Environmental and Climate Technologies doi: 10.1515/rtuect-2016-0006

2016 / 17

Street Geometry Factors Influence Urban Microclimate in Tropical Coastal Cities: A Review

Arezou SHAFAGHAT[1]*, Golnoosh MANTEGHI[2], Ali KEYVANFAR[3], Hasanuddin BIN LAMIT[4], Kei SAITO[5], Dilshan Remaz OSSEN[5]

[1]*Construction Research Center, Institute for Smart Infrastructure and Innovative Construction, Faculty of Civil Engineering, Universiti Teknologi, UTM Skudai, 81310 Johor, Malaysia*

[2]*Department of Landscape Architecture, Faculty of Built Environment, Universiti Teknologi, UTM Skudai, 81310 Johor, Malaysia*

[3]*Construction Research Center, Institute for Smart Infrastructure and Innovative Construction, Faculty of Civil Engineering, Universiti Teknologi, UTM Skudai, 81310 Johor, Malaysia*

[4]*Center of Built Environment in the Malays World (KALAM), Faculty of Built Environment, Universiti Teknologi, UTM Skudai, 81310 Johor,Malaysia*

[5]*Department of Architecture, Faculty of Built Environment, Universiti Teknologi, UTM Skudai, 81310 Johor, Malaysia*

Abstract **– Urban climatologists have moved smoothly towards urban geometry meso-scales as obstruction between buildings, streets, and urban environment. Urban climatologists and designers have expressed that urban geometry parameters affect urban microclimate conditions. Improper functioning of the geometry factors, particularly air temperature and wind speed, can increase the harshness of climate change and Urban Heat Island (UHI) defects, which are more critical in coastal cities of tropical regions. In this regard, the current study aimed to identify the impact of each street geometry factor on urban microclimate through a critical literature review. The research determined a total of twenty seven (27) factors within three clusters; 1) geometry factors, 2) meteorological factors, and 3) streetscape factors. The content analysis calculated the Depth of Citation (DoC) which refers to the cumulative importance level of each factor. The content analysis resulted air temperature (Ta) (DoC = 18 out of 28) is the most important street geometry factor that should be extensively considered in urban microclimate studies in coastal cities. In contrast, the factors (such as air pollution and traffic load) have received a minimum Doc (1 out of 28). The research has also analyzed the importance level of clusters through an expert input study using Grounded Group Decision Making (GGDM) method. The results show that meteorological cluster (92 %), streetscape cluster (86 %), and geometry cluster (85 %) have to be respectively implemented in urban microclimate studies in coastal cities. The research states there are new approaches have not yet been touched by urban climatologist affecting urban microclimate; included; surface materials, sea-borne dust and sand, user's satisfaction, user's thermal adaptive behavior. These approaches can potentially exacerbate UHI effects in coastal cities, which need further research.**

Keywords **– Urban microclimate coastal cities; Urban heat island; Street geometry**

1. INTRODUCTION

Urban climatology is a science shared between designers and climatologists [1]. The climatologists initially focused on the UHI (Urban Heat Island) issue in the macro-scale, and moved smoothly towards the meso-scale (i.e. urban geometry) [2]–[4]. The designers have been

---

* Corresponding author.

E-mail address: arezou@utm.my

more attracted to the impact of environmental forces on buildings, indoor climate of the buildings, design strategies, energy requirements for supporting the thermal comfort, and passive solar gains, since the 1973 oil crisis [3], [5]–[7]. The designers have gradually switched to urban environmental issues as the obstruction between the buildings and the urban environment. For instance, they focused to manage wind and sun energy sources to supply the demand energy [8].

Currently, the environmental quality of the urban street and open areas has turned out to be a major issue for both designers and climatologists, which can be observed through their regular scientific findings [9], [10]. For example, they indicate that the surface and form characteristics of street and open spaces vary largely in providing thermal comfort. In particular, several parameters, such as geometry, properties of surfaces, and vegetation, affect the microclimate of these spaces [4], [11]–[15]. A street’s canyon shape has been understood as a factor that affects the urban environment in terms of passive solar receiving, penetrability to wind flow, reflection of radiation versus urban absorption, and potential for urban system`s cooling.

The improper function of these parameters might increase the environment’s harshness as well as urban environment temperature, which is known as the Urban Heat Island (UHI) phenomenon [16], [17]. However, there is a lack of study in the association between street geometry effects on urban microclimate. This subject was become one of the challengeable issues to Malaysia government and its local authorities. In this regard, this research developed the conceptual framework of street geometry effects on urban microclimate in Malaysia tropical coastal cities in order to mitigate the urban heat island phenomenon.

2. TAXONOMY OF URBAN CLIMATOLOGY

The research investigated literature to establish the taxonomy body of knowledge in urban climatology studies. Investigation on literature determines that urban climatology is under the umbrella of Sustainable Urban Development studies which is involved in a holistic perspective, called ‘Built Environment Development’. The branch Urban Climatology has evolved into three sub-branches, including, urban planning, regional planning, and urban design. Figure 1 illustrates the sub-branch of urban planning in urban climatology studies. Urban planning research emerged into diverse areas of researches; including, urban street size distribution, urban boundary layer, urban growth, land use study, urban heat island, urban form, urban canopy, urban street patterns, and human comfort.

Figure 2 depicts the body of knowledge on urban climatology field of research in which has evolved from urban design and regional planning. On regional planning branch, the urban entropy study and geospatial analysis have been studied under Geographical Information System (GIS) category. On urban design branch, the urban climatology studies have focused on three branches, urban environment, urban atmosphere, and human comfort. Urban environment branch involves urban geometry and building studies. Urban atmosphere branch focuses on energy balance, solar, moisture, wind/air flow, and heat. As can be understood from Fig. 1 and Fig. 2, the human comfort approach was commonly considered in the urban design and planning branches. However, the previous researchers have not yet focused on physical health under human comfort category. In particular, they did not yet touch on human respiratory health issues in urban climatology studies through urban design and planning perspectives.

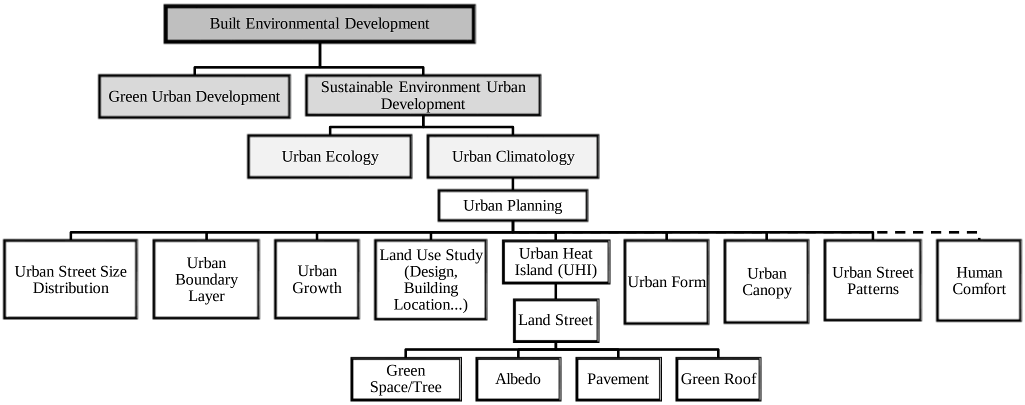

Fig. 1. Branch of urban planning in taxonomy of urban climatology studies.

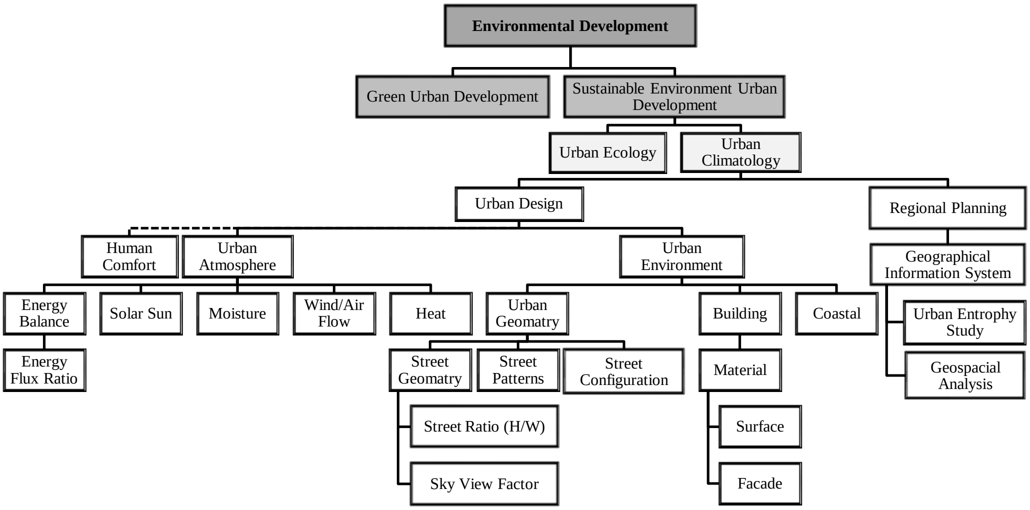

Fig. 2. Urban design and regional planning branches in taxonomy of urban climatology studies.

3. BACKGROUND OF STUDY

3.1. Microclimate of Urban Street Canyon

Urban Canyon has broadly emerged in urban climatology and urban street canyons studies [18]–[20]. The urban street canyon studies discuss the basic value of the aspect ratio (i.e. height-to-weight ratio (H/W)) in addition to the street orientation, as the most important urban features. The influence of Sky View Factor (SVF) in street design and H/W ratio on street microclimate was examined, particularly, in terms of street surface and air temperature. The studies show that SVF and the street geometry make lesser variations in air temperature compared with surface temperatures [20], [21]. On the effect of street orientation to canyon air temperature, the northwest oriented streets are 1 to 2 °C cooler than the east-west oriented streets during day time and no difference by night [22]. On impact of geometry on street microclimate, Bourbia and Boucheriba [23] argued that larger SVF makes higher air temperatures, and, higher H/W ratio causes lower air temperatures.

Moreover, to urban designers and planners, the main issue in street design is to suppress the seasonal extreme temperatures. It is necessary to cover the street from the sun over the summer period, and also, access to sky in winter. These concepts convey the message of being compact, and simultaneously, open to sky [24], [25]. Indeed, getting exposed to shadow patterns has a strong influence on the temperature of street canyon which affects heat movements for sensible fluidity [26], [27]. The chances of wind flow on the street level depend on the shadow parameters [14], [18], [27]. The building substances for the surfaces of canyon were also understood to be vital in the storage rate of diurnal heat for a street canyon in addition to the cooling rate of the night [1], [18].

3.2. *Water Body Effects on Urban Microclimate*

In order to control the urban temperature, architects and urban planners have employed water bodies in their design [28]. In general, previous studies have proven that temperatures and hence the heat stress near and downwind to the water bodies are 1 to 2 °C lower than areas nearby, and the maximum temperature decline occurs over the daytime [28]–[31]. According to Hathway and Sharples [32] in addition to the evaporation influence, water bodies have a great capacity for heat and air temperature storage. Wetlands also have a downwind cooling effect [28]. Water`s diurnal temperature range is indicated lower than the same range for a urban landscape, i.e. the suppression of maximum temperatures, and there is also a limitation for nocturnal cooling [33]. Evaporation coming from open water bodies may be helpful in lowering the temperature, but it contributes to humidity. Subsequently, the higher level of humidity causes lowering in human comfort. Water bodies offer a good source of moisture in an attempt to upkeep the oasis effect over daytime, specifically, when the discussed area is under domination from drier and larger-scale surroundings of urban environments [28].

4. PROBLEM STATEMENT

4.1. *Climate Change and Poor Outdoor Thermal Comfort in Coastal Cities*

Due to climate change, global air temperatures are expected to rise by 0.2 °C per decade over the next century [34]. Extreme weather events will be more common in the future. For example, heat waves will be stronger and will last longer. This is a particular problem in tropical climate regions which increases heat stress and other heat-related diseases [35]–[38]. Cities are especially vulnerable since they – in addition to global warming – are also exposed to the urban heat island phenomenon.

Furthermore, poor urban microclimatic conditions will indirectly lead to deteriorated thermal comfort. This will have a negative impact on performance and health, and will also lead to increased use of air conditioning, subsequently, to higher energy costs for urban dwellers. The consequences of greater energy use include increased air pollution through the consumption of fossil fuels and higher pressure on the energy supply, which may cause frequent power outages. In warm countries, there is also a risk of feedback loop: air conditioning units cool the interior of buildings but emit sensible heat to the exterior, further worsening outdoor conditions and creating a vicious circle [39]. There are quite a few studies that have examined the effectiveness of water in alleviating the heat stress. Just a few studies have hypothesized water bodies' role of cooling in urban streets and open spaces over the hot summer daytime [40], [41].

4.2. Absence of Climate-Conscious Factors in Urban Design and Planning

Urban areas often become unnecessarily uncomfortable since urban microclimate and outdoor thermal comfort generally ascribe little importance in urban planning and design processes [42]–[43]. Many studies in warm countries report that climate issues are not sufficiently considered in contemporary urban design and planning. Aynsley and Gulson [44] interpret the lack of climate consciousness in urban planning and design; “urban climate is often a largely unplanned outcome of the interaction of a number of urban planning activities […], an outcome for which no authority and no profession take responsibility”. The previous studies have shown that knowledge about climate issues among climatologists, planners and urban designers is often missing sustainable design of urban development [43], [45], [46]. De Schiller and Evans [39] and Soufiane *et al.* [38] emphasize that incorrect decisions at the urban planning level are normally impossible to correct at a later stage. Ainsley and Gulson [44] argue that outdoor thermal comfort should be a routine aspect of urban development and that climatic aspects should be included in urban development codes and guidelines at different planning levels. In developing countries, rapid urbanization often implies the uncontrolled growth of cities through the formation of substantial informal settlements. In such settlements, climate-conscious aspects are often disregarded [47].

4.3. Lack of Study in Association between Urban Street Geometry and Air Temperature in Tropical Cities

The urban street microclimate has been considerably studied in moderate regions, primarily in cities with mid-latitude; however, in low-latitude tropical climates few studies have been conducted [4]. Majority of tropical studies have addressed urban rural differences while few have studied microclimate differences within cities. Furthermore, a limited number of studies have dealt with intra-urban microclimate variances related to city design.

A majority of studies in intra-urban variations show that urban geometry has a significant influence on air temperature and that daytime maximum temperatures tend to decrease by increasing H/W ratios. However, the effect of street orientation on air temperature has proven limited and only a few studies have been conducted in hot humid climates. To some extent, the existing guidelines are vague, since, they do not define or quantify design aspects such as the space between buildings, building heights, H/W ratios, etc. In part, this is due to the fact that these guidelines are probably general for a larger region. De Schiller and Evans [39] point out that their guidelines must be adjusted to local climatic factors and to other local conditions, such as topography, existing urban form and building traditions. Hence, the vagueness of the guidelines may also be a result of lack of research on the actual effects of urban street design on the microclimate.

The previous studies indicate the climate was rarely considered in urban planning and design. Also, those studies indicate the codes and regulations were poorly adapted to local climatic conditions which often act as obstacles to climate-conscious urban design. Indeed, there are few studies from hot dry and, particularly, hot humid climates. For hot humid climates, the majority of the guidelines reviewed argue for an open, dispersed city plan. This conflicts with the need of many tropical countries in increasing population densities in cities.

In particular, the coastal zones have not received much attention compared to the other zones in tropical areas whereas the evaporative effect of water is seen as an alternative for mitigating the ambient temperature of the environment. Past studies have found that, in sub-tropical areas, water bodies can provide a significant cooling effect by lowering the ambient temperature by 4 °C compared to areas without water bodies. In addition, water ponds favouring the evaporative cooling were identified as one of the potential mitigations for UHI [5], [17], [30]. Ken-Ichi (1991) and Givoni [5] mentioned that evaporative cooling is arguably one of the most efficient ways of lowering temperature in urban spaces in hot regions. Based on the literature review, the water bodies' positive effect might work better at a low temperature and in low humidity, as in the tropical climate.

5. STREET GEOMETRY FACTORS IMPACT ON URBAN MICROCLIMATE IN TROPICAL REGION

The critical literature review has been conducted to identify the street geometry factors impact on urban climate. The current research scoped to tropical regions like Malaysia and Australia. This stage (i.e. factors identification) is the first stage of the long project that would be first a study in Malaysia. The main project plans to investigate the relationship between street canyon geometry and microclimate created in coastal cities in Malaysia. The main project's concern is the coastal city will be affected by the created microclimate, in turn, this will be folded by perusing the different street characters and proximities to the sea and specific arrangements. This study focuses on the microclimate aspects to be successfully implemented in an urban design in the coastal cities in Malaysia which can encourage the sea breeze to enter the urban area.

The research has conducted a content analysis on the literature which indicates the street geometry factors affecting urban street microclimate. According to Table 1, the factors have been clustered into three clusters; 1) geometry factors, 2) meteorological factors, and 3) streetscape factors, within which, each cluster involves a number of factors (see Table 1). The content analysis table indicates that previous studies have mostly studied the factors of temperature (Ta) and wind speed (ws), in contrast with the factors facades and luminous environment. The literature review shows that, although microclimate variation in the city is large and covering all differences which require extensive measurements, it would be restricted to existing conditions in the city. Hence, for a future simulation study on costal cities, the data of the design parameters on microclimate will be collected; including, street geometry (H/W ratio), street orientation, and wind speed & wind direction. Street orientation east-west, north-south for each H/W ratio will be studied for all simulations. Wind direction (perpendicular or parallel), and the effect of colonnades will be simulated. In addition, urban design and architectural factors (such as building height, spacing between buildings and the portion of the ground permitted to be occupied by buildings) have to be precisely measured. Moreover, the temperature and humidity of the air, and wind speed have to be measured continuously, which will be shielded against radiation. The measurements are assumed to be representative of the conditions at the pedestrian level, since temperature and humidity variations within urban canyons have proven to be small except near urban surfaces [2].

TABLE 1. ENVIRONMENTAL-CONSCIOUS FACTORS IN URBAN STREET MICROCLIMATE STUDIES

Citation	Environmental-Conscious Factors																												Climate & location
	Geometry Cluster									**Meteorological Cluster**														**Streetscape Cluster**					
																				Energy budget									
	Ratio(H/W)	Sky view factor(SVF)	Street orientation	Vegetation	Surface albedo (SA)	Asymmetrical shapes	Colour of ground & facades	Material of the ground & facades	Distance to the sea	Air temperature (Ta)	Surface temperature (Ts)	Ground surface temperature	Soil temperature	Globe temperature (Tg)	Relative Humidity (RH)	Global radiant (Gr)	Solar radiation (SR)	Mean radiant temperature(Tmrt)	Wind speed (ws)	Wind direction (dd)	**Short wave radiation (K)**	**Long wave radiation (L)**	Cloud cover(Cd)	Air pollution	Sound pressure	Luminous environment	Traffic load	Thermal comfort index	
Andreou [47]		√		√						√	√				√			√	√									√	Greece
Dimoudia, et al. (2013)	√		√					√		√					√				√	√									Greece/Serres
Yahia andJohansson,e. (2013)	√		√	√							√																	√	Hot & arid
Shashua-Bar et al. [51]	√			√	√					√	√				√				√								√		Athens/summer Hot & arid
Kantzioura, et al. [52]	√		√						√	√	√	√	√		√	√			√										Greece/Thessaloniki
Andreou and Axarli [53]	√		√	√	√		√			√	√				√				√	√									Greece/Cycladic islands (Tions city & island)
Hwang [54]		√			√					√	√			√	√	√			√		√	√	√					√	Taiwan/RayMan model
Krüger et al. [55]	√	√	√							√				√	√		√	√	√					√				√	Brazil/Curitiba
Shashua-Bar et al. [56]		√		√	√			√											√									√	Hot & arid
Mahmoud [57]		√								√					√	√			√									√	Hot & arid/Egypt
Bourbia and Boucheri [58]	√	√	√							√	√	√	√												√				Hot & arid, Constantine/Algeria
Djenane et al. [59]	√		√													√			√										Hot & dry, Mzab valley /Algeria
Ali-Toudert, and Mayer [4]	√		√	√		√				√					√				√	√	√	√				√		√	Hot & arid
Pearlmutter et al. [60]			√					√																					Hot & arid
Georgakis and Santamouris										√	√								√										Greece/Athens
Johansson [62]	√	√								√	√				√				√									√	Hot & arid/hot & humid
Johansson and Emmanuel [63]	√				√				√	√	√				√				√									√	Hot & arid
Bourbia and Awbi [64]	√	√								√	√																		Hot & humid El-Oued City/Algeria
Coronel and Alvarez [65]										√					√														Santa Cruz district in Seville/Spain
Pearlmutter et al. [66]			√							√					√						√	√						√	Arid Negev region of Israel
Nichol [67]			√					√		√	√	√																	Hot & humid/Singapore
Ahmed [68]	√									√																			Hot-humid, Bangladesh
Total	**13**	**8**	**11**	**6**	**5**	**1**	**1**	**4**	**2**	**18**	**12**	**3**	**2**	**2**	**13**	**4**	**1**	**2**	**14**	**3**	**3**	**3**	**1**	**1**	**1**	**1**	**1**	**10**	-

The content analysis table presents the depth of citation (DoC) at the last row of the table. The depth of citation refers to cumulative importance level of each factor stated by previous researchers. Figure 3 illustrates the depth of citation of street geometry factors in a bar chart. As can be seen, air temperature (Ta) (DoC = 18 out of 28) has been mostly referred to in urban climatology studies; hence, this factor should be extensively considered in future experimental and simulation microclimate studies in coastal cities in tropical regions. In contrast, some factors (such as, air pollution, and traffic load) have received a minimum frequency of depth of citation (DoC = 1 out of 28) referred by previous urban microclimate researchers.

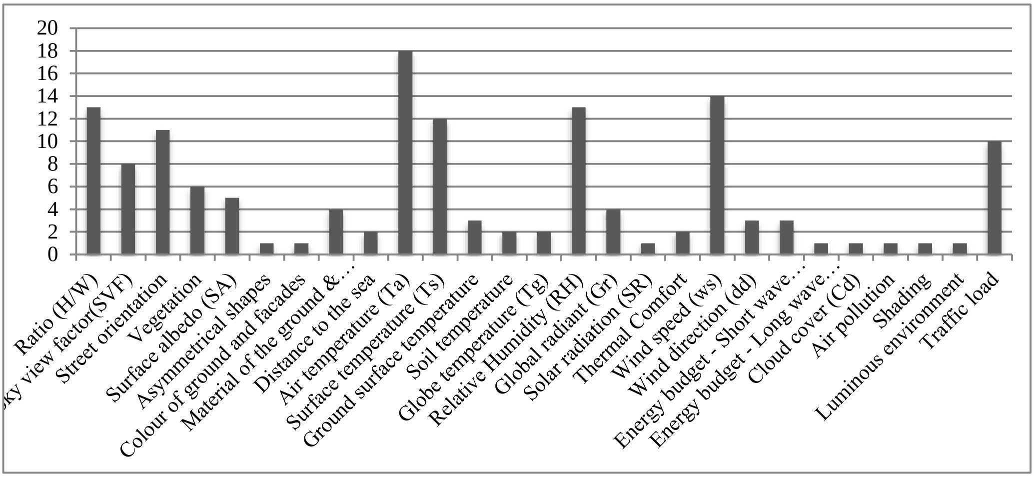

Fig. 3. Depth of Citation (DoC) of Street Geometry Factors in urban climatology studies.

6. VALIDATION STUDY ON CLUSTERS OF STREET GEOMETRY FACTORS

As mentioned earlier, this research aimed to validate the clusters of the street geometry effects as well. The validation study aided the researchers to understand the importance level of each cluster in future experimental studies of urban microclimate in tropical coastal cities.

Field expert Delphi structured Close Group Discussion was used as the method of data collection, which is the most applicable group decision making method [69], [70]. A structured fixed format self-reporting questionnaire form was designed to be filled up in discussions. The group discussions have been preceded by the collection of expert judgements using 5-point likert scaling (from number 1 refers to Weak to number 5 refers to Excellent). Based on purposive sampling method, a total number of eight experts were involved within four group decision making sessions. The experts have been invited who are practicing urban design and climotology. Data analysis was conducted using Grounded Group Decision Making (GGDM) method adapted from Lamit *et al.* [71]. FW_{a_i} (Eq. 1) is to calculate final weight (FW) of sub-issue number ‘i’, a_i of the discussion.

$$FW(a_i) = (\sum_{j=1}^{n} (\min\{WP_j, W\Pr_j\} \times SV_j)) \times a_i \tag{1}$$

for $i + 1, 2, 3, \ldots, m$

where

WP_j refers to assigned weight by participants number 'j' in close group discussion for sub-issue a_i;

$W\,\mathrm{Pr}_j$ refers to assigned weight by resource(s) relevant to the issue, whom introduced by participants number 'j' in close group discussion for sub-issue a_i;

a_i refers to sub-issue of discussion;

$FW(a_i)_{max}$ referred to maximum possible weight can be given for sub-issue a_i;

SV_j refers to CGD sessions value (SV) considered by the decision researcher which the CGD session included participant number j.

Equation (2) indicates the consensus calculation in GGDM for sub-issue a_i.

$$FW(a_i)\,/\,FW(a_i)_{\max} = Consensus\% \tag{2}$$

In GGDM application, the researcher appointed the Session Value (SV) for each session of CGD. The researcher appointed SV 1 for two first sessions and SV 3 for the session 3 and SV 4 for the session 4 of CGDs. In the first session, two (2) participants (i.e. experts) have been involved. According to Table 3, participant 1 appointed WP = 3 for the 'Geometry Factors Cluster' as his weighting value to validation. The participants were asked to introduce any other resource to validate the list of criteria, if needed. As can be seen in Table 4, participant 1 introduced participant 3 (WPr = c-WP3). Then, the research has to conclude the minimum between WP's weighting value and c-WP3's weighting value.

For example, according to WP column of the participant 3, the researcher had to select the minimum between 3 and 5 as the weighting value indicated by participant 1 and 3 for the 'Geometry Factors Cluster' which equals 3. Then, researcher considered this value in the column c-WP for the participant 1's records.

In the second, third, and fourth sessions, all the mentioned process has been conducted. For example, for the 'Geometry Factors Cluster' the following calculations have been conducted.

$$FW_{(c_1)} = (3 \cdot 1) + (4 \cdot 1) + (3 \cdot 1) + (5 \cdot 3) + (5 \cdot 3) + (5 \cdot 3) + (3 \cdot 4) + (5 \cdot 4) = 85$$
$$FW_{(C_1)}/FW_{(C_1)max} = 85/100 = 85\ \%$$

According to Table 2, the GGDM results show that expert inputs reached 85 % saturation for the 'Geometry Factors Cluster', 92 % saturation for the 'Meteorological Factors Cluster', and 86 % saturation for the 'Streetscape Factors Cluster'. These results show the priorities the urban planners have to be considered regarding microclimate phenomenon in any development/redevelopment, and corrective action. Meteorological factors, Streetscape factors, and then, geometry factors have to be respectively implemented in accreditation with sustainable urban development.

TABLE 2. SUMMARY OF GGDM DATA COLLECTION AND ANALYSIS ON VALIDATION OF CLUSTERS OF STREET GEOMETRY FACTORS

Validation of Clusters	Validation session 1							Validation session 2				Validation session 3										Validation session 4							Cons. (%)	GGDM Consensus
	Partici-pant 1			Partici-pant 2				Partici-pant 3				Partici-pant 4			Partici-pant 5			Partici-pant 6				Partici-pant 7			Partici-pant 8					
	WP	**WPr** = c-WP3	**c-WP**	**WP**	r-**WP** = c-WP4	**c-WP**	**SV**	**WP**	**WPr** = -	**c-WP**	**SV**	**WP**	**WPr** = c-WP7	**c-WP**	**WP**	**WPr**= WP7	**c-WP**	**WP**	**WPr** = c-WP7	**c-WP**	**SV**	**WP**	**WPr** = -	**c-WP**	**WP**	**WPr** = c-WP5	**c-WP**	**SV**		
Geometry Cluster	3	4	3	4	5	4	1	3	–	3	1	5	5	5	5	5	5	–	5	5	3	3	–	3	–	5	5	4	85	Aprv.
Meteorological Cluster	2	5	2	3	4	3	1	5	–	5	1	4	5	4	5	5	5	–	5	5	3	5	–	5	–	5	5	4	92	Aprv.
Streetscape Cluster	4	3	3	4	5	4	1	3	–	3	1	3	5	3	4	5	4	–	5	5	3	5	–	5	–	4	4	4	86	Aprv.

Note: WP: Participant's Rate to the validation aspect, c-WP: conclusion of Participant's Rate to the validation aspect considered as $min\{WP_j, WPr_j\}$, WPr: Participant introduced resouceRate to the validation aspect, -: Participant did not provide value, SV: CGDSession Value considered by the GGDM researcher, Aprv.: the validation aspect is approved based on GGDM Consensus rate of more than 70 % agreement, *n*-Aprv.: the validation aspect is not approved based on GGDM Consensus rate of not more than 70 % agreement.

7. DISCUSSION AND CONCLUSION

In order to reduce the negative climatic change and global warming impacts on our cities, those involved in urban development, planning, and design have to begin to incorporate urban microclimate knowledge into planning strategies, and to create links between microclimate, user comfort, street geometry. Due to ever-increasing urban heat island hazardous effects, urban environment temperature and air pollution trend [72]–[74], the urban climatologist and designers are gradually switched to micro-scale environmental issues (i.e. urban street and open spaces), particularly, in tropical coastal cities. However, the urban designers and planners do not have sufficient knowledge about street geometry effects on urban microclimate. Indeed, the current research identified the importance level of street geometry factors and involved cluster, which aids urban designers to mitigate the negative impact of microclimate in coastal cities of tropical regions.

Considerably, the coastal zones have not received much attention compared the other zones in tropical areas whereas the evaporative effect of water is seen as an alternative for mitigating the ambient temperature of the environment. Past studies have found that, in sub-tropical areas, water bodies can provide a significant cooling effect by lowering the ambient temperature that was supported by the current research as well. In particular, the sea-borne dust and sand have not yet established as the street geometry in-related factor in urban microclimate studies which can potentially cause of respiratory diseases, particularly, in coastal cities suffering from urban heat island (UHI) phenomenon. Besides, the materials science (i.e., building surface material, pavement materials, etc.) is a new approach the researchers need to consider it which plays a key role in UHI and climate change difficulties. Indeed, these new approaches can be integrated with current approaches (see Figure 1 and 2: Taxonomy of Urban Climatology Studies) like user's satisfaction, user's thermal adaptive behavior that have not yet been touched by urban climatologist.

A number of environmental assessment models and tools (such as, Wave, Envi-Net, CFD, Watch III, WRF/MM5, PRECIS, and RegCM) have scoped in predicting microclimate variables such as humidity, temperature, wind speed and radiation within the urban canopy layer. However, these existing tools are lacking with a comprehensive list of street geometry factors. The output of the current research can be potentially integrated with these tools indexing in order to measure the urban microclimate in the street scale too.

In a future study, the research output will be used in simulation of urban microclimate studies in coastal cities like Malaysia and Indonesia.

ACKNOWLEDGEMENT

Authors are thankful to the Ministry of Science, Technology, and Innovation (MOSTI) for research funding (Science Fund Grant number 06-01-06-SF1434), and Ministry of Higher Education (MOHE) for FRGS research funding R.J130000.7822.4F762 (PY/2015/05353). Authors would also like to thank, GUP Grants vote nos. Q.J130000.2609.11J04, Q.J130000.2522.13H02, Q.J130000.2522.13H06 and Q.J130000.2609.10J83.

REFERENCES

[1] Mills G. An urban canopy-layer climate model. *Theoretical and applied climatology* 1997:57(3–4):229–244. doi:10.1007/BF00863615

[2] Oke T. R. Initial guidance to obtain representative meteorological observations at urban sites. World Meteorological Organization. Report No. 81, 2006.

[3] Ali-toudert F., Mayer H. Thermal comfort in urban streets with trees under hot summer conditions. Proc. 22nd International PLEA Conference, Notre Dame University, Lebanon, 13-16 November, 2005:699–704.

[4] Ali-Toudert, F., Mayer H. Numerical study on the effects of aspect ratio and orientation of an urban street canyon on outdoor thermal comfort in hot and dry climate. *Building and Environment* 2006:41(2):94–108. doi:10.1016/j.buildenv.2005.01.013

[5] Givoni B., La Roche P. Indirect evaporative cooling with an outdoor pond. Proceedings of Architecture, City, Environment, PLEA, 2000:310–311.

[6] Markus T. A., Morris E. N., Reed P. Buildings, climate and energy: Pitman, London, 1980.

[7] Givoni B., Noguchi M., Saaroni H., Pochter O., Yaacov Y., Feller N., Becker S. Outdoor comfort research issues. *Energy and buildings* 2003:35(1):77–86. doi:10.1016/S0378-7788(02)00082-8

[8] Knowles R. L. Sun rhythm form. The MIT Press, Cambridge, MA, 1981.

[9] Steemers K. Cities, energy and comfort: a PLEA 2000 review. *Energy and buildings* 2003:35(1):1–2. doi:10.1016/S0378-7788(02)00074-9

[10] Asimakopoulos D. D. N. Energy and climate in the urban built environment. London: James & James, 2001.

[11] Yoshida A., Tominaga K., Watatani S. Field measurements on energy balance of an urban canyon in the summer season. *Energy and buildings* 1991:15(3):417–423. doi:10.1016/0378-7788(90)90016-C

[12] Bourbia F., Awbi H. Building cluster and shading in urban canyon for hot dry climate: Part 1: Air and surface temperature measurements. *Renewable Energy* 2004:29(2):249–262. doi:10.1016/s0960-1481(03)00170-8

[13] Nunez M., Oke T. R. Energy Balance of an Urban Canyon. 1977.

[14] Nakamura Y., Oke T. Wind, temperature and stability conditions in an east-west oriented urban canyon. *Atmospheric Environment* 1998:22(12):2691–2700. doi:10.1016/0004-6981(88)90437-4

[15] Santamouris M., Papanikolaou N., Koronakis I., Livada I., Asimakopoulos D. Thermal and air flow characteristics in a deep pedestrian canyon under hot weather conditions. *Atmospheric Environment* 1999:33(27):4503–4521. doi:10.1016/S1352-2310(99)00187-9

[16] Oke T. R. Boundary layer climates. Psychology Press, 1992.

[17] Maragogiannis K., Kolokotsa D., Maria E. A. Study of Night Ventilation Efficiency in Urban Environment: Technical and Legal Aspects. *Environmental and Climate Technologies* 2011:6:49–56. doi:10.2478/v10145-011-0007-1

[18] Arnfield A. Street design and urban canyon solar access. *Energy and buildings* 1990:14(2):117–131. doi:10.1016/0378-7788(90)90031-D

[19] Arnfield A. J. Two decades of urban climate research: a review of turbulence, exchanges of energy and water, and the urban heat island. *International journal of climatology* 2003:23(1):1–26. doi:10.1002/joc.859

[20] Swaid H., Bar-El M., Hoffman M. A bioclimatic design methodology for urban outdoor spaces. *Theoretical and applied climatology* 1993:48(1):49–61. doi:10.1007/BF00864913

[21] Ali-Toudert F., Mayer H. Effects of street design on outdoor thermal comfort [Online]. Available: http://www.sci.u-szeged.hu/eghajlattan/baba/Ali-Toudert.pdf

[22] Bourbia F., Awbi H. Building cluster and shading in urban canyon for hot dry climate: Part 1: Air and surface temperature measurements. *Renewable Energy* 2004:29(2):249–262. doi:10.1016/S0960-1481(03)00170-8

[23] Bourbia, F., Boucheriba F. Impact of street design on urban microclimate for semi arid climate (Constantine). *Renewable Energy* 2010:35(2):343–347. doi:10.1016/j.renene.2009.07.017

[24] Oke T. Street design and urban canopy layer climate. *Energy and building*s 1988:11(1):103–113. doi:10.1016/0378-7788(88)90026-6

[25] Herzog T., Kaiser N. Solar energy in architecture and urban planning; Solarenergie in architektur und stadtplanung. Energia solare in architettura e pianificazione urbana, Munich etc.: Prestel, 1996.

[26] Yoshida A., Tominaga K., Watatani S. Field measurements on energy balance of an urban canyon in the summer season. *Energy and buildings* 1991:15(3):417–423. doi:10.1016/0378-7788(90)90016-C

[27] Santamouris M., Papanikolaou N., Koronakis I., Livada I., Asimakopoulos D. Thermal and air flow characteristics in a deep pedestrian canyon under hot weather conditions. *Atmospheric Environment* 1999:33(27):4503–4521. doi:10.1016/S1352-2310(99)00187-9

[28] Coutts A. M., Tapper N. J., Beringer J., Loughnan M., Demuzere M. Watering our cities: The capacity for Water Sensitive Urban Design to support urban cooling and improve human thermal comfort in the Australian context. *Progress in Physical Geography* 2003:37(1):2–28. doi:10.1177/0309133312461032

[29] Chen H., Ooka R., Huang H., Tsuchiya T. Study on mitigation measures for outdoor thermal environment on present urban blocks in Tokyo using coupled simulation. *Building and Environment* 2009:44(11):2290–2299. doi:10.1016/j.buildenv.2009.03.012

[30] Nishimura N., Nomura T., Iyota H., Kimoto S. Novel water facilities for creation of comfortable urban micrometeorology. *Solar Energy* 1998:64(4):197–207. doi:10.1016/S0038-092X(98)00116-9

[31] Saaroni H., Ziv B. The impact of a small lake on heat stress in a Mediterranean urban park: the case of Tel Aviv, Israel. *International Journal of Biometeorology* 2003:47(3):156–165. doi:10.1007/s00484-003-0161-7

[32] Hathway E. A., Sharples S. The interaction of rivers and urban form in mitigating the Urban Heat Island effect: A UK case study. *Building and Environment* 2012:58:14–22. doi:10.1016/j.buildenv.2012.06.013

[33] Heusinkveld B. G., Van Hove, L., Jacobs C., Steeneveld G., Elbers J., Moors E., Holtslag A. Use of a mobile platform for assessing urban heat stress in Rotterdam. Proceedings of the 7th Conference on Biometeorology Albert-Ludwigs-University of Freiburg, 2010.

[34] IPCC. Climate change: impacts, adaptation and vulnerability. Genebra, Suíça, 2007.

[35] Harlan S. L., Brazel A. J., Prashad L., Stefanov W. L., Larsen L. Neighborhood microclimates and vulnerability to heat stress. *Social Science & Medicine* 2007:63(11):2847–2863. doi:10.1016/j.socscimed.2006.07.030

[36] Hunter M. C. Using Ecological Theory to Guide Urban Planting Design An adaptation strategy for climate change. *Landscape Journal* 2011:30(2):173–193 doi:10.3368/lj.30.2.173

[37] Klavina A., Cinis A., Zandeckis A. Experimental Study on the Effects of Air Velocity, Temperature and Depth on Low-temperature Bed Drying of Forest Biomass Residue. *Energy Procedia* 2015:2:42–48. doi:10.1016/j.egypro.2015.06.007

[38] Soufiane F., Said M., Atef A. Sustainable Urban Design of Historical City Centers. *Energy Procedia* 2015:74:301–307. doi:10.1016/j.egypro.2015.07.612

[39] De Schiller S., Evans J. M. Sustainable urban development: design guidelines for warm humid cities. *Urban Design International* 1998:3(4):165–184. doi:10.1080/135753198350299

[40] Rinner C., Hussain M. Toronto’s urban heat island – Exploring the relationship between land use and surface temperature. *Remote Sensing* 2011:3(6):1251–1265. doi:10.3390/rs3061251

[41] Olah A. The Possibilities of Decreasing the Urban Heat Island. *Applied Ecology and Environmental Research* 2012:10(2):173–183.

[42] Evans J. M., Schiller S. D. Application of microclimate studies in town planning: a new capital city, an existing urban district and urban river front development. *Atmospheric Environment* 1996:30(3):361–364. doi:10.1016/1352-2310(94)00138-3

[43] Eliasson I. The use of climate knowledge in urban planning. *Landscape and Urban Planning* 2000:48(1):31–44. doi:10.1016/S0169-2046(00)00034-7

[44] Aynsley R., L. Gulson. Microclimate and urban planning in the humid tropics. Paper presented at RAPI 27th National Congress, 19–22 September, Northern Territory Dept. of Lands, Planning and Environment, Darwin, Australia, 1999.

[45] Givoni B., Noguchi M., Saaroni H., Pochter O., Yaacov Y., Feller N., Becker S. Outdoor comfort research issues. *Energy and buildings* 2003:35(1):77–86. doi:10.1016/S0378-7788(02)00082-8

[46] Weller R. Landscape (Sub)Urbanism in Theory and Practice. *Landscape Journal* 2008:27(2):255–278. doi:10.3368/lj.27.2.247

[47] Al-Hemaidi W. K. The metamorphosis of the urban fabric in Arab-Muslim City: Riyadh, Saudi Arabia. *Journal of Housing and the Built Environment* 2001:16(2):179–201. doi:10.1023/A:1017908616597

[48] Andreou E. The effect of urban layout, street geometry and orientation on shading conditions in urban canyons in the Mediterranean. *Renewable Energy* 2014:63:587–596. doi:10.1016/j.renene.2013.09.051

[49] Dimoudia A. Kantziouraa A. Zorasa S. Pallasb C. Kosmopoulos P. Investigation of urban microclimate parameters in an urban center. *Energy and Buildings* 2013:64:1–9. doi:10.1016/j.enbuild.2013.04.014

[50] Yahia M. W., Johansson E. Influence of urban planning regulations on the microclimate in a hot dry climate: The example of Damascus, Syria. *Journal of Housing and the Built Environment* 2013:28:51–65. doi:10.1007/s10901-012-9280-y

[51] ShashuaBar L., Pearlmutter D., Erell E. The influence of trees and grass on outdoor thermal comfort in a hot arid environment. *International journal of climatology* 2011:31(10):1498–1506. doi:10.1002/joc.2177

[52] Kantzioura A., Kosmopoulos P., Zoras P. Urban surface temperature and microclimate measurements in Thessaloniki. *Energy and Buildings* 2012:44:63–72. doi:10.1016/j.enbuild.2011.10.019

[53] Andreou E., Axarli K. Investigation of urban canyon microclimate in traditional and contemporary environment. Experimental investigation and parametric analysis. *Renewable Energy* 2012:43:354–363. doi:10.1016/j.renene.2011.11.038

[54] Hwang P. L., Lin T. P., Matzarakis A. Seasonal effects of urban street shading on long-term outdoor thermal comfort. *Building and Environment* 2011:46(4):863–870. doi:10.1016/j.buildenv.2010.10.017

[55] Krüger E. D., Drach P., Emmanuel R., Corbella O. Urban heat island and differences in outdoor comfort levels in Glasgow, UK. *Theoretical and Applied Climatology* 2013:112:127–141. doi:10.1007/s00704-012-0724-9

[56] Shashua-Bar L., Tsiros L. X., Hoffman M. Passive cooling design options to ameliorate thermal comfort in urban streets of a Mediterranean climate (Athens) under hot summer conditions. *Building and Environment* 2012:57:110–119. doi:10.1016/j.buildenv.2012.04.019

[57] Mahmoud A. H. A. Analysis of the microclimatic and human comfort conditions in an urban park in hot and arid regions. *Building and Environment* 2011:46(12):2641–2656. doi:10.1016/j.buildenv.2011.06.025

[58] Bourbia F., Boucheriba F. Impact of street design on urban microclimate for semi arid climate (Constantine). *Renewable Energy* 2010:35(2):343–347. doi:10.1016/j.renene.2009.07.017

[59] Djenane M., Farahi A., Benzerzour M., Musy M. Microclimate behaviour of urban forms in hot dry regions, towards a definition of adapted indicators. 25th International Conference on Passive and Low Energy Architecture PLEA, Dublin, 2008.

[60] Pearlmutter D., Berliner P., Shaviv E. Integrated modeling of pedestrian energy exchange and thermal comfort in urban street canyons. *Building and Environment* 2007:42(6):2396–2409. doi:10.1016/j.buildenv.2006.06.006

[61] Georgakis Ch., Zoras S., Santamouris M. Studying the effect of “cool” coatings in street urban canyons and its potential as a heat island mitigation technique. *Sustainable Cities and Society* 2014:13:20–31. doi:10.1016/j.scs.2014.04.002

[62] Johansson E. Influence of urban geometry on outdoor thermal comfort in a hot dry climate: A study in Fez, Morocco. *Building and Environment* 2006:41(10):1326–1338. doi:10.1016/j.buildenv.2005.05.022

[63] Johansson E., Emmanuel R. The influence of urban design on outdoor thermal comfort in the hot, humid city of Colombo, Sri Lanka. *Int. Journal of Biometeorology* 2006:51(2):119–133. doi:10.1007/s00484-006-0047-6

[64] Bourbia, F., Awbi, H. Building cluster and shading in urban canyon for hot dry climate: Part 1: Air and surface temperature measurements. *Renewable Energy*. 2004:29(2):249–262. doi:10.1016/S0960-1481(03)00170-8

[65] Coronel J., Alvarez S. Experimental work and analysis of confined urban spaces. *Solar Energy* 2001:70(3):263–273. doi:10.1016/S0038-092X(00)00096-7

[66] Pearlmutter D., Bitan A., Berliner P. Microclimatic analysis of “compact” urban canyons in an arid zone. *Atmospheric Environment* 1997:33(24):4143–4150. doi:10.1016/S1352-2310(99)00156-9

[67] Nichol J. E. High-resolution surface temperature patterns related to urban morphology in a tropical city: A satellite-based study. *Journal of applied meteorology* 1996:35(1):135–146. doi:10.1175/1520-0450(1996)035<0135:HRSTPR>2.0.CO;2

[68] Ahmed K. S. A comparative analysis of the outdoor thermal environment of the urban vernacular and the contemporary development: Case studies in Dhaka. Proc. 11th International PLEA Conference, Dead Sea, 3–8 July, Ben Gurion, University of the Negev, Sede-Boker, 1994.

[69] Green K. C., Armstrong J. S., Graefe A. Methods to elicit forecasts from groups: Delphi and prediction markets compared. *The International Journal of Applied Forecasting* 2007:8:17–20.

[70] Ozer I. Multi-criteria group decision making methods using AHP and integrated web-based decision support systems. *Masters Abstracts International* 2007:46(3):168–180.

[71] Lamit H, Shafaghat A, Abd. Majid MZ, Keyvanfar A, Bin Ahmad MH, Malik TA. Grounded Group Decision Making (GGDM) Model. *Advanced Science Letters* 2013:19(10):3077–3080.

[72] Zvingule L., Kalnins S.N., Blumberga D., Gusca J., Bogdanova M., Muizniece I. Improved Project Management via Advancement in Evaluation Methodology of Regional Cooperation Environmental Projects. *Environmental and Climate Technologies* 2013:11:57–67. doi:10.2478/rtuect-2013-0008

[73] Safikhani T., Abdullah A. M., Ossen D. R., Baharvand M. Thermal Impacts of Vertical Greenery Systems. *Environmental and Climate Technologies* 2014:14(1):5–11. doi:10.1515/rtuect-2014-0007

[74] Bolonina A., Bolonins G., Blumberga D. Analysis of the Impact of Decreasing District Heating Supply Temperature on Combined Heat and Power Plant Operation. *Environmental and Climate Technologies* 2014:14(1):41–46. doi.10.1515/rtuect-2014-0013

Dr. Arezou Shafaghat has a Post-Doctoral award in Urban Computing. She received PhD in Urban and Transportation Planning in 2013 and M.Sc in Urban Design in 2009 from Faculty of Built Environment, Universiti Teknologi Malaysia.

At the moment, she is working as a senior lecturer Construction Research Center (CRC), Institute for Smart Infrastructure and Innovation Construction (ISIIC), Faculty of Civil Engineering, Universiti Teknologi Malaysia. She is the member of editorial board of the MIT-UTM joint journal.

Following are recently published journal articles; (i) Arezou Shafaghat, Ali Keyvanfar, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Kherun Nita Binti Ali, Mohd Hamdan Ahmad, Mohd Warid Hussin, Applicable User Satisfaction Index Analysis Model For Measuring User Satisfaction From Adaptive Behavior In Energy Efficient Buildings, Journal of Renewable & Sustainable Energy Reviews, Elsevier, in press, ISSN: 1364-0321. (ii) Ali Keyvanfar, Arezou Shafaghat, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Mohd Warid Hussin, Kherun Nita Binti Ali, Alshahri Dhafer Saad, User Satisfaction Adaptive Behavior Criteria For Assessing Energy Efficient Building Indoor Cooling And Lighting Qualities, Journal of Renewable & Sustainable Energy Reviews, Elsevier, 2014, Volume 39, 277–293, Elsevier ISSN: 1364-0321. (iii) Arezou Shafaghat, Ali Keyvanfar, Hasanuddin Lamit, Seyed Ali Mousavi, Mohd Zaimi Abd Majid, 2014, Open Plan Office Design Features Affecting Staff's Health and Well-being Status, Jurnal Teknologi (Sciences & Engineering) 70:7 (2014), 83–8.

In 2014, she awarded a Gold medal for development of the Path Walkability Index (PAWDEX) analysis software, and a Gold Model for production of Bio-Self-Healing Concrete (SUSCRETE).

Contact Details:
Construction Research Center (CRC), Institute for Smart Infrastructure and Innovation Construction (ISIIC), Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia
Email: arezou@utm.my, arezou.shafaghat@gmail.com; Office Tel.: +60-7-55-32728; H/P: +60-17-8430730

Golnoosh Manteghi received M.A of architecture (sustainability) in 2009 and bachelor of architecture in 2004, from Islamic Azad University of Iran "Qazvin branch," with first class honor. She started her PhD in university technology Malaysia since 2013. At the moment, she is a graduate assistant at university technology Malaysia.

She has conducted some studies in the different field such as sustainable solar design, green architecture and mitigating urban heat islands and thermal comfort. Following is recently published journal articles; (i) Golnoosh Manteghi, Hasanuddin bin limit, Dilshan Remaz (2015); "Water Bodies an Urban Microclimate: A Review" modern applied science. vol. 9, no. 6 Canadian Center of Science and Education 2015. (ii) Ardalan Aflaki, Norhayati Mahyuddin, Golnoosh Manteghi, Mohamad Rizal Baharum (2014); "Building Height Effects on Indoor Air Temperature and Velocity in High Rise Residential Buildings in Tropical Climate" OIDA International Journal of Sustainable Development. vol. 9, issue 07 (39–48). She got International Doctorate fellowship 2014/2015; and the Graduate assistantship (GA) Scheme Award 2013/2014 from University Technology Malaysia (UTM).

Contact details:
Centre for Study of Built Environment in the Malay World (KALAM), Faculty Built Environment, University Technology Malaysia, UTM Skudai, 81310, Johor, Malaysia
E-mail: mgolnoosh2@live.utm.my; Tel.: +60-1-11-0692007

Dr. Ali Keyvanfar has a Post-Doctoral award in Civil Engineering. He received PhD in Civil Engineering in 2013 and M.Sc in Construction Managemnet in 2009 from Faculty of Civil Engineering, Universiti Teknologi Malaysia.

At the moment, he is working as a senior lecturer in Construction Research Center (CRC), Institute for Smart Infrastructure and Innovation Construction (ISIIC), Faculty of Civil Engineering, Universiti Teknologi Malaysia. He is a editorial board member of the MIT-UTM joint journal.

Following are recently published journal articles; (i) Ali Keyvanfar, Arezou Shafaghat, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Mohd Warid Hussin, Kherun Nita Binti Ali, Alshahri Dhafer Saad, User Satisfaction Adaptive Behavior Criteria For Assessing Energy Efficient Building Indoor Cooling And Lighting Qualities, Journal of Renewable & Sustainable Energy Reviews, Elsevier, 2014, Volume 39, 277–293, Elsevier ISSN: 1364-0321. (ii) Arezou Shafaghat, Ali Keyvanfar, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Kherun Nita Binti Ali, Mohd Hamdan Ahmad, Mohd Warid Hussin, Applicable User Satisfaction Index Analysis Model For Measuring User Satisfaction From Adaptive Behavior In Energy Efficient Buildings, Journal of Renewable & Sustainable Energy Reviews, Elsevier, in press, ISSN: 1364-0321.

In 2014, he awarded a Gold medal for development of the Path Walkability Index (PAWDEX) analysis software, and a Gold Model for production of Bio-Self-Healing Concrete (SUSCRETE).

Contact Details:
Construction Research Center (CRC), Institute for Smart Infrastructure and Innovation Construction (ISIIC), Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia
Email: akeyvanfar@utm.my, alikeyvanfar@gmail.com; Office Tel.: +60-7-55-31612, H/P: +60-17-7033482

Assoc. Prof. Dr. Hasanuddin Lamit obtained his PhD in Landscape and Urban Design and M.A. in Landscape Design from University of Sheffield, and Bachelor of Architecture from University of Western Australia.

He is currently the head of Department of Landscape Architecture, Faculty of Built Environment at Universiti Teknologi Malaysia.

Following are recently published journal articles; (i) Arezou Shafaghat, Ali Keyvanfar, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Kherun Nita Binti Ali, Mohd Hamdan Ahmad, Mohd Warid Hussin, Applicable User Satisfaction Index Analysis Model For Measuring User Satisfaction From Adaptive Behavior In Energy Efficient Buildings, Journal of Renewable & Sustainable Energy Reviews, Elsevier, in press, ISSN: 1364-0321. (ii) Ali Keyvanfar, Arezou Shafaghat, Muhd Zaimi Abd Majid, Hasanuddin Bin Lamit, Mohd Warid Hussin, Kherun Nita Binti Ali, Alshahri Dhafer Saad, User Satisfaction Adaptive Behavior Criteria For Assessing Energy Efficient Building Indoor Cooling And Lighting Qualities, Journal of Renewable & Sustainable Energy Reviews, Elsevier, 2014, Volume 39, 277-293, Elsevier ISSN: 1364-0321. (iii) Arezou Shafaghat, Ali Keyvanfar, Hasanuddin Lamit, Seyed Ali Mousavi, Mohd Zaimi Abd Majid, 2014, Open Plan Office Design Features Affecting Staff's Health and Well-being Status, Jurnal Teknologi (Sciences & Engineering) 70:7 (2014), 83–8.

In 2014, she awarded a Gold medal for development of the Path Walkability Index (PAWDEX) analysis software.

Contact Details:
Department of Landscape Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia, 81300 UTM Skudai, Johor Bahru, Johor State. Malaysia; E-mail: b-hasanuddin@utm.my; H/P: 060-16-6912818

Dr. Kei Saito received his Master of Engineering degree in architecture and civil engineering from the Shibaura Institute of Technology (SIT), Japan in 2000, and his PhD degree in regional environment system from the SIT in 2003. From 2003 to 2007 he worked as a research fellow of Japan Society for the Promotion of Science (JSPS). Currently he has been working at University Technology Malaysia as a senior lecturer since 2008. His main fields of interest include urban environment analysis and design, urban greenery studies, and computer-aided design systems.

Contact details:
Department of Landscape Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia, Skudai, Johor, 81310, Malaysia
E-mail: kei@utm.my; Office Tel.: +60-7-55-37378, Fax: +60-7-5566155

Assoc. Prof. Dr. Dilshan Remaz Ossen obtained his PhD (Architecture) from Universiti Teknologi Malaysia in 2005, Bachelor of Science in Built Environment Degree in 1995 and Masters in Architecture Degree in 1998 from University of Moratuwa, Sri Lanka.

He worked as an architect in Sri Lanka before serving as a senior lecturer and as an associate professor at the Faculty of Built Environment Universiti Teknologi Malaysia. Following are recently published journal articles; (i) Tareq Gaber Farea, Dilshan Remaz Ossen, Saqaff Alkaff, Hisashi Kotani (2015) "CFD modeling for natural ventilation in a lightwell connected to outdoor through horizontal voids". Energy and Building 86 (2015) 502–513. (ii) Adeb Qaid Ahmed, Dilshan Remaz Ossen, Elmira Jamei & Norhashima Abd Manaf, Ismail Said, Mohd Hamdan Ahmad (2015); "Urban surface temperature behaviour and heat island effect in a tropical planned city". Theoretical and Applied Climatology. vol. 119, Issue 3–4 (493–514) Springer-Verlag Wien 2015. (iii) Tabassom Safikhani, Aminatuzuhariah Megat Abdullah, Dilshan Remaz Ossen, Mohammad Baharvand (2014), "A Review of Energy Characteristic of Vertical Greenery Systems". Renewable & Sustainable Energy Review 40 (450–462) Elsevier ISSN: 1364-0321. His research focus is on Sustainable City & Urban Climate, Climatic Consideration and Passive Design Strategies in Building, Energy Efficiency in Buildings and Urban Design & Conservation.

In year 2000, he obtained his professional qualification as a Chartered Architect and Associate membership after completion of SLIA Part III examination from Sri Lanka Institute of Architects (AIA-2000, ARB-2008).

Contact Details:
Fakulti Alam Bina, Universiti Teknologi Malaysia, 81300 UTM Skudai, Johor Bahru, Johor State. Malaysia
E-mail: ardrossen@gmail.com / b-dilshan@utm.my; Office Tel.: +(6)07-55-37364; Fax No: +(6)07-55-66155