



Performance standard for tropical outdoors: A proposal in a time of climate change

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1. Introduction

Unusual (>3 standard deviations [SD] above the base climate of 1951-1980) and unprecedented (>5 SD) heat extremes are expected to be the norm in much of Asia and Africa in the near term even as these regions undergo transformational social and economic change (IPCC, 2013). The most populous parts of these continents are within the Tropical belt. Consequently, tropical cooling load – much of which is currently latent due to low levels of economic development – is likely to be the dominant category of global energy demand. Yet, deep technological developments and efficiency improvements in cooling systems are yet to be achieved. To make matters worse, contemporary cultural practices and attitudes limit adaptive possibilities to warmer temperatures as the improving socioeconomic conditions lead to ‘thermal indulgence.’ One likely outcome of these developments is an unrealistic thermal comfort expectation in the tropics that is in direct conflict with the ‘global good’ of low/zero carbon economy. A compromise has to be reached based on societal priorities to ensure low energy expenditure without confining tropical dwellers to an ‘inferior’ thermal comfort.

2. Background

While the general global climatic trend is towards a warmer future, regional variations are particularly problematic in the tropics. Irrespective of the future emission paths South and Southeast Asia will experience unprecedented heat extremes while Central and Sub-Saharan Africa will experience extreme heat and drought even under moderate (<2°C increase in global average temperature) global warming scenario (Schellnhuber, et al., 2013). Reduction in cold days (Yan et al., 2002), increase in both cold and warm tails (Klein Tank et al., 2006), significant increases in the annual number of hot days and warm nights, decreases in cold days and cold nights (Manton et al., 2001; Griffiths et al., 2005) and increases in warm extremes were all likely in much of Asia and Africa.

Much of the climate change risks are concentrated in urban areas. These include rising sea levels and storm surges, heat stress, extreme precipitation, inland and coastal flooding, landslides, drought, increased aridity, water scarcity and air pollution (Revi, et al., 2014). Given the current level of urban growth and the concentration of populations involved, climate change will interact with the urban risks in a variety of ways, some of which will exacerbate the level of climate risk (IPCC, 2013). Furthermore, there are health inequalities, especially in developing cities that are further exacerbated by urban warming (cf. Campbell-Lendrum and Corvalán, 2007).

However, research on the augmentation of climate change effects by local urban warming (characterised by urban heat islands) remains weak. Initially, even the Intergovernmental Panel on Climate Change (IPCC) overlooked the role of cities both as a forcing factor as well as a key stakeholder in managing climate change (Hebbert and Jankovic, 2013). Even when the role of cities in what is termed as the ‘transformative adaptation’ is acknowledged (as in IPCC’s 5th Assessment Report, cf. Revi et al., 2014) strategies to tackle local warming barely gets a mention. Additionally, translating future climate change projections at finer spatial scales relevant to cities typically use statistical downscaling techniques to global climate models without modelling the urban areas themselves (Lemonsu et al., 2013). Although the situation is continuing to improve much more still need to be done to (a) ameliorate the urban heat island (UHI) effect and (b) use UHI mitigation as part of climate change adaptation (Emmanuel and Loconsole, 2015).

The amelioration of the heat island effect in the urban tropics is particularly weak. On the one hand, knowledge of tropical heat islands remains patchy and numerically weak (cf. Hung et al., 2006; Roth, 2007). On the other, the proliferation of strategies focusing on heating-only climates (or the dual-mode heating-and-cooling load climates) do not readily translate to cooling-only (or, soon-to-be cooling-only) regions.

2.1 Uniqueness of cooling load

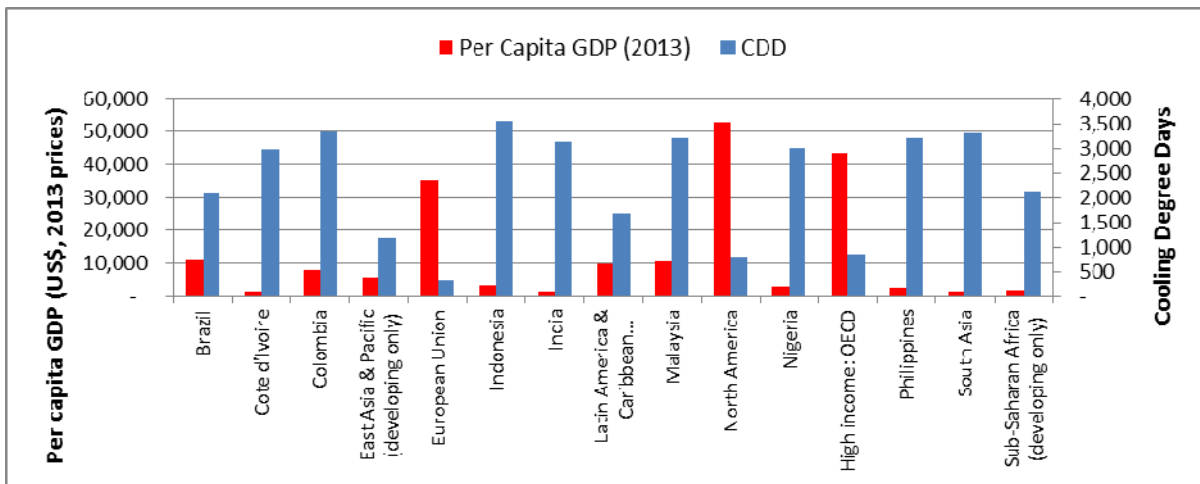


Figure 1 Income vs cooling load comparison (Source: Emmanuel, 2015)

The task of cooling is very different from the act of heating due to physical, social and economic reasons. A key difference between heating and cooling is in the respective load structure. Cooling requires the tackling of the increases in both the sensible as well as the latent loads (Kalveleage et al., 2014). Secondly, increased use of air conditioning in a warming world will only make the urban situation worse. A recent study in Malaysia found that every 1°C increment in outdoor temperature will cause a 2% drop in the coefficient of performance of split-type air conditioners (Yau and Pean 2014). This is in sharp contrast to heating in urban areas, where, wasted heat tends to reduce the heating load for surrounding buildings (Futcher, 2013). The current increase in temperature due to air conditioner use was estimated to be 0.5°C but could be up to 2°C if the air conditioner use is to double (de Munck et al., 2013: 210).

Thirdly, even when run on fossil fuels, heating could be provided by a variety of fuels (gas, oil, etc.) that have lower carbon footprints than electricity (especially coal-fired electricity) which is the predominant source of power for most air conditioners. Thus, even a small increase in cooling load could vastly inflate global carbon emissions.

Fourth, much of the global heating demand is already manifest while much of the cooling demand is still latent. Üрге-Vorsatz et al., (2015) found that regions dominated by heating load will see reduced or stagnant growth in energy use while warm regions dominated by cooling load will see exponential increase in cooling loads (see Figure 1 and Table 1). This will be further exacerbated by trends within countries with heating and cooling demand – for example, USA (Kalveleage et al., 2014) where heating demand is expected to decrease while cooling demand will soar. Currently heating load dominated countries too, are also expected to have significant cooling loads in the coming decades.

Table 1 Trends on global space heating and cooling demand (Source: Üрге-Vorsatz et al., 2015)

	2010	2020	2030	2040	2050
Pacific OECD¹	126.1	122.4	119.1	116.0	113.4
N America	147.5	138.4	131.0	124.9	119.7
W Europe	128.3	123.1	118.4	114.2	110.4
Central & E Europe	152.6	148.1	144.8	141.8	139.1
Former Soviet Union	205.1	198.4	194.5	191.6	189.0
Latin America	63.3	60.2	59.5	59.3	59.6
Sub-Saharan Africa	56.2	53.4	52.9	53.0	53.4
Middle East and N Africa	55.6	55.1	56.0	57.4	58.0
Centrally Planned Asia²	37.4	41.2	43.8	46.8	47.5
South Asia	60.1	77.1	85.0	89.2	88.2
Other Pacific Asia³	46.4	45.5	45.6	45.9	46.5

Finally, cooling itself is potentially more harmful from a global warming perspective than heating in that the refrigerants used in the process (mostly hydro-fluorocarbons – HFCs) have greater global warming potential than CO₂. Thus, any leakage in the system could be a direct contributor to global warming as opposed to heating where no such danger exists (Cox, 2012).

While the physics and the practicalities are more complex than heating, cooling – especially the mechanised variety – is also harder to divest of, given its social construct. The comfort of 'coolth' is often seen as a sign of progress, initially a sign of luxury but eventually, the fulfilment of desire. Heating does not have this association with 'luxury' since warmth was always seen as a primordial need (cf. Sivak, 2009).

2.2 Current impasse in climate-sensitive design in the tropics

In spite of the changes to tropical climate both at global/regional level as well as at city level there is little evidence that climate sensitive design has received any greater attention than it had ever had. Three broad categories of barriers need to be overcome if we are to enhance the reputation of climate-sensitive design and take its development further: technical, institutional and cultural.

a. Technical

Our ability to provide passive (i.e. without the use of energy) adaptive opportunities at temperatures tropical dwellers expect, is steadily diminishing. This is so even if we are able to provide maximum adjustability. Herein lies the crux of the technical problem: the tropics (especially the urban tropics) have warmed to an extent that passive, building-level strategies to tackle it have been more or less exhausted. The ability of traditional approaches to climate-sensitive design appears less effective under a changing and extreme climate (Nguyen et al., 2011). In other words, the technical requirements of climate-sensitive design are approaching the impossible in the tropics, as the background climate continues to warm. We need agreement on the 'what' (i.e. the scope) of climate-sensitive design.

b. Institutional/governance issues

Equally importantly, the 'how' of climate sensitive design, too, needs attention. Urban design, unlike the design of individual buildings and areas, concern that which belongs to all and is therefore subject to the 'tragedy of the commons' (Hardin, 1968). The promotion of good urban design therefore needs strong institutional underpinning. On its own, climate sensitive design lacks the clout and capacity to grab and hold the attention of key decision makers. This is especially the case in tropical cities where the problem of overcrowding and the more immediate risks associated with climate-change (such as flooding, coastal erosion, dust storms and drought) are ever more pressing. The embedding of climate sensitive design into everyday planning decisions will be important to success. Climate-sensitive planning needs to be linked to broader agendas such as poverty alleviation, economic development and urban regeneration.

Furthermore, innovative institutional arrangements are needed to link on-the-ground scientific expertise to the needs and requirements of local decision-makers at city level (cf. Rosenzweig et al., 2010). In this connection the governance arrangements in cities too needs consideration: who will champion climate-sensitive design? Whose priorities are dominant in urban contexts; and what are the implications of this to climate sensitive design? Finally, how 'autonomous' are cities in being able to chart their own adaptation destiny?

c. Cultural barriers

Perhaps the greatest challenge to climate-sensitive design in the tropics is cultural. Openness to passive climate sensitive design depends on the socioeconomic status. Those who can afford the energy expenditure (on air conditioning, for example) tend to be 'thermally indulgent' to the point of low tolerance for thermal displeasure (Indraganti, 2010a). Additionally, cultural practices and preferences/attitudes lead to "restrained adaptive opportunity" (Indraganti, 2010b). An immersion in greater comfort (i.e. greater pleasure) appears to hyper-sensitize us to a point of inability to cope with natural variations in temperature. While the use of air conditioning undoubtedly leads to 'superior' comfort (and is a 'birthright' of all tropical dwellers!) it also diminishes the coping mechanisms of tropical dwellers.

Climate-sensitive design could help, but, unfortunately it had hitherto largely remained an elite project in the tropics, where the vast majority of buildings continue to be relegated to the intolerable-to-barely-passable margins. No context exists for the enjoyment of an otherwise pleasant climate by a majority of citizens.

3. Where do we go from here?

It is said that thermal comfort (in temperate climates) needs to be 're-contextualised' in light of climate change (Cole et al., 2008). This often means a more inclusive, inhabitant-controlled, flexible notion of thermal comfort that allows for 'inhabitant agency' (Cole, et al., 2008) but questions remain as to its applicability in the high-density, rapidly growing and generally resource-poor urban tropics. The nature of tropical thermal comfort, especially in light of changing urban climate, is not always achievable even with 'inhabitant agency,' at least not most of the time. What therefore must we do in the tropics?

It is proposed that the changing tropical climate, especially in the cities could only be made comfortable (and places for human thriving) by climatizing the urban realm. We do not expect that doing so will eliminate the need for air conditioning. Far from it; climate-sensitive urban design is a crucial enabler of outdoor living, even in the face of climate change. This could create the condition for alternate ways of enhancing urban quality of life while individual buildings may or may not need additional coolth.

This endeavor is wider than what a planning or an urban design remit would allow. We need a new way of *being*, which has implications to the way tropical dwellers perceive clothing, furniture, food and indeed their bodies. While this is far too wide a subject that could be covered here, we propose three ideas that are crucial to the achievement of thermal comfort in the tropics as a starting point for climate-sensitive design:

Reformulation of thermal pleasure in the tropics
Linking the 'in' and the 'out'
Adaptive opportunities varied by activity patterns

3.1 Reformulation of thermal pleasure in the tropics

There is anecdotal as well as increasingly sophisticated socio-technical evidence that those tropical dwellers used to air conditioned way of life experience both physiological as well as cultural changes that makes the toleration of tropical climates all but impossible.

This calls for a reformulation of thermal pleasure in the tropics. Thermal pleasure in a hot environment is very different to that in a cold environment: coolness is only 'skin deep' (i.e. we feel evaporative and convective cooling on the surface of the skin, as opposed to warmth, which is internal – cf. Heschong, 1979). It is also about calming the senses in a highly- (almost over-) simulated environment where deep shade, vegetation, water all play a role in creating a serene and calming effect

At the heart of this formulation of thermal pleasure is an urban asymmetrical thermal environment dominated by cool spots that enables greater enjoyment of the outdoors, thus enabling low-energy cooling in the indoors. An urban asymmetrical thermal environment could be achieved in a number of different ways, all aiming to create climatically 'cool' urban public spaces:

- Partially shaded pathways
- Strategically placed and adequate vegetation cover
- Water misting

a. Shaded pathways

The key to cool asymmetry in the public realm is to mix shade and light. This could be achieved by mandating minimum arcade cover around public buildings (e.g. 75% in Havana, Cuba) or regular shade intrusion on pedestrian streets (say, minimum 10m wide shade/rain structures @ every 100 m – Brisbane, Australia).



Figure 2 Shaded pathways

b. Vegetative cover

Tropical cities are naturally green. Excessive rainfall makes urban vegetation an attractive UHI mitigation option, even in high density cities. However, 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.



Figure 3 Urban green cover: (left) Green cover in Porto Alegre, Brazil, (right) Brisbane's South Bank Parklands

c. Water misting

Evaporative cooling (water misting) has been employed as an outdoor cooling strategy for a number of years in hot, dry climates (Pearlmutter, et al., 1996). However, there is increasing evidence that such an approach

could be successfully adapted to sub-tropical and even tropical areas experiencing severe urban heat island effects to provide instant cooling in the outdoors (Farnham et al., 2015).

3.2 Linking the 'in' and 'out'

The achievement of thermal comfort in the tropics is about the "integration of microclimate, form and fabric of the building" (Rajapaksa and Hyde, 2012). Substantial improvement in indoor thermal comfort is possible only if efforts to do so begin at the *neighbourhood* scale (i.e. outside the building). Indeed, the manipulation of settlement geometry, street orientation and external factors such as street trees are central to achieving thermal comfort in the tropics. This would help climatically link the inside of buildings with the outside. Such a link between the two ought to reflect the purpose for which thermal comfort standards are being promulgated. Lenzuni et al (2009) suggest differentiation of thermal standards along the following: the subject's thermal sensitivity, accuracy required for carrying out the task and the practicality of thermal control. We suggest a fourth, the difference between indoor and outdoor conditions to be achieved.

3.3 Adaptive opportunities varied by activity patterns

Given the year-round possibility to use the outdoors for daily living, urban thermal comfort gains greater importance in the overcrowded tropics where room occupancy rates are unhealthy (cf. Correa, 1989). A critical need is to specify outdoor thermal standards in terms of urban activities (Emmanuel, 1993) that facilitate comfortable movement in the outdoor, leading to higher quality-of-life.

Such extension to the comfort zone could be greatly facilitated by the provision of adaptive opportunities that are organised around activity patterns of tropical urban life. Emmanuel (2005) suggested four such adaptive opportunities organised around tropical activity patterns:

- a. Shopping Streets – create canyon-like shopping streets in large neighbourhoods, where the street itself is north/south running, with buildings on the west being slightly taller than those on the east. Line both facades of street-facing buildings with arcades, so as to provide adequate protection from rain and sun. If north/south running streets are not available, create narrow shopping cul-de-sacs off major traffic arteries, thus ensuring adequate protection from traffic, while maintaining accessibility.
- b. Gathering Places – surround urban waterbodies with a built form edged by arcades. Locate public activities along the arcade, overflowing into the commons. If north/east facing promenades are desired, locate the buildings in an "L" shape along the southern and western edges of water. If south/west facing arcades are desired, locate buildings along the northern edge of water, in a staggered manner. The commons in the latter case needs to be wider. Trees need to be planted so as to provide intermittent shading to the commons. Dissuade all activities that do not directly benefit from water's edge from locating on urban waterfronts.
- c. Provisions for evening life – Evenings are tropics' winter (Rao, 1981). The places deserted in the heat of the day are slowly re-occupied by throngs of people as the searing afternoon sun bids farewell and darkness envelopes the land. Street corners are especially attractive to be incorporated into the evening life, particularly if they intersect northerly and easterly orientation.
- d. Pedestrian Paths and Nodes - The problem of pedestrianizing cities lies in the connections provided. Not only the provision of a safe lane, but also connecting activities that people most frequently use, is necessary. Therefore, establish a network of pedestrian links independent of city street network. Paths within city blocks could be the primary carriers of cool air (say from a pond). Wherever the pedestrian path crosses the vehicular path, establish a place to pause. At places, let the pedestrian path merge with the street network, especially if the street is north/south running. Let such streets be very narrow, buildings on both sides providing shade to the entire street. Line the rest of the path with trees, or alternatively, cover it with a light roof.

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. Tackling the urban climate change on the other hand, offers immediate and tangible benefits since the negative consequences of haphazard urbanization is plain to see. 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 to facilitate quality living in a warming world.

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