RESILIENCE OF HISTORIC CITIES AND ADAPTATION TO CLIMATE CHANGE

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Abstract. In recent years the interest for the resilience of cities and historic urban centers is growing. Climate change is one of the challenges of this century and it is having a great impact on the society and economy of cities and buildings. According to climate change scenarios cities will have to face frequent extreme events in the future years, like droughts, heat waves, abundant precipitations or snowfalls. However, there are little studies that try to analyze the effects from different points of view and to find a solution that can have an impact on buildings, the town environment as well as on the well being of the society. Therefore this article proposes a complex assessment and intervention strategy based on the case study of Oravita, a small mountain town from the western part of Romania, that will improve the resilience of the town trough a multidisciplinary approach. The aim is to understand and to adapt the historic town to the contemporary climatic needs by an interdisciplinary holistic understanding of the context through different professional views: architectural, landscape architecture, historical, engineering, social, economical and geographical.

Key words: Historic cities, urban resilience, mitigation, climate change, multidisciplinary.

1. Introduction

Cities are constantly influenced by different environmental factors, which are affecting its society as well as the built environment (UNESCO, 2011). In historic urban centers besides the general wellbeing of the society two additional factors have to be taken into consideration: the aesthetic and architectural value of the built heritage, which is severely influenced by new climatic conditions (Brimblecombe, 2014a, 2014b; D'Ayala and Aktas, 2016; Nik *et al.*, 2015).

According to De Wilde (2012) changing climate is one of the treats of this century. Recent scenarios show that the risk to heritage from climate changes is going to increase gradually. In the long term, this changes may lead to risks for the built heritage, urban areas, inhabitants and economic growth of the cities (IPCC, 2014; Curcic *et al.*, 2012).

This is why in recent years many studies have been done in order to identify the influence of climate change on urban areas and buildings and to mitigate their effects. Some studies tried to identify complex interactions between all the layers of the built heritage and its corresponding urban area taking historical and aesthetic factors into account (Solecki *et al.*, 2015; Ghoneem, 2016), but no studies have attempted to analyze the problems of climate change and their effects on cultural heritage and historic urban centers from different perspectives and generate strategies and solutions that reduce the impact of climate change, thus improving the quality of life of the residents.

According to Tomaskinova and Tomaskin (2013), heritage conservation should be a complex combination between ecological, social, economic and cultural interactions. Interventions on historic urban centers and the built heritage should not be meant to just rehabilitate and preserve their value. Every action should adapt them for the future by increasing their resilience (de Santoli, 2015; Meerow, 2016). By increasing the resilience of a town the impact of current and future climatic condition and natural hazards can be reduced and the capability of the town to recover after extreme events is enhanced too (Leichenko, 2011; Brown *et al.*, 2012; Wamsler *et al.*, 2013).

From this reason, a strategy was developed in order to assess climate change impacts on the cities containing mitigation and adaptation elements from the perspective of several professionals: architects, engineers, landscape designers, historians, sociologists, economists and geographers. The strategy has the role to improve the town's resilience through a multidisciplinary approach and adapt the town in the context of the current climate which is already representing a challenge for cities (Heinrichs *et al.*, 2013; Wamsler *et al.*, 2013).

By understanding current and future climatic threats (Alcoforado *et al.*, 2009), by linking different professionals and by enhancing the dialogue between them (Pickett *et al.*, 2004) a better understanding of the problem can be achieved and comprehensive solutions can be developed. In this way the value and authenticity of the inherited built heritage and historic urban centers can be preserved for future generations as an whole (Pujia, 2016; Yahner and Nadenicek, 1997).

2. Case study Oravița

The study was carried out on Oravita, a town located in the south-western part of

Romania in the valley of the Oravița river, in the Banat Mountains. The town was developed, starting with the 18th century along the main street placed in the mountain valley which is connected to a series of irregular secondary streets going up the hill-slopes. The buildings present a clear pattern: two story buildings with public functions in the center of the town, along the main street, and one story buildings on the secondary streets and the outer parts of the town center (Fig. 1). All buildings were built using a mixture of limestone and brick masonry.

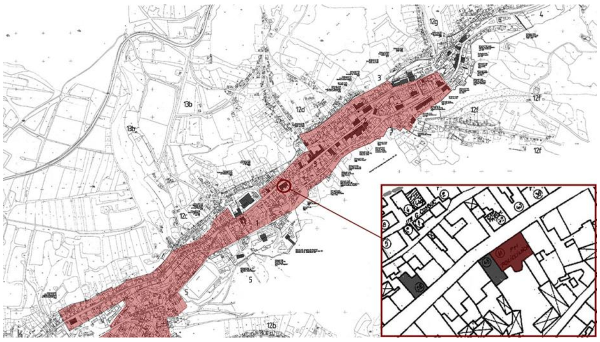

Fig. 1. Oravita town plan (After Oravita Town Plan)

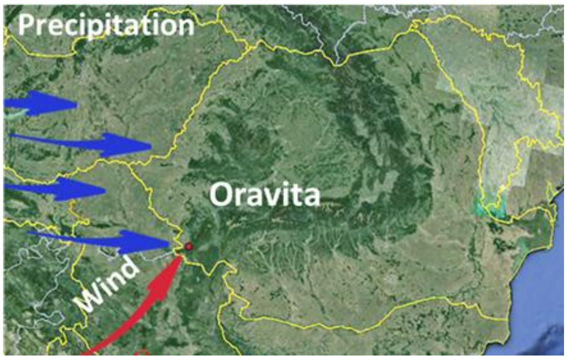

Fig. 2. Oravita – climatic conditions

Being located in the south-western part of the country, the main climatic influences that can be felt here are Sub-Mediterranean, with warm tropical air moving from the Mediterranean Sea and oceanic, with humid air and big quantities of precipitation from the Atlantic ocean (Fig. 2). This is why winter and summer tend to be warmer than in other regions of the country with occasional heavy rainfalls.

3. Architectural point of view

In recent years reduced studies have been made concerning the influence of current and future climatic conditions on the interior microclimate of historic buildings (Lankester and Brimblecombe, 2012). This is why a vernacular historic building was chosen from Oravita and its microclimate was analyzed with and without insulation interventions.

Because the climatic conditions are changing, people try to protect their interior microclimate by applying board-insulation on the facades of historic buildings. This results in building with no historic, aesthetic and architectural value, which reduce the quality of the historic urban center (Fig. 3). Preliminary analysis showed that local people tend to use extruded polystyrene with a thickness of 3 to 6 cm. This solution proved to have e low durability in time being easily affected by hailstone. While historic, traditional plaster showed no signs of degradation due to hailstone impact, newly retrofitted building presented numerous impact points (Fig. 4). In order to keep the identity of the cultural heritage an other solution had to be found (Walker and Sara, 2015).

Fig. 3. Historic building in Oravita after retrofit

Fig. 4. Low resilience of current used retrofit methods – hailstone impact points

In order to protect the aesthetic value of the built heritage and to raise its energy efficiency, the effect of a new insulating plaster was analyzed. According to its technical file the insulating plaster contains only natural raw, recyclable materials and minerals like hydraulic lime mortar, cork, white pumice and dolomitic limestone, being a green alternative to generally used insulation materials (Balliana, *et al.*, 2016). Due to its high porosity it is a good solution for heritage building rehabilitation, enabling the natural ventilation of the building and can be applied on both the outer and inner face of walls. With a thermal conductivity of 0,075 W/mK and a specific heat capacity of 1,08 kJ/kgK (KERAKOLL Biocalce® Termointonaco data sheet) the plaster is being half as efficient as the used extruded polystyrene, with a thermal conductivity of 0,035 W/mK (INCERC, 2002). The maximum thickness of the insulating plaster is according to the technical file 60 mm, on both interior and exterior face of walls.

There are 2 different approaches to evaluate the interior microclimate of a building (Zhu *et al.*, 2016), by performing a statistical analysis or by using a building simulation tool (Leissner *et al.*, 2015). In order to evaluate the effectiveness of the insulating plaster, a energy efficiency simulation was conducted using a parametric energy efficiency analysis software, Design Builder, on a chosen vernacular building from Oravita. The software is analyzing the energy efficiency of the chosen building based on its structural conformation and the thermal conductivity of the wall material and was used in various studies, from historic (Cardinale *et al.*, 2013) to contemporary buildings (Raji *et al.*, 2015) and insulating material problem evaluation (Boafo *et al.*, 2015).

The analyzed building, the polyclinic from Oravița, a national historic monument, was built at the end of the XXIth century and presents all the features that are characteristic for the town: rectangular shape, baroque decorations, structural system made from limestone with local insertion of brick masonry and a building-block made using a German „Fachwerk" (Fig. 5)

Fig. 5. Case study- the polyclinic from Oravita

The building was evaluated taking current climatic conditions and future climate scenarios into consideration. Simulation results showed that the structure is very vulnerable to temperature rises and slightly less vulnerable to temperature falls, the interior microclimate changing easily according to the exterior temperature (Keller *et al.*, 2016).

Since the structure proved out not to have a good energetic performance, thermal insulation was applied on the building model and additional simulation were run. To evaluate the effect of the insulating plaster on the interior microclimate of the historic building, the results were compared with the maximum applied thickness of extruded polystyrene to the outside face of the exterior walls (60 mm). Simulation results show that the effect of a 120 mm (60 mm interior and exterior) insulating plaster on the interior microclimate of the building is almost the same as 60 mm extruded polystyrene. The same effects could be observed for both winter (Fig. 6) and summer time (Fig. 7) simulations.

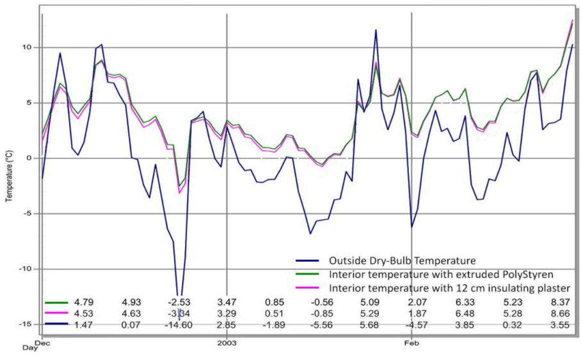

Fig. 6. Simulation result – Comparison of the effect of extruded polystyrene insulation and insulating plaster on the interior temperature in the polyclinic from Oravita – winter (Keller *et al.*, 2016)

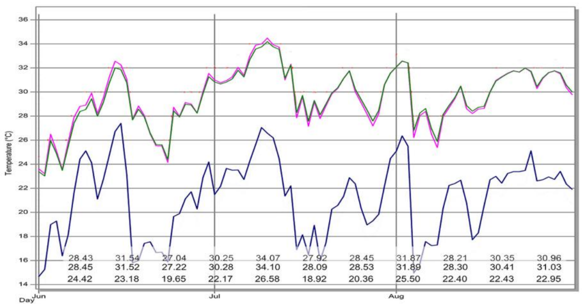

Fig. 7. Simulation result – Comparison of the effect of extruded polystyrene insulation and insulating plaster on the interior temperature in the polyclinic from Oravita – summer (Keller *et al.*, 2016)

According to the winter simulation results (Fig. 6), even with thermal insulation, the most sever interior temperature drops still take place when the exterior temperature under -10ºC falls. The main difference is that the gap between interior and exterior temperature with 2ºC bigger is than in the simulation without insulation. The same observation can be made when exterior temperatures rise.

During summer on the other hand, interior temperatures rise above the comfort level with and without insulation. Still, in the case of the insulated building simulation the difference between interior and exterior temperatures are 8ºC, compared to the 10ºC of the simple building (Fig. 7).

The interior climate of historic buildings is easily influenced by all environmental factors. The study shows that there is an alternative to the usual locally used extruded polystyrene, the natural material based insulating plaster. By using this type of insulation, the nature and details of the historic building is preserved and the unitary appearance of the historic urban center is ensured. In the same time, by using traditional materials or those similar with traditional ones, like the analyzed insulating plaster, carbon emissions are reduced and the resilience of the exterior surfaces is ensured.

4. Engineering point of view

The consequences of climate change, such as heavy rains and landslides, can have negative effects on the built-up of Oravita. In particular, such natural hazards could cause both the failure of the existing retaining walls and the partial collapse of the historical vault serving as a protection to the river flowing under the town.

First of all, heavy rains can result in abnormally high water levels. As a consequence, the ground in a particular area may become saturated, causing unabsorbed water to pool, when a warm or cold front stalls over it, dumping a large amount of precipitation, or when a quickly moving storm keeps passing over the same area in a phenomenon called "training", drenching the land below. Saturation and flooding are also dependent on the ground's ability to accept copious amounts of moisture.

Precipitation sinks into the ground and through layers of soil and porous rock, filling underground holes until this groundwater hits solid rock and can not sink any further. The saturated soil is no longer able to absorb water and consequently starts to move. According to the Theory of Coulomb, the shear resistance of the soil tends to be reduced considerably and, accordingly, the soil particles lose friction, causing the movement of large portion of land.

With respect to the rehabilitation of existing retaining walls, located in the northern side of Oravița, various consolidation techniques may be used. They are structures capable of guaranteeing stability and security in front of a potentially unstable ground. In the specific case, it is possible to adopt support walls, which are anchored to the ground by means of metal ties in order to either eliminate or reduce the pressure generated by water and soil along the wall inner facing (Fig. 8). This solution is generally adopted when the wall disruption has already occurred. In fact, metal ties represent the best solution, since they anchor the retaining walls to stable and deeper layers of soil. Moreover, the insertion of ties in the soil has positive effects because a friction at the tie-ground interface is activated with the task of eliminating the wall displacements, therefore guarantying the work stability.

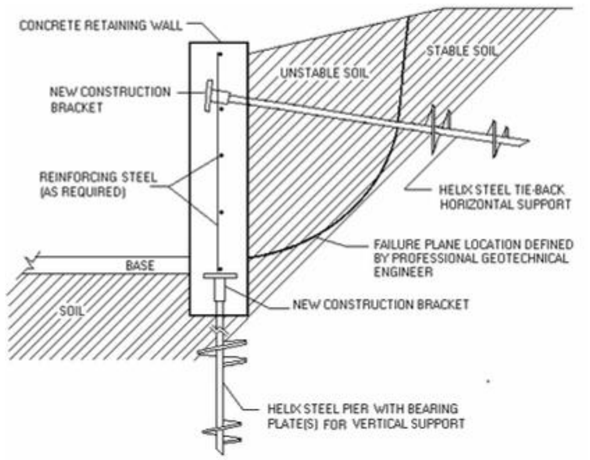

Fig. 8. Consolidation of an existing retaining wall by means of a steel tie (http://southcoasthelix.com/about.html – 02/05/16).

Another solution, which could be instead used to replace the retaining walls, is given by the cage-walls (Fig. 9). These cages are made up of independent elements, having typical dimensions of 1x1x2m side, which are first filled in-situ by stones, pebbles and clean gravels and then placed one over another.

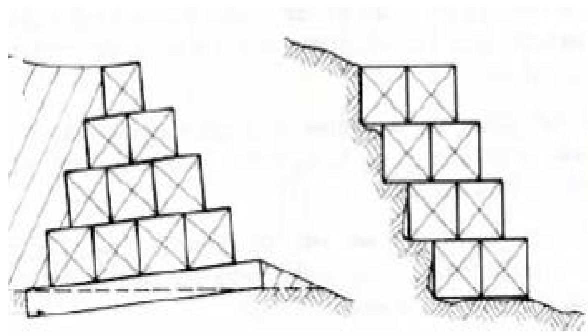

Fig. 9. Cage-walls - arrangement of cages (Facciorosso *et al.*, 2011)

These retaining systems have the advantage of being very flexible, adapt very well to the soil configuration, without any damage to any vertical and horizontal surface, and have a high water permeability. These characteristics are essential to stabilize the landslide slopes and protect from the erosion of the river banks.

Another case to be analyzed concerns the vaulted structure (Fig. 10) that covers the river flowing beneath the town of Oravita. This structure was partially collapsed as a result of heavy rains and landslides that occurred in 2015 (Fig. 11).

Fig. 10. Vaulted structure over the Oravita river

The structure consists of bricks arranged along the major inertia axis and joined by lime mortar. The upper part is covered with concrete made of medium-small size aggregates and cement mortar. As a result of the water seepage, the failure affecting a fairly large portion of the entire structure occurred. The causes of collapse were mainly due to two main factors: the increase of the load due to the landslide and the infiltration of the rain water. Experimentally (Uranjek *et al.*, 2015) it was seen how the water permeated into the vaulted structure produced a decay of the modulus of elasticity of the masonry, therefore compromising its resistance to external actions.

The structural restoration of the vault can be applied through a combined reconstruction-reinforcing process that involves the following phases:
1) demolition of the covering concrete;
2) cleaning of the structure;
3) reconstruction of vault parts collapsed;
4) application of Fiber Reinforced Polymers (FRP) layers and
5) reconstruction of the upper covering concrete.

Fig. 11. Collapse of a part of the existing vault

The fibers give rise to a composite material when they are immerged into a matrix based on epoxy resins or low viscosity bi-component polyesters, which ensure both the transfer of stresses to the reinforcing fibers and the protection of the fibers from chemical attacks and temperature variations.

The benefits of the use of FRP materials to the inspected structure are: low-impact of the intervention; easy adaptability to the shape of the curved support; negligible increase of the structure weight and, therefore, unchanged seismic forces to be sustained; preservation of the original static load pattern and augment of the load-bearing capacity due to increased strength and ductility.

For the above reasons, this system is generally used into vaulted surfaces, also in advanced instability conditions. The technique is based on the use of different types of strips (carbon, aramid, glass), which can have different dimensions and can be oriented in unidirectional (oriented according to a single direction) or bi-directional (oriented according to two orthogonal directions, 0° and 90° or -45° and 45°) ways (Fig. 12, 13).

Applications of FRP for reinforcing vertical and horizontal masonry structures are interventions very diffused worldwide (Formisano *et al.*, 2014).

Fig. 12. Positioning of FRP: unidirectional strips (http://resimix.com/categorie-di-intervento/rinforzo-volte – 02/05/16)

Fig. 13. Positioning of FRP: bi-directional strips (http://resimix.com/categorie-di-intervento/rinforzo-volte – 02/05/16).

5. Landscape architecture point of view

In terms of landscape, the effects of climate change can be reduced at a microclimatic level in the town, because the built areas attract and radiate heat, forming heat islands in and around the town.

In Oravita, like in many other towns, developed no plans until now in order to reduce the effects of climate change and natural extreme events. There are few notable examples of cities that developed their urban planning taking climatic conditions into account (Alcoforado *et al.*, 2009; Wastvedt and Spim, 2013; MVI Baden-Wuttenberg, 2012). This is why a landscape based strategy was developed in order to prevent natural hazards, highlighted by climate change. The strategy aims to combat landslides around the city, to reduce extreme winds, to improve air quality, to reduce air pollution and to improve the quality of life.

The strategy starts from interventions in the surrounding area of Oravita with the aim to reduce the effects of main threats to the microclimate of the town and gradually moves towards local interventions in the town in order to raise the quality of life of the inhabitants.

Fig. 14. The viaduct from Oravita - different state of conservation of the two faces

The dominant wind of this region is called "Coşava", blowing from the south with a wind speed that often reaches 20 m/s, exceptionally reaching 35 m/s (Barbu *et al.* 2009). Historic buildings from the town are already showing degradation signs because of the high wind speed. A good example of the effect of the Cosava wind, is the railway viaduct. The viaduct is showing signs of wind erosion on the south-western side, from which this wind in blowing, while the other side it is perfectly intact (Fig. 14).

In the southern part of the town, it is proposed to fill the forests with deciduous and coniferous species, specific for an altitude of 500 m, where the town is located (Fig. 15). For a long term effect all the chosen species have to be well adapted to the climatic condition and to the altitude of Oravita (Conway and Vecht, 2015; Lanza and Stone Jr., 2016). The chosen species of trees and shrubs are predominant species like oak (*Quercus robur*), sessile oak (*Quercus petraea*), beech (*Fagus sylvatica*) and secondary species like spruce (*Picea abies*), yew (*Taxus bacata*) and hazel shrubs (*Corylus avellana*) (Dagmar, 2004; Sandu, 2008; Szekely, 2012) . Besides reducing the wind speed all these species have the role of binding soil and prevent landslides. The new forest will reduce the wind speed only from south, which proved out to have negative effects on the built heritage, while secondary winds, coming from the west enhance the natural ventilation of the town and prevent the appearance of heat-islands.

Fig. 15. Proposal reforestation and terracing

In nearby places designated today for hay fields, grass strips are proposed with various widths depending on the inclination of the hill slopes: as the slope get steeper, the grass strip get more narrow. All this interventions positively influence the quality of air and soil through the fact that there will be no longer loss of nutritive macro and micro elements and water.

Because of the narrow profile of the road, some of the heavy traffic will be diverted around the town, and on the one-way roads that cross the historic area, a strategy of urban acupuncture be used in order to develop a moderate microclimate. The implementation of green urban acupunctures will have a benefic effect of temperature reduction while reducing in the same time the pollution in the town (Norton *et al*., 2015).

To do this, pergolas, with benches, will be placed along the streets in front of the houses with no architectural value. In the remaining areas strips of hedges will be planted, with species of Turkestan elm (*Ulmus pumila*) and privet (*Ligustrum vulgare*), which have an increased resistance to pollution, drought and nutrients (Fig. 16). In the areas with pergolas and benches are proposed creeper species (Fig. 17). The trumper vine (*Campsis radicans*), a creeper plant with the minimum required front soil and water, will climb on a metal support that will overshadow the bench attached to the base. From a technical standpoint, the surface of the street will be finished with cobblestone, for water drainage. In order to protect the foundations from the roots of the plants, metal strips will be introduced at a angle of 80° to the road axis. In this way, the roots will have to expand into the other area of exploration.

In the town, in order to eliminate the effect of heat islands, punctual and equilibrated green areas are proposed, in the places where the river Oravița comes to surface along the road network (Fig. 18).

Fig. 16. Green spaces along streets

Fig. 17. Points arranged along water areas

Fig. 18. Proposed circuit of leisure

The two dams and anthropic lakes, placed strategically before the river entrance the town, built to protect the town from flooding in the 18th century, represent an area of great interest. The area around the Lacul Mare (Great Lake) was developed with the aim of attracting tourist and amateur fishermen. This is why the slopes of the dams are terraced, filled with grass and planted with species of trees, for a pleasant appearance.

The Lacul Mic (Small Lake), currently not used because of a breach in the dam will be transformed in a floating park. The park will basically have an underground watercourse visible in some compositional centers in form of water islands. Plants will be proposed for the arrangement of water spots, which are suitable for wetlands, plants like reeds and rushes. The elevation of the alleys will be higher, so that they can be used even after a heavy rainfall. These will have a consolidation based on a drainage system that allows communication between the flooded islands and their slopes, which are terraced and planted with alignments of willow (*Salix*) and cypress (*Taxodium distinctum*).

The high slopes of the former lake, preserved around the park, will be terraced and strengthened with gamine species. These terraces can be visited and have the aim to center the lookout and recreation.

The punctual solutions for urban microclimate will be integrated in a circuit for tourists and locals, which will be able to move from one place to another, by foot.

4. Conclusions

This study shows the diversity of problems and complexity of solution that can be found by various professionals in order to raise the resilience of a town. Each professional identified the main problem of the urban area or built heritage from his point of view and proposed a solution given his area of expertise in order to protect the town from current and future climatic conditions. In this way a possible solution for all the identified problems was developed and possible future research directions were identified.

In conclusion, it is important to protect the built heritage in order to preserve the identity and culture of a place. To accomplish this, a better understanding of the threats and effect of possible solutions is necessary from the point of view of more professionals, who will offer a global perspective upon the problems.

In the case of Oravita, this approach drew the attention of local authorities. Identified vulnerable urban areas and future development strategies will therefore be included in the "General Urban Plan" of the town.

REFERENCES

Alcoforado M. J. , Andrade H., Lopes A., Vasconcelos J. (2009), *Application of climatic guidelines to urban planning: The example of Lisbon (Portugal)*, Landscape and Urban Planning **90(1–2)**: 56-65.

Balliana E., Ricci G., Pesce C., Zendri E. (2016), *Assessing the Value of Green Conservation for Cultural Heritage: Positive and Critical Aspects of Already Available Methodologies*, International Journal of Conservation Science **7**: 185-202.

Barbu S., Moisa C., Mircov V. D. (2009), *Cosava-a banatean wind*, Research Journal of Agricultural Science **41(1)**: 365-371.

Boafo F. E., Ahn J. G., Kim J. T., Kim J. H. (2015), *Computing Thermal Bridge of VIP in Building Retrofits using DesignBuilder*, Energy Procedia **78**: 400-405.

Brimblecombe P. (2014a) *Damage to Materials and Buildings in a Changing Urban Climate*, Handbook of Global Environmental Pollution **1**: 455-460.

Brimblecombe P. (2014b), *Refining climate change threats to heritage*, Journal of the Institute of Conservation **37(2)**: 85-93.

Brown A., Dayal A., Rumbaitis Del Rio C. (2012), *From practice to theory: Emerging lessons from Asia for building urban climate change resilience*, Environment and Urbanization **24(2)**: 531-556.

Cardinale N., Rospi G., Stefanizzi P. (2013), *Energy and microclimatic performance of Mediterranean vernacular buildings: The Sassi district of Matera and the Trulli district of Alberobello*, Building and Environment **59**: 590-598.

Conway T. M., Vander Vecht J. (2015), *Growing a diverse urban forest: Species selection decisions by practitioners planting and supplying trees*, Landscape and Urban Planning **138**: 1-10.

Curcic L., Stepanov J., Prokic D., Aleksic D. (2012), *Interaction between tourism and climate change*, Journal of Environmental Protection and Ecology **13(2)**: 620-627.

Dagmar V. (2004), *Ornamental ligneous species in Romania* [in Romanian], Editura Eurobit, Timisoara, Romania.

D'Ayala D., Aktas Y. D. (2016), *Moisture dynamics in the masonry fabric of historic buildings subjected to wind-driven rain and flooding*, Building and Environment **104**: 208-220.

de Santoli L. (2015), *Guidelines on energy efficiency of cultural heritage*, Energy and Buildings **86**: 534-540.

de Wilde P., Coley D. (2012), *The implications of a changing climate for buildings*, Building and Environment **55**: 1-7.

Facciorosso J., Madiai C., Vannucchi G. (2011), *Geotechnical Lecture,* University of Florence, Department of Civil and Environmental Engineering, Florence, Italy.

Formisano A., Iaquinand A., Mazzolani F. M. (2014), *Seismic retrofitting by FRP of a school building damaged by Emilia-Romagna earthquake*, Key Engineering Materials **624**: 106-113.

Ghoneem M. Y. M. (2016), *Planning for Climate Change, Why does it Matter?(From Phenomenon to Integrative Action Plan),* Procedia-Social and Behavioral Sciences **216**: 675-688.

Heinrichs D., Krellenberg K., Fragkias M. (2013), *Urban Responses to Climate Change: Theories and Governance Practice in Cities of the Global South*, International Journal of Urban and Regional Research **37(6)**: 1865-1878.

INCERC (2002), *Standard for the design and execution of thermal insulation for buildings C107/0-02* [in Romanian], Bucarest, Romania.

IPCC (2014), *Summary for Policymakers, Climate change 2014*, in: *Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (Eds.), Cambridge University Press, New York, USA.

Keller A., Petrus C., Mosoarca M. (2016), *The impact of climate change on the energy performance of historical buildings*, in: Vaništa Lazarević E., Vukmirović M., Krstić-Furundžić A., Đukić A. (Eds.), *Proceedings of the 3rd International Academic Conference on Places and Technologies, 14-15 April 2016, Belgrade, Serbia,* UB Publishing house, Belgrade, Serbia, pp. 167-174.

Lankester P., Brimblecombe P. (2012), *The impact of future climate on historic interiors*, Science of the Total Environment **417-418**: 248-254.

Lanza K., Stone B. Jr. (2016), *Climate adaptation in cities: What trees are suitable for urban heat* *management?*, Landscape and Urban Planning **153**: 74-82.

Leichenko R. (2011), *Climate change and urban resilience*, Current Opinion in Environmental Sustainability **3(3)**: 164-168.

Leissner J., Kilian R., Kotova L., Jacob D., Mikolajewicz U., Broström T., Ashley-Smith J., Schellen H. L., Martens M., van Schijndel J., Antretter F., Winkler M., Bertolin C., Camuffo D., Simeunovic G., Vyhlídal T. (2015), *Climate for Culture: assessing the impact of climate change on the future indoor climate in historic buildings using simulations*, Heritage Science **3**: 28.

Meerow S., Newell J., Stults M. (2016), *Defining urban resilience: A review*, Landscape and Urban Planning **147**: 38-49.

MVI Baden-Wuttenberg (2012), *Urban Climate Booklet. Instructions for urban planning* [in German], http://mvi.baden-wuerttemberg.de/de/service/publikation/did/staedtebauliche-klimafibel/

Nik V. M., Mundt-Petersen S. O., Kalagasidis A. S., De Wilde P. (2015), *Future moisture loads for building facades in Sweden: Climate change and wind-driven rain*, Building and Environment **93**: 362-375.

Norton B. A., Coutts A. M., Livesley S. J., Harris R. J., Hunter A. M., Williams N. S. G. (2015), *Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes*, Landscape and Urban Planning **134**: 127-138.

Pickett S. T. A., Cadenasso M. L., Grove J. M. (2004), *Resilient cities: meaning, models, and metaphor for integrating the ecological, socio-economic, and planning realms*, Landscape and Urban Planning **69(4)**: 369-384.

Pujia L. (2016), *Cultural Heritage and Territory. Architectural Tools for a Sustainable Conservation of Cultural Landscape*, International Journal of Conservation Science **7**: 213-218.

Raji B., Tenpierik M. J., van den Dobbelsteen A. (2015), *An assessment of energy-saving solutions for the envelope design of high-rise buildings in temperate climates: A case study in the Netherlands*, Energy and Buildings **124**: 210-221.

Sandu T. (2008), *Forestry course* [in Romanian], Editura Pim, Iasi, Romania.

Solecki W., Seto K. C., Balk D., Bigio A., Boone C. G., Creutzig-Fragkias M., Lwasa S., Marcotullio P., Romero-Lankao P., Zwickel T. (2015), *A conceptual framework for an urban areas typology to integrate climate change mitigation and adaptation*, Urban Climate **14**: 116-137.

Szekely G. (2012) *Landscape planning* [in Romanian], Editura Eurostampa, Timisoara, Romania.

Tomaskinova J., Tomaskin J. (2013), *Integrated Management of the National Park Slovak Karst*, Journal of Environmental Protection and Ecology **14(2)**: 664-674.

UNESCO (2011), *Recommendation on the historic urban landscape, Records of the General Conference 36th session*, http://unesdoc.unesco.org/images/0021/002150/215084e.pdf#page=52

Uranjek, M., Bokan-Bosiljkov, V. (2015), *Influence of freeze–thaw cycles on mechanical properties of historical brick masonry*, Construction and Building Materials **84**: 416-428.

Walker R., Sara P. (2015), *Thermal performance of a selection of insulation materials suitable for historic buildings*, Building and Environment **94(1)**: 155-165.

Wamsler C., Brink E., Rivera C. (2013), *Planning for climate change in urban areas: from theory to practice*, Journal of Cleaner Production **50**: 68-81.

Wastvedt T., Spim A. (2013), *Urban Microclimates. Case studies in outdoor climate control*, http://www.mit.edu/people/spirn/Public/Ulises-11-308/UrbanMicroclimates.pdf

Yahner T. G. , Nadenicek D. J. (1997), *Community by design: contemporary problems—historic resolve*, Landscape and Urban Planning **39(2–3)**: 137-151.

Zhu M., Pan Y., Huang Z., Xu P. (2016), *An alternative method to predict future weather data for building energy demand simulation under global climate change*, Energy and Buildings **113**: 74-86.

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