

Effect of densification on outdoor thermal comfort in warm-humid Dar es Salaam, Tanzania



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About the project

 Ongoing cooperation between Housing Development &



- Management, Lund University & Urban Climate Group, Gothenburg University
- Local cooperation, Dar es Salaam:
 - Ardhi University
 - Ministry of Lands, Housing and Human Settlements Development
 - Dar es Salaam City Council

Dar es Salaam, Tanzania

- Latitude: 7^oS
- Largest city in Tanzania with over 4 millions in the metropolitan area



- Annual growth of 4.4%
- 70% informal (unplanned) neighbourhoods

Variation of urban design













Solar radiation in Dar es Salaam, Tanzania



Urban renewal in Dar es Salaam

- Current urban development lack adequate urban planning standards
- Redevelopment schemes were introduced 2000
- Their aim:
 - Densification more efficient land use in a controlled way
 - Guidelines to assist urban planners and managers in preparing, controlling and coordinating urban renewal processes

Examples of redevelopment schemes

- Kariakoo (dense, low to high-rise, no vegetation)
- Upanga (dispersed, low-rise, plenty of vegetation)



Methods

- Field measurements
 - Wind speed & direction
 - Direct and diffuse radiation -
 - Air temperature & Relative humidity
- Computer simulations
 - ENVI-met 3.1







ENVI-met models of the areas





Kariakoo

Upanga

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Simulated T_{mrt} at 12:00



Kariakoo

Upanga

Simulated wind speed, Kariakoo



Simulated wind speed, Upanga



Conclusions

- Increased building heights have a positive effect regarding shade
- The octagonal street pattern in Kariakoo is oriented according to the prevailing wind directions
- Increased density leads to decreased wind speeds, especially in Kariakoo



Closely spaced buildings in Kariakoo

Conclusions (cont.)

- In Upanga the buildings in the north-east of the area tend to block the north-easterly winds during the warmest part of the year (February – March).
- Suggested improvements (both areas):
 - Introduce a variation in building height which would stimulate downwash of wind to pedestrian level.
 - Try to create wind corridors in the prevailing wind directions to increase ventilation
 - Increase setbacks between buildings



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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.

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ENVI-met: input data

Parameter	Value
Wind speed in 10 m above ground	1.5 m/s
Wind direction	SSW
Initial temperature of the atmosphere	301 K
Specific humidity at 2500 m	18 g/kg
Initial relative humidity at 2 m	90%
Fraction of low/medium/high clouds	2/2/2 oktas
Albedo of facades	0.5
Albedo of the ground: pavement/roads	0.2/0.4

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Overhead shading of walkways and streets





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Use of vegetation





Future studies

To improve ventilation:



- Increase space between buildings
- Buildings raised on stilts
- Varying building height



Calculation of thermal comfort

- Air temperature
- Mean radiant temperature
- Wind speed
- Relative humidity

Physiologically equivalent temperature (PET)

Consequences of poor microclimate

- Decreased mental and physical performance
- More heat strokes, heart problems etc
- Increased energy use (air conditioning)



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Poor urban design: less possibilities to use outdoor space

- Less social activities
- Less commercial activities (cafés, restaurants, etc)



Vegetation shading the street



Consequences of poor thermal comfort

- Efficiency:
 - Decreased mental performance
 - Decreased physical performance
- Health:
 - Heat strokes (heat)
 - Heart diseases (heat)
 - Dehydration (heat)
 - Frostbite (cold)

Psycho-physiological aspects

- Acclimatization:
 - Changes in the thermoregulatory system of the body (days, weeks)
- Behavioural adaptation:
 - Adjustment of clothing
 - Opening/closing windows
- Psychological factors:
 - Expectations
 - Thermal history

The role of urban planning regulations

- Rules stipulate:
 - Maximum building heights
 - Minimum street widths
 - Minimum setbacks
- These rules encourage:
 - Solar access around buildings
 - Daylight in buildings

Current rules are poorly adapted to the local climate







