Urban planning and climate issues of Beirut and Hamburg: Comparison of approaches and decision-making tools

Noushig Kaloustian[1], Youssef Diab[2], Benjamin Bechtel[3], Jürgen Ossenbrügge[3]

[1] *Université Paris-Est, Marne La Vallée, France in joint supervision with Institut d'Urbanisme, Académie Libanaise des Beaux-Arts – ALBA, Université de Balamand, Beirut, Lebanon* noushigk@gmail.com

[2] *Université Paris-Est, Ecole des Ingènieurs de la Ville de Paris, France,* youssef.diab@univ-mlv.fr

3 Institute of Geography, University of Hamburg, Germany benjamin.bechtel@uni-hamburg.de juergen.ossenbruegge@uni-hamburg.de

dated: 29 August 2015

1. Introduction

One of the best-known effects of urbanization on the local climate is urban warming, more commonly referred to as the urban heat island (UHI). The UHI can lead to negative effects on air quality, energy consumption levels, human health, and even mortality rates. Besides these impacts and the ongoing research in urban climatology, a lack of transfer to town planning has been reported (e.g. Oke, 2006). Moreover, there are clear links between the climate of a settlement and its potential sustainability – i. e energy supply and demand, and generation of airborne wastes depend on the climate while urban designs create microclimatic conditions that either accentuate or moderate the background climate (Mills, 2006). Hence, settlement planning can be considered a key aspect of sustainability in an urbanizing world and the routine incorporation of urban climate knowledge has large potential. Applied urban climate research therefore has to link more explicitly to the objectives of the sustainable settlement (ibid). Additionally, global warming is likely to increase some of the negative effects of the urban thermal climate and adaption must start early given the long cycles in typical urban renewal processes. While certain progress in this direction can be seen in some cities, the way ahead is still far. However, there are discrepancies in the problems themselves, the achieved level of integration of urban climatic aspects in the planning process, as well as the hindering factors. Therefore, comparison between cities as well as propagation of good practice might be a suitable approach to improve the incorporation of urban climatic knowledge in the planning process. In this paper, a comparison of the various approaches and decision-making tools for urban planning and related climatic issues in Beirut and Hamburg is made with the aim to improve the current management of urban climatic risks.

2. The cities of Beirut and Hamburg

Beirut (33.9 ° N, 35.5° E) is the capital city of Lebanon. It is a coastal city along the Mediterranean Sea, covering a surface area of approximately 20 km^2 (Figure 1) with a population of about 500,000 (MOE/ECODIT/LEDO, 2001) and a very high population density of about 21,000 inhabitants per km^2. Beirut is a predominantly artificial city, comprised primarily of concrete roofs, asphalted roads and a small fraction of urban vegetation; therefore contributions to the effects on UHI are expected to be high.

The Free and Hanseatic City of Hamburg (53.5° N, 10.0° E) is the second biggest city in Germany with about 1.8 Mio inhabitants within the administrative borders and about 4.3 million in the metropolitan region. It covers an area of 755 km^2 and is situated in the northern German lowlands. Unlike Beirut, the city is characterized by large water bodies and numerous green spaces as well as street trees and is therefore already quite well adapted to heat stress.

Figure 1. (a) Dense artificial city of Beirut; (b) City of Hamburg (administrative borders) and observation networks. Imagery: Google Earth (2015).

3. Urban climate in Beirut and Hamburg

3.1 Beirut

Beirut has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters. The number of a hot summer days has been found to be increasing significantly especially during this last decade (Hatzaki, Giannakopoulos, Hadjinicolaou, & Kastopoulou, 2010). A recent modeling of the urban heat island phenomenon in Beirut city (Kaloustian & Diab, 2015) using the Town Energy Balance of Météo France (Masson, 2000) indicates that the few existing areas covered with larger fractions of vegetation have much cooler air temperatures than the rest of the city which is mainly covered by artificial, as opposed to natural, surfaces, with a difference in canyon temperatures that goes up to as high as 6^{o} C during the summer season (see Fig. 2 and Fig. 3). This is attributed to the lower solar reflectivity of the dominating urban surfaces and the cooling effect of trees via the process of evapotranspiration.

Although these results are not based on observational data, they reflect the significant impact of dominating dark artificial surfaces on the urban temperatures as opposed to areas with higher vegetation fractions. Therefore, these simulation results help to recommend suitable mitigating actions that involve increasing the albedo of rooftops and the fraction of gardens strategically throughout the city.

Figure 2. Canyon temperature simulations for the Control Run across Beirut on 01-Feb., 1200 UTC

Figure 3. Canyon temperature simulations for the Control Run across Beirut on 01-July, 1200 UTC

Being located within the Westerlies about 80 km from the North Sea and 70 km from the Baltic Sea, air temperatures are moderate throughout the year (with an annual mean of 9.0 °C) and mean wind speeds are comparably high (monthly means between 3.2 m/s and 4.7 m/s, Rosenhagen & Schatzmann 2009).The UHI of Hamburg was first analysed by Reidat (1971) who found a mean air temperature difference of 0.6 K in January and 1.0 K in July between meteorological stations in St. Pauli (a densely built district close to the inner city) and at the airport in Fuhlsbüttel in the periphery. Schlünzen et al. (2010) analysed the mean daily heat island of five stations in Hamburg and one station in Ahrensburg, a town close to Hamburg, for the decade between 1988 and 1997. They report a mean heat island of 1.1 K for St. Pauli and 0.6 K for Fuhlsbüttel compared to a reference station in Grambek east of Hamburg. Arnds et al. (2015) extended this work and analyses data from six station networks and more recent data. Figure 4 shows the mean nocturnal UHI (differences in minimum temperatures compared to two rural reference station) for these networks. The 40 stations showed an average nocturnal UHI of 1.2 K and a considerable spatial variation which essentially showed a radial gradient and good agreement with the urban morphology.

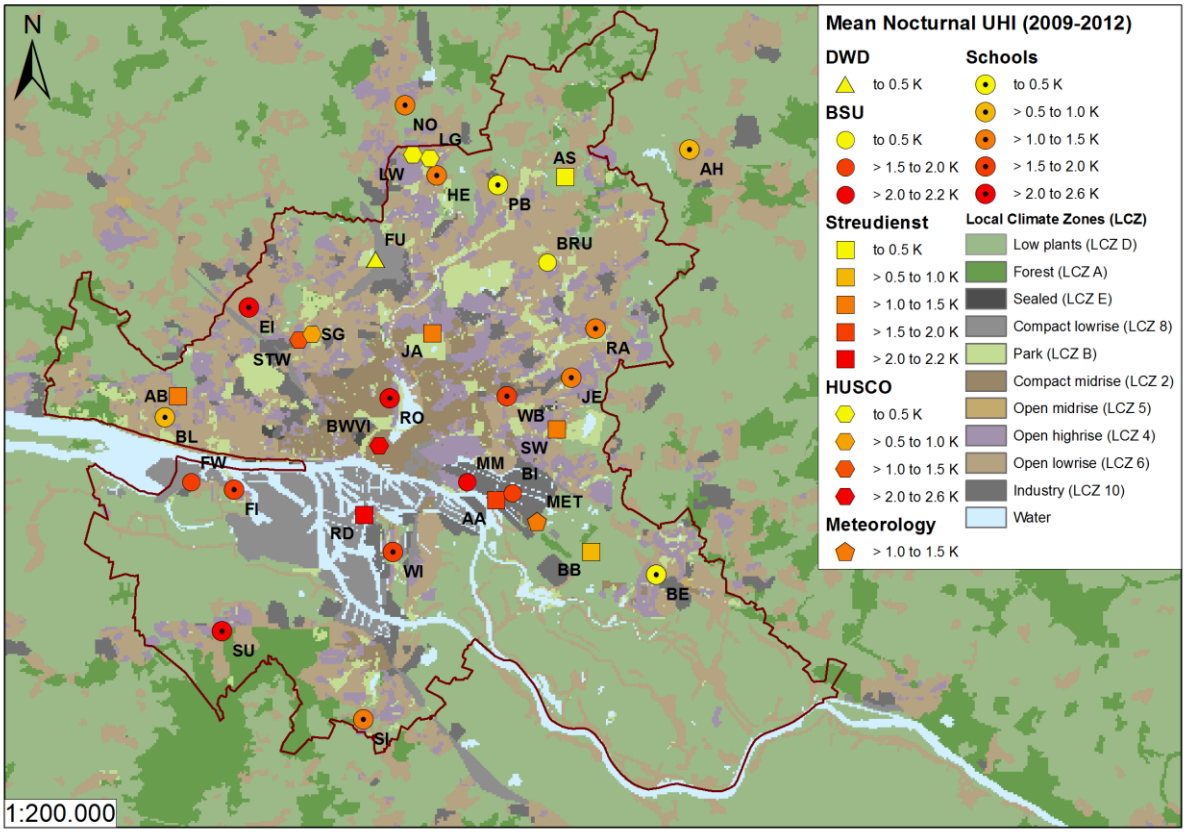

Figure 4. Spatial distribution of mean nocturnal UHI intensity in K from 2009 to 2012 (Arnds et al. 2015).

4. Urban planning policies in Beirut and Hamburg

4.1 Beirut

The urban planning framework of Lebanon is comprised of the Urban Planning Law #69 (dated 1983) and the Building Code #646 (dated 2004). Although drafted and approved during a period of great civil unrest and political insecurity in the country, the new modified law took into consideration the environmental discipline in 8 of its directives but none of these mention the strong need to protect the urban climate. Today, it is the Construction Law #646 that is the centerpiece of all construction activities in Lebanon. This code introduced some important requirements for the protection of the environment and landscape although again there are no specific requirements that take into consideration the urban

climate. In addition, communication amongst all relevant authorities and parties is not efficient and actions toward achieving more sustainable urban planning practices are weak and can have serious implications on the surrounding environmental quality as witnessed in the recent assessment of the state of the environment of Beirut (MOE/UNDP/ECODIT, 2010). These conditions can consequently have serious repercussions on the health and overall quality of life of Beirut's urban dwellers as concluded in an important study that found a close link between high temperatures and mortality in Beirut (El Zein, et al., 2004). It is therefore imperative to ensure that the relevant decision-makers more seriously take into consideration the impacts of UHI and implement measures that can help to alleviate their impacts. As a first step and in order to potentially provide the scientific evidence to decision-makers, it is necessary to analyze the intensity of this phenomenon in the city of Beirut which has not previously been conducted.

4.2 Hamburg

Environmental protection as a distinct political field has been established in the *Free and Hanseatic City of Hamburg* already in the 1980s because of growing problems with air pollution, congestion of the river Elbe and the port of Hamburg, and derelict areas of old industries. Because of growing concern on climate issues the Senate of the city launched a first program with far reaching mitigation goals for the period between 2007 and 2012 which listed about 500 different projects which have been planned, started or realized within this period. A strong support for these ambitious efforts was the competition for being *European Green Capital* which was achieved for the year 2011. Further efforts to improve climate protection have been provided by special financial support for energy efficient new buildings, retrofitting the existing building stock and the integration of renewable energies which are besides greening public transport and port related issues still main fields of climate protection politics in Hamburg. Additionally, the *International Building Exhibition* (IBA) served as an innovation lab, because Hamburg used the site of the IBA, Wilhelmsburg, to set up important pilots for the integration of renewable energies, different types of passive or plus-energy homes, and urban climate labs to change consumer behaviour.

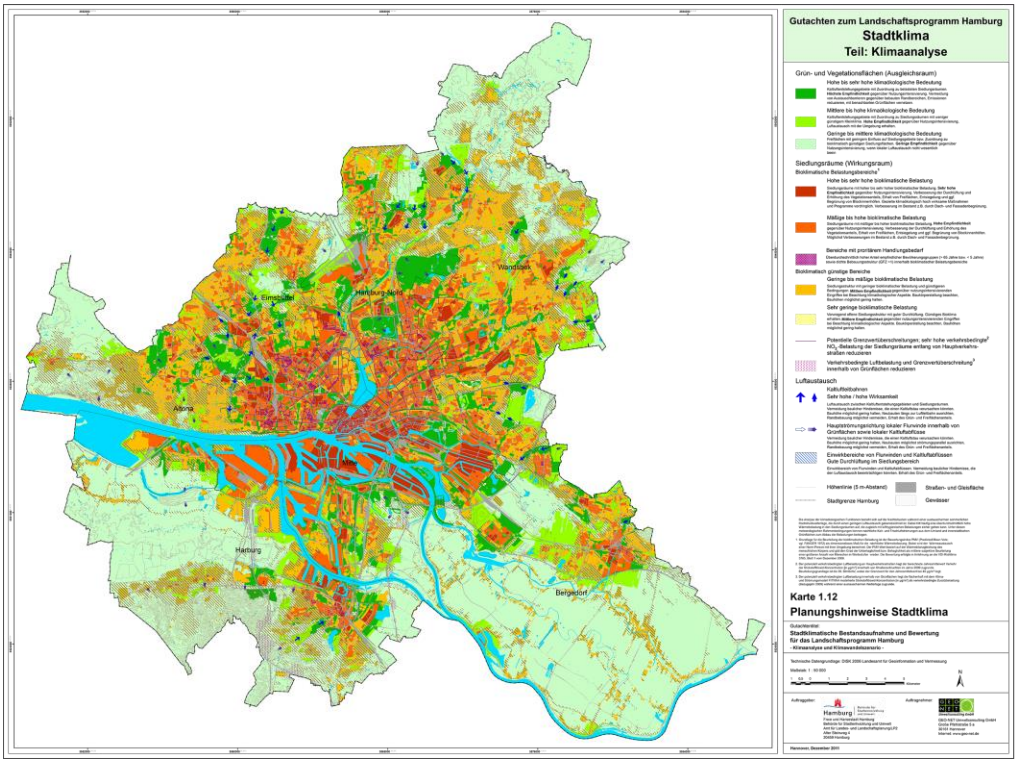

Figure 5. Climate analysis map based on FITNAH model simulations (GEO-NET, 2012).

In 2013 the *master plan climate protection* was introduced in order to update the old program (BÜSCHA, 2011). The overall goals were underlined which attempt to reduce CO_2 of about 40 % with

reference to 1990 until 2020 and about 80 % to 2050. The master plan outlines a holistic approach which includes the already mentioned intervention fields. As a new element the plan outlines goals for climate change adaptation, which is also subject of the *action plan adaption to climate change* (BÜSCHA, 2013). Measures against overheating, flooding and heavy precipitation are mentioned. Additionally, the *landscape programme* (a supplementary planning guideline) includes a climate analysis map (see Figure 5) based on an urban climatic assessment with the model FITNAH (GEO-NET, 2012). An important element in the adaption policy is the green roof strategy, which promotes roof greening by direct subsidies as well as well as reduced sewage charges. Further, the city founded several reports on the urban climate. Generally, the awareness about potential future urban heat risks is high in administration and government.

4.3 Comparison

A comparison between Beirut and Hamburg for approaches and tools used in management of urban climates is given in Table 1.

Table 1. Comparison between Beirut and Hamburg for approaches and tools used in management of urban climates

Approaches and tools	Beirut	Hamburg
Meteorological stations for observation/measurement of UHI	None	Several networks of differing accuracy (see Figure 4): i.e. synoptic station of the German Weather Service; observational networks including flux measurements of the Meteorological Institute.
Decision-making tools to protect the urban climate	None although it has been proposed to use TEB as a decision-making tool in future sustainable urban planning and design practices of the city as part of an evidence-based planning approach.	Urban climatic assessment and climate analysis map based on model FITNAH as basis of the *landscape programme* (GEO-NET, 2012), see Figure 5. Study of German Weather Service is currently in preparation.
Relevant urban policies and legislation	UP Law #69 (1983) Building Code #646 (2004): neither consider protection of the urban microclimate	Building code (BauGB), *Fortschreibung des Hamburger Klimaschutzkonzepts 2007–2012* (BÜSCHA 2011), *Aktionsplan Anpassung an den Klimawandel* (BÜSCHA 2013)
Institutional framework	No communication between relevant parties and clear lack of urban climatic knowledge amongst the decision-makers	Increased awareness in the municipal administration. No persistent framework but good cooperation within projects and studies.
Adaptation measures	The Ministry of Environment has recently published its second national communication to the United Nations Framework Convention on Climate Change in which some adaptation measures targeting the environmental sector are highlighted although none specifically mention measures for the urban microclimate such as building code modifications, planting of more urban vegetation and so on (MOE/GEF/UNDP, 2011).	Green roof strategy, development of street trees.

5. Conclusions

In this paper, the thermal urban climates in both the cities of Beirut and Hamburg are outlined and approaches and tools for UHI management are compared. In Beirut, no observations or data are available on this topic, however, a recent simulation of the UHI of the city was conducted using the Town Energy Balance of Météo France and these results show the significant impact of urban surfaces on urban temperatures as opposed to vegetated areas. A future campaign that can be organized by relevant

authorities and that involves setting up meteorological stations as a start to obtain observational data across the entire city is recommended, in order to closely follow-up on the UHI of Beirut and the proposed adaptation measures. In Hamburg on the other hand, observational data is available from several networks, which partly compensates that the German Weather service recently shut down some of its stations.

In terms of approaches and tools for UHI management, these are nominal in Beirut since not even the relevant legislations like the Urban Planning Law #69 or the Building Code #646 consider the need to protect the urban microclimate. In addition, transfer of urban climatic knowledge amongst the relevant authorities is clearly lacking and thus far there has been no scientific evidence to indicate the intensity of UHI at the city scale. As for Hamburg, the city is already quite well adapted to heat stress and much work has been carried out in this regard as outlined in *the master plan climate protection*, and the *action plan adaption to climate change*. Even though these guidelines are not binding and it remains to be seen which weight climate protection and adaption will finally have in the consideration of various conflicting interests, it can be stated that the awareness in administration and government is quite high. Although Hamburg is certainly privileged in some general conditions including economic, climatic and security factors, it might be concluded that Beirut can learn from the experiences of Hamburg and potentially implement similar measures to combat heat stress in the city.

References

Arnds, D., J. Böhner, and B. Bechtel, 2015: Spatio-temporal variance and meteorological drivers of the Urban Heat Island in a European city. *Theor Appl Climatol*, **in review**.

BÜSCHA, 2011: Drucksache 19/8311. Fortschreibung des Hamburger Klimaschutzkonzepts 2007–2012. http://www.hamburg.de/contentblob/4028938/data/klimaschutzkonzept-fortschreibung-3.pdf

BÜSCHA, 2013: Drucksache 20/8492, Aktionsplan Anpassung an den Klimawandel, http://www.hamburg.de/contentblob/4357564/data/d-20-8492-aktionsplan-anpassung-an-den-klimawandel.pdf

El Zein, A., M. Tewtel-Salem, & G. Nehme. 2004. A Time-Series Analysis of Mortality and Air Temperature in Greater Beirut. *Science of the Total Environment,* **330**, 71-80.

GEO-NET, 2012: Stadtklimatische Bestandsaufnahme und Bewertung für das Landschaftsprogramm Hamburg Klimaanalyse und Klimawandelszenario 2050. http://www.hamburg.de/contentblob/3519382/data/gutachten-stadtklima.pdf

Hatzaki, M., Giannakopoulos, C., Hadjinicolaou, P., & Kostopoulou, E. 2010. Information sheet on observed climate indicators for the CIRCE urban case studies: Beirut, Lebanon.

Kaloustian, N., & Diab, Y. 2015. Effects of Urbanization on the Urban Heat Island in Beirut. Manuscript submitted for publication.

Masson, V. 2000. A physically-based scheme for the urban energy budget in atmospheric models. *Boundary-Layer Meteorology,* **94(3**), 357-397.

Ministry of Environment/UNDP/ECODIT. 2011. Lebanon State of the Environment Report. Retrieved from http://www.undp.org.lb/communication/publications/downloads/SOER_en.pdf

Ministry of Environment/Lebanese Environment and Development Observatory (LEDO)/ECODIT. 2001. Lebanon State of the Environment Report. Retrieved from http://www.unep.org/dewa/westasia/Assessments/national_SOEs/west%20asia/Lebanon/Chap1Population.pdf

Ministry of Environment/GEF/UNDP. 2011. Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change. Retrieved from http://unfccc.int/resource/docs/natc/lebanon_snc.pdf

Oke, T. R., 2006: Towards better scientific communication in urban climate. Theoretical and Applied Climatology, **84**, 179–190.

Reidat, R., 1971: Temperatur, Niederschlag, Staub. Deutscher Planungsatlas Band VIII: Hamburg, Lieferung 7.

Rosenhagen, G., M. Schatzmann, and A. Schrön, 2011: Das Klima der Metropolregion auf Grundlage meteorologischer Messungen und Beobachtungen. *Klimabericht für die Metropolregion Hamburg*, Springer, 19–59.

Schlünzen, K. H., P. Hoffmann, G. Rosenhagen, and W. Riecke, 2010: Long-term changes and regional differences in temperature and precipitation in the metropolitan area of Hamburg. Int. J. Climatol., **30**, 1121–1136, doi:10.1002/joc.1968.