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Publication date:
2009

Citation for published version (Harvard):
Emmanuel, R 2009, 'Sustainable urbanity and urban climate change: amelioration of UHI's as a quality-of-life agenda for tropical megacities', Paper presented at 7th International Conference on Urban Climate (ICUC7), Yokohama, Japan, 29/06/09 - 3/07/09.

SUSTAINABLE URBANITY AND URBAN CLIMATE CHANGE: AMELIORATION OF UHI'S AS A QUALITY-OF-LIFE AGENDA FOR TROPICAL MEGA-CITIES

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Abstract

The urban heat island effect exemplifies the pressing environmental problems facing rapidly growing tropical mega-cities. These cities are doubly disadvantaged due to the already oppressive heat made worse by the deteriorating urban climate and, being largely cities of the developing world, they lack financial resources and political will to re-direct urban growth towards a qualitatively more favorable outcome. A planning approach to ameliorate the urban climate change offers a tangible starting point for action that enhances the quality-of-life of urban dwellers which in turn may set the stage for greater receptivity to global change action.

Key words: urban sustainability, urban design, tropical cities

1. INTRODUCTION

There are strong incentives now for climate-sensitive design and planning, and these emanate not only from a concern for energy efficiency and sustainability, but also "good design" (CABE, 2002). The late 20th century trend of "*design whatever the client wants, mostly on the basis of cost or aesthetics*" (Butler, 2008) is an aberration, in historical terms, and is not likely to hold much traction in our '*ecological age*' (Head, 2008). At the same time, climate-sensitive design itself is becoming more difficult in the face of changing urban climate. This is especially problematic in the urban tropics, which are doubly disadvantaged on account of the already oppressive heat being made worse by the deteriorating urban climate and the lack of financial resources and political will to re-direct urban growth towards more favorable outcome. The worsening microclimate casts doubt on the efficacy of tropical design ethos of open buildings with fuzzy demaracation between the inside and the out.

2. CLIMATE SENSITIVE DESIGN IN THE TROPICS – WHAT WE KNOW

The year round negative effects of urban heat islands in the topics include nighttime warming, an unintended mix of "cool" and "warm" patches during the day, weakening wind speeds and significant alterations to wind direction, increased amounts of moisture adding to thermal discomfort and changes to frequency and intensity of precipitation. Contextually, the region is known for abundant rainfall, near constant temperatures, seasonality in wind speed and direction, and high humidity. Design response that takes into account the altered local climate and the contextual realities of the tropics usually take one of three forms.

2.1 Promotion of urban ventilation

Increasing wind penetration to enhance the thermal comfort of pedestrians in warm climates is exemplified by Ng's work in Hong Kong (Ng et al. 2006; Ng, 2009). This approach relies on Air Ventilation Assessment (AVA) – a protocol for weak wind design. AVA is based on the "Wind Velocity Ratio" (VR_w), between pedestrian level (2m above ground) and the top of the boundary layer, as weighted for wind direction. Ng et al. (2004) has suggested a four-step procedure including: 1) initial performance-based evaluation, 2) development of an urban climatic map identifying wind "hot spots" and resources that need to be preserved, 3) performance-based evaluation (with the aid of wind tunnel tests and numerical models) establishing performance standards, and 4) quantitative guidelines for use at the individual project level.

2.2 Promotion of urban shade

Since the principal design requirement in hot,humid regions is shelter (Lin 2009), the aim of this approach is to shade urban public spaces during thermally critical times of day, by manipulating urban geometry (height and width of buildings, building and street orientation and street width) to enhance shading of public spaces. The approach is exemplified by the "*shadow umbrella*" concept (Emmanuel 1993; 2005), where the critical starting point is to establish the shadow angles. These angles vary by location (latitude), time of day, and orientation. The goal is to seek an urban geometry that is self-shading of its interstitial spaces without compromising buildings' ability to draw in the sunlight as and when needed. Due to high zenith angles in the tropics an intelligent combination of building heights and geometry together with horizontal shading elements such as canopies, awnings and urban vegetation is needed. Once the shading is thoughtfully arranged the cooling potential of wind can be enhanced, bringing in double benefits of high density living with enhanced cooling from urban winds.

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The design ques for urban shading needs to be tempered with consideration of the monsoonal wind pattern, typical dimensions of city blocks in a given city and its activity patterns. In the case of an equatorial city, Lam et al. (2008) found the "ideal" proportion (W:L:H) of a shaded urban volume to be 1:1.5-2:0.27-0.5. Another approach is to place tall towers strategically, with a view to reducing street canyon temperature by shading while simultaneously inducing pedestrian-level air flow (Priyadarsini et al., 2008)

2.3 Strategies based on urban vegetation

Tropical cities are naturally green: Bangkok has 11.8m^2 of green space per capita (Thaiutsa et al., 2008); Singapore - 10m^2 (Chow and Roth, 2006); Beijing - 6 m^2 (Dembner, 1993) as opposed to sub-tropical cities such as Mexico City - 1.9 m^2 (Deloya, 1993); New Delhi - 0.12 m^2 (Kuchelmeister, 1998) (the WHO-recommended minimum green cover is 9 m^2 per capita, Deloya, 1993, quoted by Thaiutsa et al., 2008). Excessive rainfall makes urban vegetation an attractive UHI mitigation option, even in high density cities:

"Green roofs" – Due to high zenith angles, the single most thermally active building surface in the tropics is the roof. Any reduction in its contribution to urban warming will help reduce not only the heat island effect but also energy consumption for space cooling, which in turn will lead to lower anthropogenic waste heat (and further lowering of urban warming). Green roofs are a major part of UHI mitigation strategies in other climatic regions as well (Bass and Krayenhoff, 2002), with notable planning and legal provisions already in place in Tokyo and Chicago (Onmura et al., 2001). In addition to their positive contribution to heat island mitigation, green roofs enhance thermal comfort by insulating buildings (Kumar and Kaushik, 2005), improving air quality (Rosenfeld et al. 1998), reducing storm water runoff intensity (Carter and Jackson, 2007; Mentens et al., 2006), improving run-off water quality (Köhler et al., 2002) and creating new habitat for wildlife (Brenneisen, 2003). These benefits, together with the thermal protection that a vegetation layer offers to the roof insulation, make green roofs highly valuable during their life cycle (Kosareo and Ries, 2007; Wong et al., 2003; Saiz et al., 2006), compared to flat roofs in the tropics.

"Street greening" – Although tropical cities are still relatively green, urban pressure on street trees is immense. At the same time, a cooling strategy based on urban greening can work in the tropics on account of the abundance of water availability and high humidity combined with year-round warm temperatures. In addition to their thermal benefits, street trees are also useful for removing pollutants from the air and for absorbing carbon dioxide, giving off oxygen, and relieving human stress. Additionally, street trees modulate run-off intensity during storms, thus helping modulate urban flood events. During periods of heat stress, there is evidence that urban greenery provides a feeling of psychological wellness (Lafortezza et al., 2009).

3. THE WAY FORWARD: AMELIORATION AS A QUALITY-OF-LIFE AGENDA

The emergenece of the above outlined strategies to ameliorate the urban heat island problem in the tropics makes the present moment an opportune time to explore the way forward. Three factors need to be taken into account in devising the way forward. First, tropical megacities have a myriad of environmental problems but the principal physical environmental issues have to do with air (air pollution), water (floods and storms) and climate quality (heat waves) (Campbell-Lendrum and Corvalan, 2007), likely in that order of diminishing importance. A redeeming feature is that the causes for their deterioration often have links to one another. Urban planners will therefore need a practical and unifying starting point for action to adapt to the rapid environmental changes. Second, the development path traduced by human civilisation to-date make it almost inevitable that population growth and urbanization in the developing world (much of which is in the tropics) will continue at their current rapid pace of expansion for the forseeable future. Massive amounts of new build is therefore necessary (China's housing sector alone accounted for 40% of global new building volume in 2007 – Fernandez, 2007). It is necessary to ensure new construction in the developing world employs the most efficient building methods and technologies possible (Rees, 2009). Third, only a tiny fraction of the building stock in developing countries have professional design input and the situation is likely to get worse with increasing demand. Thus it is necessary to concentrate on getting the context (i.e. the urban fabric) right, so that individual buildings have the possibility to achieve their maximum environmental potential with or without professional input.

Based on what we know of the tropical urban climate anomaly and the factors outlined above, it is possible to delieneate a way forward for climate-sensitive urban design and planning in the tropics. It is argued that amelioration of urban heat island effect has the ability to capture citizen's imagination by way of illuminating the direct connection between human action and physical environmental change. It is possible to piggyback urban and neighborhood development/regeneration actions on UHI ameliration for greater public acceptability and active support. The amelioration of UHI effect not only tackles the unintended climatic consequences of urbanization but also address sustainability in a tangible and resource-efficient manner to enhance the quality-of-life of urban dwellers, as recognised by the *SmartGrowth* movement in the USA (US EPA, 2001).

The net effect of urban climate changes super-imposed on regional changes in tropical cities is the increasing need for building cooling energy. Planning strategies that address urban climate change can not only enhance the urban energy efficiency but also reduce the national and even regional carbon footprint. The city is local enough of an arena for local political action to have meaningful environmental impacts yet large enough to make a difference to the global problem. Additionally the amelioration of urban heat island problem has synergies with sustainable urban transportation solutions. Often the transportation ills that arise out of haphazard urban form also contributes to the UHI effect.

3.1 A vision for sustainable urbanity in the tropics

In the rapidly growing urban tropics the essential features of an approach to tropical urban climate amelioration will include high-density development with low vehicular traffic, high greenery and well ventilated urban form organically grown from within the constraints of existing city structures. This needs to be sold to city authorities as a unifying action plan to tackle physical environmental change. It needs to be marketed to urban stakeholders as part of an effort to create healthy places. "*Healthy places need to be more than free of toxic exposures; they need to be well designed, well built, attractive, and functional for all people who live, work, learn, and play in them*" (Frumkin, 2005). Good design cannot ignore climate and it is in here that we find "*clear opportunities for simultaneously improving health and cutting greenhouse gas emissions most obviously through policies related to transport systems, urban planning, building regulations and household energy supply*" (Campbell-Lendrum and Corvalan, 2007).

3.2 Operationalization of UHI amelioration in the tropics

Urban development is piece-meal and occurs over an extended peiriod of time, under the influence of several actors and across several urban adminsitrations. A convincing narrative is therefore needed to sustain the growth in a manner conducive to positive QoL. UHI amelioration provides such an approach. A critical metric to ensure continuity of vision is to use a new yardstick based on climate change potential, termed here as the Urban Climate Change Potential (UCCP). The UCCP is the measure of the likely local climate effects of a proposed urban physical developmental action. In so far as is practicable, the numerous social, economic and environmental measures needed for sustainable urban development should be converted to physical climatic effects and expressed in terms of UCCP. The UCCP offers not only an integrated metric but also leads to something easily understood by all stakeholders in an environment already too hot for comfort. It has the advantage of being applicable to physical infrastructure development at all stages, be it building construction, transportation development, urban green enhancement, water-front development or urban regeneration. In operational terms, the following outline is suggested as the broad outlines of such actions in the tropics:

* An AVA be made mandatory for all neighborhood and city-wide planning efforts
* Urban densification with the aim of increasing street-level shading be the principal planning goal
* Street-level vegetation be part of the design template
* Contiguous shading of public realm should drive urban regeneration efforts
* Design for walking (i.e. re-configuration of street network to faciliate shaded pedestrian movement independent of paths for vehicular movement
* Use of harvested rainwater as climate-tempering agent

Since climate change agenda is now at the center of public consciousness, amelioration of UHI provides a local narrative within which strategies for the enhancement of urban quality-of-life can find acceptance and even active support. A political difficulty with action against global climate change is the inability to see results in the here and now. This is further confounded by weak science in terms of cause and effect. Tackling the urban climate change on the oher hand, offers immediate and tangible benfits since the negative consequences of haphazard urbanization is plain to see. Herein lies a possibility to marry both adaptive and mitigatory action at the local scale where the benefits are immediate and local (and therefore politically feasible), while contributing over an extended period of time, to the global efforts at adapting to climate change. Rapidly growing tropical cities need to play this role now before the local climate turns irreversibly intolerable. In the face of global climate change, this will also give tropical cities a leg-up in the two-way knowledge transfer (between the developed and developing worlds) of experiential awareness and local action for living in a warming world.

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