The role of urban design in enhancing the microclimate and thermal comfort in warm-humid Dar es Salaam, Tanzania

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Introduction

• In developing countries, the rapid urbanization generates a mixture of regular and irregular housing areas with different urban design patterns. This complexity of different urban forms and building densities affects the microclimate and thermal comfort in the related area.

• In the warm-humid city of Dar es Salaam which is considered as one of the fastest growing cities in the world.
• The poor planning has led to different characters of low, mid and high-rise zones in the city.
Introduction

In the latest Urban planning regulations (2012), different urban forms were applied (high-rise and low-rise buildings) with different building densities.

However, the consideration of microclimate and outdoor thermal comfort in urban design and planning regulations has received little attention although the urban planning authorities try to develop the quality of planning and design.

The aim of this paper is to investigate the relationship between urban design, urban microclimate and outdoor comfort in four different areas in the city of Dar es Salaam, during the wet and dry seasons.
Methodology

This investigation is mainly based on microclimate simulations using ENVI-met 3.1 and different existing urban morphologies are climatically and thermally studied including low, medium and high rise buildings.

The studied parameters are:
- Mean Radiant Temperature (MRT)
- wind speed
- Physiological Equivalent Temperature index (PET)
- Sky View Factor (SVF)

Simulation month: mainly in February (28th). But also a complementary simulation in July (15th).

Hour of focus: 14:00 local time where MRT and Ta are at the maximum.
Methodology - Studied areas

Kariakoo  City Center  Manzese  Upanga
Results: Mean radiant temperature

Mean Radiant Temperature
- unter 34 C
- 34 bis 37 C
- 37 bis 41 C
- 41 bis 44 C
- 44 bis 48 C
- 48 bis 51 C
- 51 bis 55 C
- 55 bis 58 C
- 58 bis 62 C
- über 62 C
Results: Wind speed

- Kariakoo: 0.30 m/s, 0.50 m/s, 0.70 m/s, 0.90 m/s, 1.10 m/s, 1.30 m/s, 1.50 m/s, 1.70 m/s, 1.90 m/s
- City Center: 0.30 m/s, 0.50 m/s, 0.70 m/s, 0.90 m/s, 1.10 m/s, 1.30 m/s, 1.50 m/s, 1.70 m/s, 1.90 m/s
- Manzese: 0.30 m/s, 0.50 m/s, 0.70 m/s, 0.90 m/s, 1.10 m/s, 1.30 m/s, 1.50 m/s, 1.70 m/s, 1.90 m/s
- Upanga: 0.30 m/s, 0.50 m/s, 0.70 m/s, 0.90 m/s, 1.10 m/s, 1.30 m/s, 1.50 m/s, 1.70 m/s, 1.90 m/s

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Results: PET

[Color scale with temperatures from 32°C to 50°C]

- Upanga (February)
- Upanga (July)
Results: SVF, MRT and Vegetation

The relationship between SVF and MRT for the four studied areas in February at 14:00 LT
Conclusion

1. The MRT values at the spaces between buildings tend to be lower than at the streets due to the compact urban morphologies with high buildings that provide shading. Therefore, it is highly recommended to consider the microclimate street design as a part of urban planning regulation in the city.

2. The study showed the positive effect of the combination of geometries and trees regarding the shade. Thus, such combination is strongly recommended to have different solutions to provide shade.

3. Manzese and Upanga are slightly more ventilated due to the low building heights as well as the street orientation towards the prevailing wind. City center is better than Kariakoo because the spaces between buildings are wider. Therefore, orienting the streets towards the breeze wind direction (with wide corridors) has definitely a positive effect to ventilating the urban areas.

4. Regarding the thermal comfort, the month July is more comfortable than February (a difference of 4 °C was recorded as an average value in the urban spaces of Upanga.

5. The relationship between SVF and MRT is strongly significant when detached geometries are investigated without vegetation, whereas this relationship is less significant when the vegetation is taken into account.
Future studies

• The redevelopment schemes of the city centre and Oyster Bay will also be evaluated.
• A more profound analysis including the effect of H/W ratio, material properties and type of vegetation.
• Effect of changing street orientation and widening of streets.
• Thermal comfort indices such as PET and/or UTCI will be calculated.
Thank you very much....