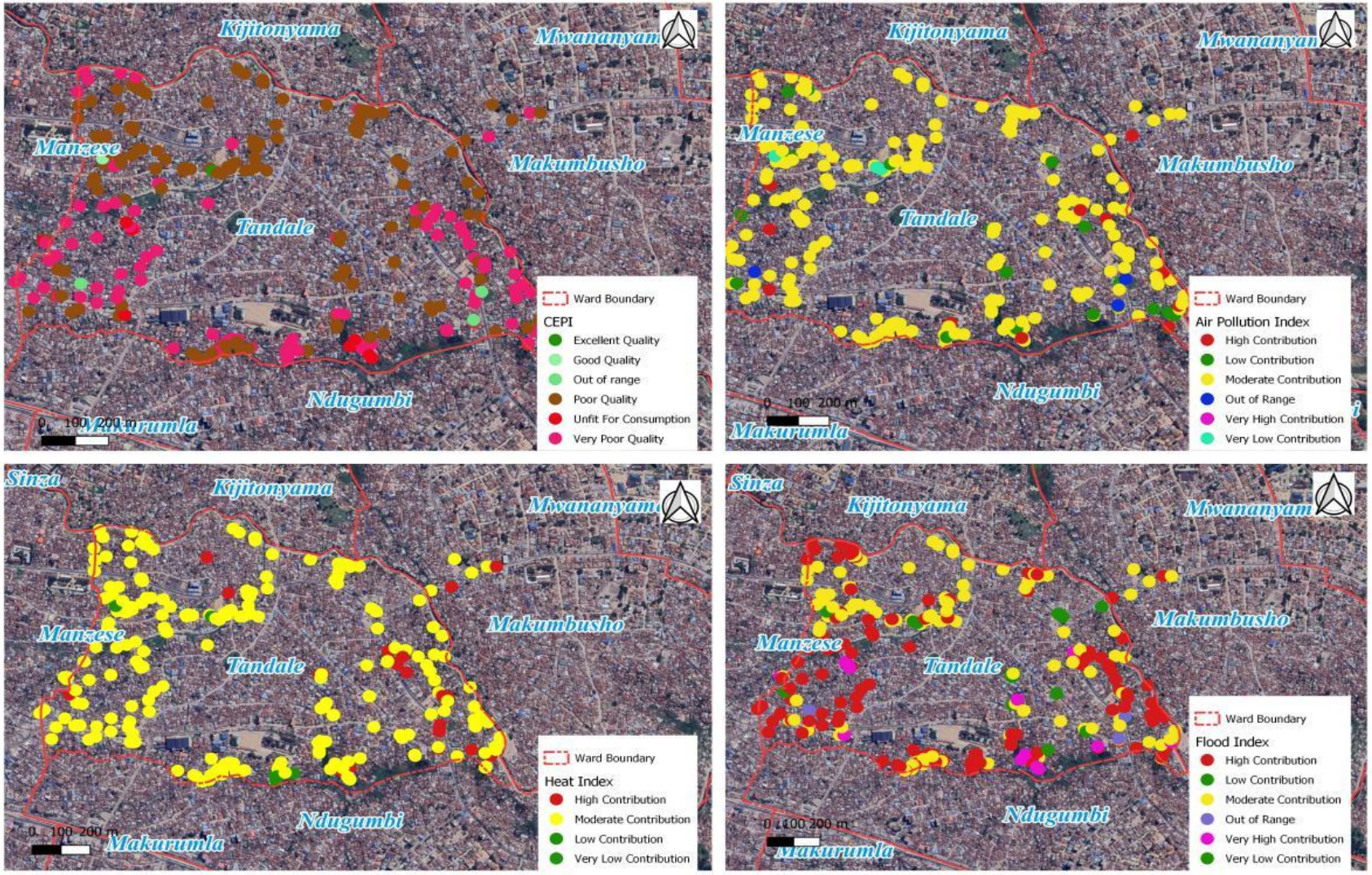
Pollution Indices and Spatial Distribution

Flood Pollution Index (FPI):

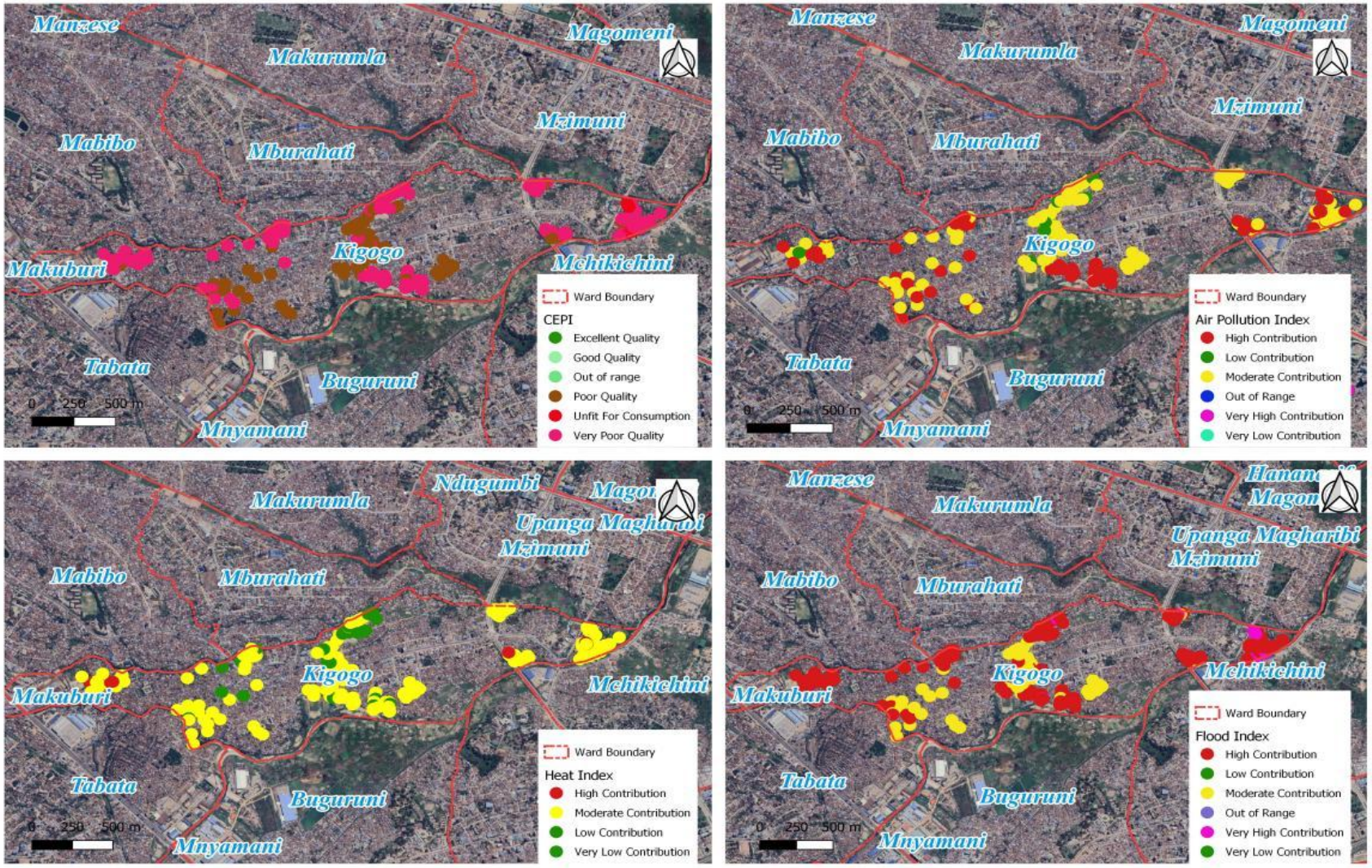
- The average FPI is 60, indicating poor environmental quality
- This is contributed by most houses location in low laying areas and close/besides river banks, high river erosion, disposal of solid waste in water ways, and poorly functioning drainage systems

Comprehensive Environmental Pollution Index (CEPI):

- CEPI average: 2.4 (56.9%) – indicates poor environmental quality. Generally caused be flood and heat stressors
- Tandale: moderate-high contributions to all stressors.
- Kigogo: high flooding, moderate air pollution, lower heat stress



Spatial distribution of heat stress, air pollution, flooding indices and the Comprehensive Pollution Index for Tandale



Spatial distribution of heat stress, air pollution, flooding indices and the Comprehensive Pollution Index for Kigogo

Discussion – Key Insights

- Multiple environmental stressors co-exist, intensifying vulnerability.
- CEPI provides a composite measure for household-level environmental stress.
- Spatial analysis identifies hotspots for targeted interventions.
- Need for integrated, multi-sectoral policy responses.

Proposed Adaptation Mechanisms

- Increase green spaces, use reflective roofing materials.
- Promote cleaner cooking fuels and proper waste disposal.
- Upgrade and maintain drainage systems; implement Early Warning Systems.
- Construct flood-resilient infrastructure.

Conclusions

- Tandale and Kigogo face moderate to high environmental stress.
- Flooding and heat stress are major concerns; air pollution stress varies by area.
- Systemic urban challenges exacerbate risks.
- Integrated and participatory solutions required.