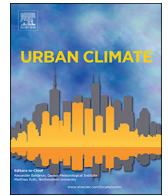




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Collection of refined architectural parameters by crowdsourcing using Facebook social network: Case of Greater Tunis

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ABSTRACT

The urban heat island, especially in low-income countries, increases the consequences of heatwaves. Urban micro-climate studies could help to manage heatwave crises and improve urban planning. However, they require accurate urban data, and such are often not available in African countries. This paper presents a crowdsourcing methodology using a very popular social media in this region, Facebook, to gather architectural information on buildings in the Greater Tunis agglomeration. Following WUDAPT protocol, the questions encompassed number of floors, window pattern, color, wall fabric, air-conditioning (AC) and building's use. More than 100 answers were gathered. An expert validation shows an accuracy of more than 85% on all parameters. The geo-localized sampled buildings were associated to Local Climate Zones. These are shown to be pertinent in Tunis. In this hot and dry climate, recent houses with many windows are found to be more equipped with AC than those using traditional construction methods with just a few windows. Mid-rise buildings follow modern construction paradigm, with many or even plate glass windows, and therefore use AC. Finally, this application of crowdsourcing to urban climate science through a social media questionnaire allows to propose architectural parameters for urban climate models in this region of North Africa.

1. Introduction

In the current context of climate change, cities play a major and complex role by amplifying this phenomenon at different scales. On the one hand, they contribute to global warming, through greenhouse gas emissions from human activities (road traffic, domestic heating and cooling, industries, etc.); on the other hand, this global warming is amplified in the heart of the cities by the specific micro-climates that reign there, a well-known phenomenon called 'urban heat island'. This makes adaptation to climate change a new challenge for all cities in the world, regardless of their location and size. Many efforts are being made in northern cities to integrate climate issues into urban planning and development, such as the development of cartographic analysis tools. Among the efforts provided by the researcher community, the WUDAPT project aims to collect at international scale urban data needed for urban climate simulation, the results of which will support climate change adaptation policies.

Different methods are being used to collect architectural information for micro-climatic modelling purposes depending on the availability of morphological urban data. There is mainly the expertise produced by architects such as that of Tornay et al. (2017) when such data is available, but also the crowdsourcing approach, that can be especially efficient for regions with scarce urban data.

In the urban climate scientific field, the use of crowdsourced meteorological observations, especially from personal miniature meteorological stations has been explored (e.g. Chapman et al., 2017 in London, De Vos et al., 2017 in Amsterdam, Napoly et al., 2018 in Paris and Berlin). Fenner et al. (2017) studied the variability of urban air temperature in Berlin at different scales using such crowdsourced meteorological stations. However, crowdsourcing methods are still rarely developed in the objective to describe the

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city structure in relation with urban climate issues. The few existing research actions aiming to provide urban morphological parameters are usually grounded on crowdsourced data that was gathered for other aims. Open Street Map (OSM), which gathers millions of contributors around the world, provides open-source road and building maps. This offers a lot of opportunities to derive urban parameters at the scale pertinent for urban climate models. Olbricht (2015) and Boeing (2017) used OSM to define refined land cover maps. Concerning morphological parameters, Biljecki et al. (2017) developed a statistical method to be able to estimate building heights in OSM, because this information, crucial for urban climate as for many urban scientific fields, is often missing. Several methodologies are also developing on the analysis of Google street view images to derive estimated morphological information, and especially the Sky View Factor (the fraction of sky seen from the ground) (Liang et al., 2017; Middel et al., 2018, 2019). Thanks to the tags available in OSM to describe the functions of the buildings, methodologies have been developed to estimate building's uses (Fonte et al., 2018; Kunze and Hecht, 2015). About building materials, Han and Golparvar-Fard (2017) propose a tool to annotate buildings pictures used in Building Information Modelling (BIM) to describe the type of material used. They suppose that the use of their tool could help to enlarge their Construction Material Library. However, only 3 building projects were explored to validate the method, and no practical case to gather information at city scale was done. Furthermore, this require to have access to BIM information.

So, very few methodologies exist to gather architectural and material information by crowdsourcing techniques. So, a sampling methodology was proposed within the framework of the WUDAPT project (See et al., 2015). WUDAPT is an initiative of researchers in urban climate to provide mapping of cities for high-resolution urbanized atmospheric models. Several levels of details are proposed in this framework. Level 0, WUDAPT-L0 (Ching et al., 2018), aims at describing the neighborhoods of the city using the Local Climate Zones (LCZ) land cover classification. For each LCZ urban parameters have to be set for modelling, as proposed by Stewart and Oke (2012). Then parameters can be computed at finer spatial scale in order to describe the real heterogeneity of the city structure (Ching et al., 2019). WUDAPT Level 1 methodology refines the definition of the LCZ parameters using local information. This may then provide variability between each LCZ, so variability at neighborhood scale. WUDAPT level 2 refers to mapping of parameters independently of LCZ, typically from building data (actual or 3D modelled, Ching et al., 2019) or possibly other sources (e.g. from remote-sensing evaluation, or other types of road surfaces). Such level 1 or level 2 fine description of the urban fabric will then have to be translated into pertinent model parameters, and will allow to evaluate urban climate impacts.

For this paper we will focus on the Greater Tunis case that belongs to the crowdsourcing approach. The aim is to collect architectural parameters such as building height, window description, building color and so on, that would be typical of neighborhoods in Greater Tunis Agglomeration (that refers to WUDAPT-level1 terminology, hereafter WUDAPT-L1). For this, we adopt a new method for collecting data based on a questionnaire diffused on social networks.

2. Study area

Greater Tunis is the capital region of Tunisia. It is located along the coast of the Mediterranean Sea. It covers a surface area of about 256,000 Ha and its population is about 2.6 million inhabitants. This region presents a complex environment consisting of basins, plains, lakes, lagoons and in particular a gulf that stretches about 200 km long.

This region is characterized by the lack of data describing urban areas. When it exists, it is scattered among different administrations and present difficult access even for research purposes.

In order to characterize the Tunis agglomeration site, a classification in LCZ was conducted according to the WUDAPT methodology (Bechtel et al., 2015). In total 226 training areas were collected using Google Earth. The spatial extent was set according to the overlap between different tiles of the Sentinel 2a data. The classification was conducted in SAGA-GIS (Conrad et al., 2015) using a Random Forest classifier and a majority post-filtering with a radius of 2. As features data from Sentinel 2, 6 scenes (level 1C) were selected (see Appendix A). All scenes were acquired between July 2017 and April 2018. All features were resampled to a common 100 m grid. The final features set is presented in Table A1.

On the LCZ map of Greater Tunis (Fig. 2), it can be seen that the urban structure is dominated by compact morphologies in the city center of Tunis. In the west of the city informal urbanization (compact low-rise zones) are in the areas adjacent to natural and agricultural spaces. We also notice the existence of two Lagoons (locally called Sebkh) one in the Northeast near to the Mediterranean Sea (lagoon of Ariana) and the other one more south west of the city (lagoon of Sijoumi). Another urban center is located in the southwest corner of Ariana Lagoon, this is Ariana downtown. The lake of Tunis is located between these two lagoons. On the north of the lake we notice the preponderance of LCZ 5 (open midrise). This area corresponds to a relatively new zone built as part of the project of urban development on the banks of the lake of Tunis.

3. Methodology: a social media questionnaire

A social media questionnaire was produced to collect WUDAPT-L1 architectural data. We focused on the following architectural parameters: height of building, roof types, building materials and windows description. This work contributes to the methods proposed to collect WUDAPT-L1 (Ching et al., 2019) architectural data in any city all over the world and more particularly in cities where there is a real lack of data such as southern cities.

To test and validate our crowdsourcing method, we chose to deploy it first on Tunis. Indeed, the fact that this city has partially the Google Street View tool, since March 2017, should allow us to test the questionnaire and then assess the relevance of the approach by comparing the results obtained through the investigation with those resulting from the use of Google Street View.

This method is part of the crowdsourcing approach of WUDAPT (See et al., 2015) with some modifications to adapt it to the

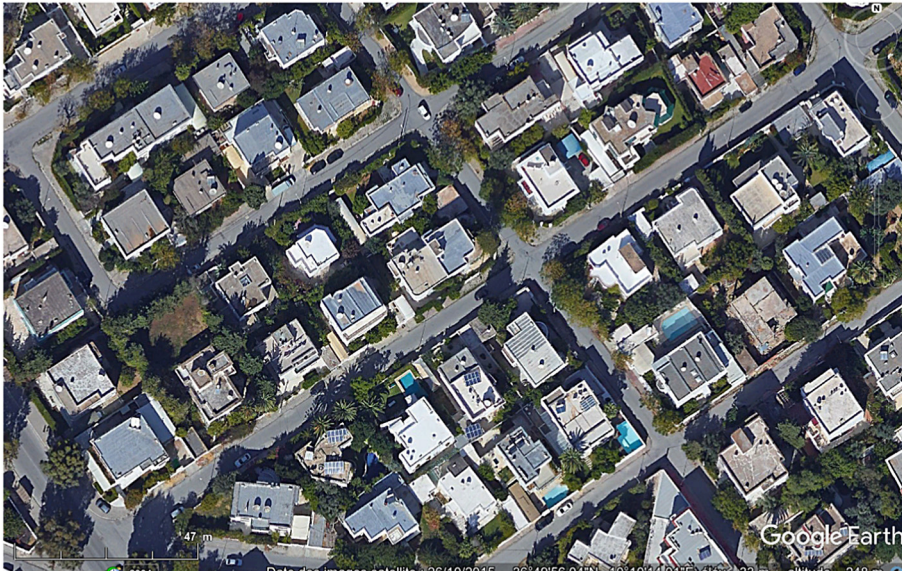


Fig. 1. Examples of roof Terrace in Mutuelleville neighborhood in Tunis (Google Earth Image).

targeted population. Indeed, the WUDAPT mobile application is intended for experts (architectural communities, students in urban planning or in architecture, etc.), while our questionnaire is aimed to a wider audience. For this, we changed the language to French and the order of the questions: the location first, followed by the question on the number of floors. We have removed the question on the roof description because in Tunisia, the majority of roofs are rooftop terraces as shown in Fig. 1.

We removed also the question related to the age of the building as we estimate that is complicated to answer for no expert contributors.

Most importantly we created a Google Form questionnaire, accessible on all devices with no installation necessary and shared it via Facebook in groups with motivated participants such as those of associations working on environmental issues. Our choice is based on the fact that social networks are very popular media in Tunisia. Since 2008, the use of Facebook has grown strongly in Tunisian society to circumvent the censorship that dominated the traditional media before the revolution of 2011 (Lecomte, 2011). According to the Medianet labs report (Medianet, 2016), Facebook remains the most used social-digital media in Tunisia with 6,100,000 users in 2016, so 55% of the population. We started from the assumption that the interest manifested for political life through social networks - and especially Facebook - could extend to environmental issues.

The questions and, when pertinent, the available answers of the questionnaire are the following (Table 1):

The French version of the questionnaire is presented in Appendix B.

For this questionnaire we have not established a sampling strategy, contrary to what is done in the method proposed in WUDAPT aimed to an expert public (See et al., 2015). For our methodology, we leave the free choice to the contributor to choose the building to inform about.

4. Results

The questionnaire was launched in January 2018 for a period of 5 months. We collected 110 responses concentrated mainly in Tunisia and its northwest. We had fewer responses in the south and northeast of the metropolitan area (Fig. 2).

Table 1
Questionnaire (translated in English).

-
- 1.Location (address)
 - 2.How many floors does the building have?
 - 3.What's the building use?
Residential/offices/industrial/commercial/mixed/other
 - 4.Is there an air conditioning system?
 - 5.Describe the building materials
Concrete&cement/brick/stone/metal/wood/raw earth (several answers available)
 - 6.Describe the windows
Plate glass windows/many windows/a few windows/no window
 - 7.Are the walls light or dark?
 - 8.Take a photograph of the building
-

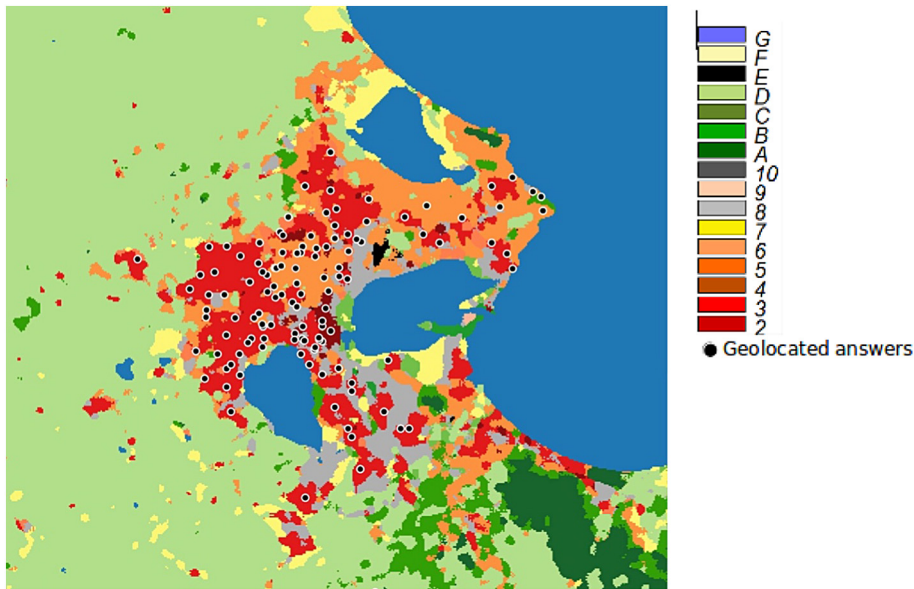


Fig. 2. Local Climate Zone map of Tunis with questionnaire's responses.

4.1. Validation of questionnaire's answers using Google Street View

To validate the questionnaire answers, we compared the results obtained through the investigation with those resulting from the use of Google Street View. As we mentioned earlier, Google Street View does not cover the entire territory of Greater Tunis, consequently we have 24 buildings located in these uncovered areas. So, we could not use them in the validation method. Therefore, up to 86 buildings, depending on the question, were available for cross-checking between the answers to the questionnaire from crowdsourcing and by the authors using Google Street View (Table 2). The few 'I do not know' answers were excluded from this comparison.

Number of floors are correct for 72 buildings (85%). An error of only 1 floor is encountered for 10 buildings (12%), seven of which are estimated to have one more floor by the authors. The question could have been understood ambiguously by the people, that could have counted only the upper floors and not included the ground floor. Complex shape of buildings could also potentially lead to various estimation of number of floors.

Building's use is a priori trickier to apprehend, even if it seems that the quality of the answers is comparable (81%). In the 86 compared buildings, identical answers were given for 51 residential buildings, 5 office buildings, 11 mixed buildings, 1 industrial one and 3 'other'. 15 answers were considered similar with the authors estimation when there was a combination of 'mixed/residential' (10 of them), 'mixed/office' (2 occurrences) or 'other/office' (3 occurrences). The latter often occurred for administration or school buildings, that we consider may indeed behave as offices from the micro-climatological point of view. The distinction between a 'mixed' building' use and a single use is also strongly subject to interpretation. One mixed building was also classified as 'other' by the contributor.

Wall color was very simple to identify (96% of accuracy), but this is linked to a strong bias in Tunis, where the vast majority of buildings are white painted (Fig. 4). From the 79 buildings where answers where identical, only 4 were dark, 75 being light-colored.

Windows coverage on building facades is in general difficult to evaluate; this is why it was decided within WUDAPT to ask for a broad description of windows (no window, a few, many, plate windows, glass building). Using such a description will need further a guess of building fraction from architectural expertise. The answers to the questionnaires showed that this approach was efficient, because it leads to high accuracy of 86%. The 10 similar answers are all between 'a few windows'/'many windows' different evaluations for each given building. This may be due to different interpretation again, or to window coverage somehow in the middle of

Table 2

Validation of questionnaire's answers: Number of identical, similar or different questionnaire answers between the crowdsourced responses and the authors for each parameter. See text for definition of 'similar' and 'different'.

	Identical	Similar	Different
Number of floors	72	10	3
Building's use	70	15	1
Air-conditionning	69		16
Wall color	79		3
Windows	72	10	1

each class.

The accuracy concerning the system of air conditioning is 81% (47 buildings with air-conditioning, 22 without, on this sample). This is slightly lower than for most of the other parameters. This can be explained by the fact that air conditioning systems are not always visible by Google Street View imagery. Of the 16 different answers, 12 are indeed due to an estimation of presence of air-conditioning by the contributor (who may know or even inhabit the building), and absence of it by the author (relying on Google Street View). This may be seen as a potential strongly positive contribution of crowdsourcing, by its local knowledge.

The results of validation show the relevance of this method of collecting data. Accuracy of identical answers varies at least between 81% and 86% for most of the different parameters (and 96% for wall color). When counting both identical and similar values, the accuracy goes up to 96% and 99% for number of floors, window coverage and building's uses. For air-conditioning, crowdsourcing is even probably more exact than the expert remote estimation. From this overall evaluation of the answers of the questionnaire, we consider the method, adapted from WUDAPT for Facebook diffusion, good for gathering architectural information for urban climate studies.

4.2. Urban structure analysis from the crowdsourced data

Looking at the results we got from the social media questionnaire, we have noticed that there are some homogeneous parameters such as buildings colors: the vast majority of buildings have light colors mostly white, we got only 6 buildings having dark colors. All crowdsourced answers also indicated the houses and buildings were built with concrete, brick and cement. For air-conditioner system, referring to the questionnaire, 71% of the answers indicate that buildings are air-conditioned, this even for some buildings in poor neighborhoods such as Ettadhamen.

When focusing on building height we can conclude that for low rise LCZ the two-storey buildings are preponderant, and more than 90% have no more than 3 floors (so approximately 10 m in height). Concerning LCZ 2 and LCZ 5 it is rather buildings of 4 or 6 floors (Fig. 3), and more than 85% have 4 floors or more. These results seem to indicate that the LCZ classification in low and mid-rise buildings is pertinent for the agglomeration of Tunis. There are few individual buildings that would have a height corresponding to another LCZ in each LCZ.

For window coverage fractions on facades, mid-rise buildings follow European ways of construction, with many windows (Fig. 4). Concerning houses and low buildings, one can consider that roughly half of low buildings have few windows and half have many regular windows. From Fig. 4, 'few windows' corresponds roughly to a coverage fraction of 0,1, and 'many windows' cover typically a fraction of 0,25 (a quarter) of each wall. There are 65 Residential houses (buildings less than or equal to 3 floors) documented by the questionnaire. One can suppose that houses with 'a few windows' correspond to traditional houses, and those with many regular are more recent. The answers cover almost evenly the traditional houses (30) and more recent ones (35).

There exist several reasons explaining why traditional houses have few, or even no window, on the road side. This type of houses is mainly located in informal neighborhoods of Tunis. For example, the popular neighborhoods of Saida Manoubia and Mellasine were built progressively on the shores of the Sijoumi lagoon during the 1940s. Their inhabitants are of rural origin so they reproduced the typical rural houses with a courtyard in the center (Fig. 5) which distributes all the rooms. So, all windows open on the courtyard and no or few windows are present on the outer walls (Santelli and Tournet, 1987).

Windows can be small in order to protect the house from thievery, as such houses often are in neighborhoods with a dangerous reputation (personal communication with local architects). Small windows also allow to protect themselves from external view. It can also be linked to vernacular architecture, helping to keep the heat outside the houses (El-Shorbagy, 2010). Finally, it should be noted that many of these houses are built without having to use (and pay) an architect. It is intuitively tentative to assign these traditionally

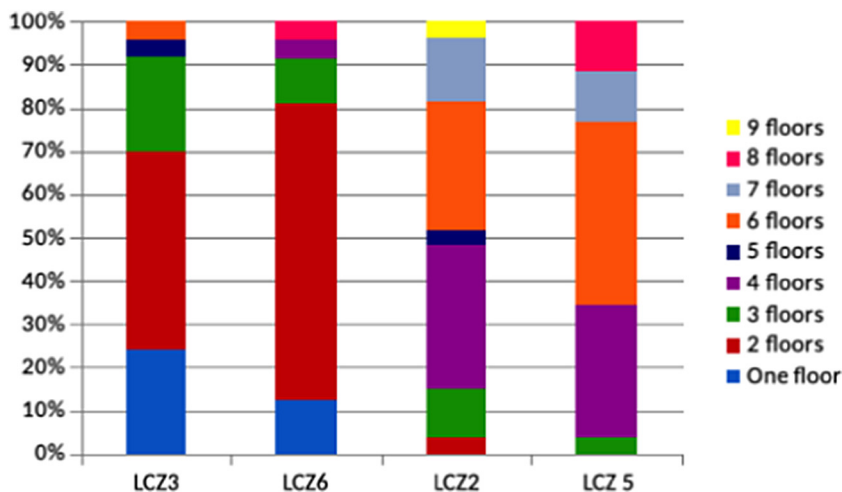


Fig. 3. Analysis of Number of floors of sampled buildings depending on LCZ.



Fig. 4. Example of windows description.

built houses to popular neighborhoods. However, from the building address from the questionnaires, only 19 such houses were in such areas, while the other are located in richer neighborhoods. It is not possible to assign traditional low buildings and houses to a given LCZ (e.g. LCZ 3, dense low-rise, corresponding to more popular neighborhoods, Fig. 6) and the more recent ones with a large number of windows to another LCZ (e.g. LCZ 6, open low-rise). Both types of houses are intertwined in the various neighborhoods of the city. We still noticed that for low rise LCZ (LCZ 3 and LCZ 6) the use of buildings is usually residential and such buildings often have few windows (Fig. 7).

This indeed corresponds to parts of Tunis that have old houses as well as traditional architecture houses. For LCZ 2 buildings there are many regularly spaced windows, we can find this type of buildings in the city centers and neighborhoods built during the 90s. Concerning LCZ 5, other than regularly spaced windows they are also characterized by buildings with plate glass windows usually found in rich neighborhoods built recently which include offices, residential and mixed usage.

In the 65 Residential houses sampled in the questionnaire, 37 are air-conditioned (57%), while 28 are not. When crossing with the air-conditioning equipment with the window coverage, one can see a tendency for the 30 houses with few windows, to have slightly less air conditioning (40%), than for the 35 houses with many regular windows (74% having air-conditioning). The number of answers is low from a statistical point of view. Still, these results, as well as the common architectural sense (traditional methods of



Fig. 5. Courtyards in Mellasine neighborhoods (in yellow, Google Earth Image). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)



Fig. 6. Examples of dense popular neighborhoods of Tunis (Google Earth Image).

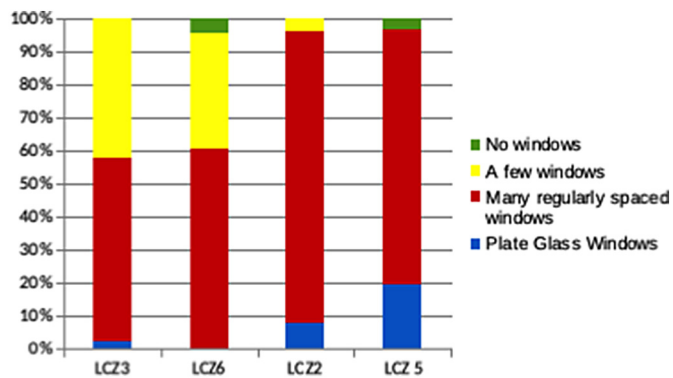


Fig. 7. Analysis of windows pattern by LCZ.

construction are more adapted for this hot and dry climate) allows us to propose a first guess on the proportion of air-conditioned houses in Greater Tunis.

Almost all other buildings (other heights and/or use) have air-conditioning (40 on 45). Therefore, a good approximation is to suppose they are systematically equipped with air-conditioning systems.

Table 3
Proposition of architectural information for Greater Tunis buildings' archetypes.

Archetype	Building's use	Time period	Wall color	Window coverage	Proportion of AC	Material	Present in
House	Residential	Traditional	White	0,1	0,4	Brick	LCZ 3, 6
House	Residential	Modern	White	0,25	0,7	Brick	LCZ 3, 6
House	Office	All	White	0,15	1	Brick	LCZ 3, 6
House	Mixed/other	All	White	0,15	1	Brick	LCZ 3, 6
Mid-rise	Residential	All	White	0,25	1	Brick	LCZ 2, 5
Mid-rise	Office	All	White	0,25	1	Brick	LCZ 2, 5
High-Rise	Office	All	White	0,5	1	Brick	LCZ 5

Building materials information was not discriminative enough in the questionnaire, almost all answers being 'concrete/cement' and 'brick'. This may be because the construction practice in Tunisia is that the walls are constructed of brick, the coatings are made of cement and the roofs in solid slab (reinforced concrete) or hollow slab (subfloor structure and reinforced concrete) (Comete engineering, 2011). So, we assume, from architectural expertise, that all low-rise buildings are primarily made of brick.

From the questionnaires results, we are now able to propose some values for the buildings' archetypes encountered in Greater Tunis (Table 3). These parameters can then be used to initialize urban climate models for the Greater Tunis, and, most probably, for whole Tunisia.

5. Conclusion

While they are of primarily importance for the description of the city and many urban studies, including urban climate, architectural parameters are difficult to gather and collect. We adapted a questionnaire, first aimed for mobile applications in the frame of the WUDAPT initiative, and deployed it using the Facebook social network. The choice of this social media was governed by the specificities of the studied site, in North Africa, where it is widely used.

Through the results of our questionnaire we managed to characterize LCZ architectural parameters for the case of Greater Tunis. The quality of the results has been evaluated through comparison with evaluations by the authors using Google street view (a rarity in the North Africa and Arabic countries), and showed very good accuracy. This gives us a part of the needed accurate urban data for urban climate simulations. A proposition to determine the actual value of several architectural and uses parameters for each of the LCZ present in Tunis has been done using the data locally collected by crowdsourcing.

This media questionnaire, with no need for installation, makes it possible to reach a wide audience in order to collect WUDAPT level 1 architectural data. Beyond this methodological objective, the proposed approach could strengthen the involvement of civil society in southern cities in the production of expertise on the city and raise citizens' awareness on the adaptation to climate change.

Declaration of Competing Interest

The authors do not declare any conflict of interest.

Acknowledgments

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Appendix A. Satellite information for the creation of Tunis LCZ map

Here is the reference to the satellite images used to produce the LCZ map of Greater Tunis that is used in this paper for the analysis of the crowdsourced questionnaire.

Table A1
Satellite images used for LCZ map creation.

Satellite	Scene ID	Date	Bands
Sentinel 2	S2B_OPER_MSI_L1C_TL_SGS_20170708T153020_A001764_T32SNF	08-07-2017	2–8, 8A, 11–12
	S2B_OPER_MSI_L1C_TL_SGS_20170708T153020_A001764_T32SPF		
	S2B_OPER_MSI_L1C_TL_MPS_20171105T122430_A003480_T32SNF	05-11-2017	
	S2B_OPER_MSI_L1C_TL_MPS_20171105T122430_A003480_T32SPF		
	S2B_OPER_MSI_L1C_TL_SGS_20180424T140025_A005911_T32SNF	24-04-2018	
	S2B_OPER_MSI_L1C_TL_SGS_20180424T140025_A005911_T32SNF_SPF		

Appendix B. Facebook questionnaire (in French)

Fig. B1 presents the introduction to the questionnaire. Page 1 is a presentation of the issue. Page 2 is an overview of all the questions. Fig. B2 are the details of each question on the Google doc form distributed by Facebook, with the available answers to select.

Participez à la description de votre ville pour le climat

« Vous habitez le Grand Tunis et vous n'en pouvez plus des périodes caniculaires pendant lesquelles il fait chaud même la nuit? Sachez que par la forme de ses bâtiments et par la nature de ses matériaux, la ville stocke et piège la chaleur issue du rayonnement solaire pendant la journée pour ensuite la libérer durant la nuit. C'est pour cela que vous êtes exposés à la chaleur jour et nuit.

En répondant à ce questionnaire, aidez nous à étudier l'environnement urbain du Grand Tunis et participez ainsi à la conception de stratégies d'adaptation de votre ville au risque de vagues de chaleur. Nous proposons ce questionnaire dans le cadre d'un travail de recherche que nous menons au LISST (Laboratoire Interdisciplinaire Solidarités, Sociétés, Territoires) et au CNRM (Centre National de Recherches Météorologiques) pour étudier les modalités d'adaptation du Grand Tunis aux vagues de chaleur. »



SUIVANT Page 1 sur 2

Pour nous aider à proposer aux acteurs locaux de votre ville des pistes d'amélioration de votre confort thermique estival, veuillez répondre à ce questionnaire.

Adresse du bâtiment que vous voulez décrire *
Numéro de bâtiment, Rue, Ville

Indiquez le nombre d'étages du bâtiment *

Quel est l'usage du bâtiment?

Existe-il un système de climatisation?

Quels sont les matériaux de construction?

Description des fenêtres

Les murs sont ils de couleur claire ou foncée?

Pourriez vous ajouter une photo du bâtiment?

RETOUR ENVOYER Page 2 sur 2

Fig. B1. Overview of the questionnaire.

Participez à la discription de votre ville pour le climat

*Obligatoire

Pour nous aider à proposer aux acteurs locaux de votre ville des pistes d'amélioration de votre confort thermique estival, veuillez répondre à ce questionnaire.

Adresse du bâtiment que vous voulez décrire *

Numéro de bâtiment, Rue, Ville

Votre réponse _____

Indiquez le nombre d'étages du bâtiment *

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- ~

Quels sont les matériaux de construction?

- Béton/ciment
- Brique
- Pierre
- Métal
- Bois
- Terre
- Je ne sais pas

Description des fenêtres

- Bâtiment tout en verre
- Des fenêtres nombreuses
- Des fenêtres peu nombreuses
- Pas de fenêtres
- Je ne sais pas

Les murs sont ils de couleur claire ou foncée?

- Claire
- Foncée

Quel est l'usage du bâtiment?

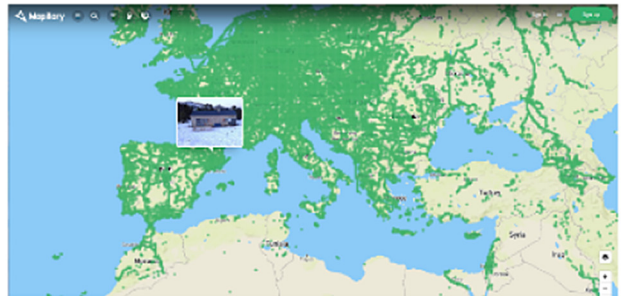
- Résidentiel
- Bureau
- Industriel
- commercial
- Mixte
- Autre
- Je ne sais pas

Existe-il un système de climatisation?

- Oui
- Non



Pourriez vous ajouter une photo du bâtiment?



- Oui. Pour ajouter la photo en un simple click, veuillez SVP vous connecter à Mapillary (www.mapillary.com)
- Oui. Vous pouvez également nous envoyer la photo avec l'adresse du bâtiment à l'adresse mail: ville.climat@gmail.com
- Non

RETOUR

ENVOYER

Page 2 sur 2

N'envoyez jamais de mots de passe via Google Forms.

Fig. B2. Detail of the questions and available answers. *top left:* Address & number of floors; *top right:* building's use and AC; *bottom left:* buildings materials, windows description and wall color; *bottom right:* picture of the building.

References

- Bechtel, B., et al., 2015. Mapping local climate zones for a worldwide database of the form and function of cities. *ISPRS Int. J. Geo Inf.* 199–219.
- Biljecki, F., Ledoux, H., Stoter, J., 2017. Generating 3D city models without elevation data. *Comput. Environ. Urban Syst.* 64, 1–18. <https://doi.org/10.1016/j.compenurbsys.2017.01.001>.
- Boeing, G., 2017. OSMnx: new methods for acquiring, constructing, analyzing, and visualizing complex street networks. *Comput. Environ. Urban Syst.* 65, 126–139. <https://doi.org/10.1016/j.compenurbsys.2017.05.004>.
- Chapman, L., Bell, C., Bell, S., 2017. Can the crowdsourcing data paradigm take atmospheric science to a new level? A case study of the urban heat island of London quantified using Netatmo weather stations. *Int. J. Climatol.* 37, 3597–3605. <https://doi.org/10.1002/joc.4940>.
- Ching, J., Mills, G., Bechtel, B., See, L., Feddema, J., Wang, X., Ren, C., Brousse, O., Martilli, A., Neophytou, M., Mouzourides, P., Stewart, I., Hanna, A., Ng, E., Foley, M., Alexander, P., Aliaga, D., Niyogi, D., Shreevastava, A., Bhalachandran, P., Masson, V., Hidalgo, J., Fung, J., Andrade, M., Baklanov, A., Dai, W., Milcinski, G., Demuzere, M., Brunsell, N., Pesaresi, M., Miao, S., Mu, Q., Chen, F., Theeuwes, N., 2018. WUDAPT: an urban weather, climate, and environmental modeling infrastructure for the Anthropocene. *Bull. Am. Meteorol. Soc.* 99, 1907–1924. <https://doi.org/10.1175/BAMS-D-16-0236>.
- Ching, J., Aliaga, D., Mills, G., Masson, V., See, L., Neophytou, M., Middel, A., Ren, C., Ng, E., Huang, Y., Stewart, I., Fung, J., Wong, M., Zhang, X., Shehata, A., Martilli, A., Miao, S., Wang, X., Duarte, D., Schwandner, L., Wang, W., Li, Y., Bechtel, B., 2019. Pathway using WUDAPT's digital Synthetic City tool towards generating urban canopy parameters for multi-scale urban atmospheric modeling. *Urban Clim.* 28, 100459. <https://doi.org/10.1016/j.uclim.2019.100459>.
- Comete engineering, 2011. Étude – Diagnostic pour la mise en place du processus bâtiment et constructions durables Phase I – Version définitive. In: Technical Report, (in French).
- Conrad, O., Bechtel, Benjamin, Bock, M., Dietrich, H., Fischer, E., Gerlitz, Lars, Wehberg, J., Wichmann, V., Böhner, Jürgen, 2015. System for automated geoscientific analyses (SAGA) v. 2.1. 4. *Geosci. Model Dev.* 8 (7), 1991–2007.
- De Vos, L., Leijne, H., Overeem, A., Uijlenhoet, R., 2017. The potential of urban rainfall monitoring with crowdsourced automatic weather stations in Amsterdam. *Hydrol. Earth Syst. Sci.* 21, 765–777. <https://doi.org/10.5194/hess-21-765-2017>.
- El-Shorbagy, A.M., 2010. Traditional Islamic-Arab house: vocabulary and syntax. *Int. J. Civil Environ. Eng. IJCEE-IJENS* 10 (4), 15–20.
- Fenner, D., Meier, F., Bechtel, B., Otto, M., Scherer, D., 2017. Intra and inter 'local climate zone' variability of air temperature as observed by crowdsourced citizen weather stations in Berlin, Germany. *Meteorol. Z.* 26, 525–547. <https://doi.org/10.1127/metz/2017/0861>.
- Fonte, C.C., Minghini, M., Antoniou, V., Patriarca, J., See, L., 2018. Classification of buildingfunction using available sources of VGI. *ISPRS Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. XLII-4* 209–215. <https://doi.org/10.5194/isprs-archives-XLII-4-209-2018>.
- Han, K., Golparvar-Fard, M., 2017. Crowdsourcing BIM-guided collection of construction material library from site photologs. *Vis. Eng.* 5, 14. <https://doi.org/10.1186/s40327-017-0052-3>.
- Kunze, C., Hecht, R., 2015. Semantic enrichment of building data with volunteered geographic information to improve mappings of dwelling units and population. *Comput. Environ. Urban Syst. Spec. Issue Volunteered Geogr. Inf.* 53, 4–18. <https://doi.org/10.1016/j.compenurbsys.2015.04.002>.
- Lecomte, R., 2011. Tunisian revolution and the internet: The role of social media. In: *Révolution tunisienne et Internet: le rôle des médias sociaux. L'Année du Maghreb*, vol. VII. pp. 389–418 (in French).
- Liang, J., Gong, J., Sun, J., Zhou, J., Li, W., Li, Y., Liu, J., Shen, S., 2017. Automatic sky view factor estimation from street view photographs—a big data approach. *Remote Sens.* 9, 411. <https://doi.org/10.3390/rs9050411>.
- Medianet, 2016. Key numbers on social media in Africa: Facebook, LinkedIn, Instagram. *Blog medianet, Tunis* (in French).
- Middel, A., Lukaszcyk, J., Maciejewskic, R., Demuzered, M., Rothe, M., 2018. Sky view factor footprints for urban climate modeling. *Urban Clim.* 25, 120–134.
- Middel, A., Lukaszcyk, J., Zakrzewskib, S., Arnoldc, M., Maciejewskid, R., 2019. Urban form and composition of street canyons: a human-centric big data and deep learning approach. *Landsc. Urban Plan.* 183, 122–132.
- Napoly, A., Grassmann, T., Meier, F., Fenner, D., 2018. Development and application of a statistically-based quality control for crowdsourced air temperature data. *Front. Earth Sci.* 6, 118. <https://doi.org/10.3389/feart.2018.00118>.
- Olbricht, R., 2015. Data retrieval for small spatial regions in OpenStreetMap. , in In: *Jokar Arsanjani, J., Zipf, A., Mooney, P., Helbich, M. (Eds.), OpenStreetMap in GIScience. Lecture Notes in Geoinformation and Cartography Springer International Publishing, Cham*, pp. 101–122.
- Santelli, S., Tournet, B., 1987. Évolution et ambiguïté de la maison arabe contemporaine au Maghreb?: étude de cas à Rabat et Tunis. In: *Espace centré: Figures de l'architecture Domestique dans l'Orient Méditerranéen*, (in French).
- See, L., Ching, J., Masson, V., Feddema, J., Mills, G., Neophytou, M., Foley, M., O'Connor, M., Milcinski, G., Repse, M., 2015. Generating WUDAPT's specific scale - dependent urban modeling and activity parameters: Collection of level 1 and level 2 data. In: *ICUC9 - 9th International Conference on Urban Climate Jointly with 12th Symposium on the Urban Environment, France*.
- Stewart, I.D., Oke, T.R., 2012. Local climate zones for urban temperature studies. *Bull. Am. Meteorol. Soc.* 93, 1879–1900. <https://doi.org/10.1175/BAMS-D-11-00019.1>.
- Tornay, N., Schoetter, R., Bonhomme, M., Faraut, S., Lemonsu, A., Masson, V., 2017. Genius: a methodology to define a detailed description of buildings for urban climate and building energy consumption simulations. *Urban Clim.* 10, 75–93. <https://doi.org/10.1016/j.uclim.2017.03.002>.