BUILT ENVIRONMENT AND CLIMATE CHANGE

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Abstract
The present paper aims to raise awareness of climate change impacts on the urban areas. The article presents the current state of research at international and Romanian level, proposing several solutions that should be considered in relation to the built environment and the mitigation of its impact on climate.
Keywords: urban climate, built environment.

1. INTRODUCTION

Since the beginning of the Industrial Revolution, many debates took place regarding the carelessness in which the industrialization proces evolved and took form, in light of its dimension and with all its potential consequences and effects on the environment. Not only the Industrial Revolution, but also the increase in world population, the relatively chaotic urbanization and the inadvertent use of resources, including the not so environmentally-friendly obtained energy, led to increased concern over this matter and its consequences over the environment, especially within the scientific communities all around the world. Unfortunately, the many debates and arguments over the subject, had only a futile impact on the political decisions, which were mainly driven by financial reasons, in a context of strong and aggressive economical competition between countries. As human activities continued to impact the environment, the awareness and concern levels dramatically increased, especially within the world top decision makers, only when the effects and consequences of Climate Change and of the human impact on it, became more and more visible and undeniable.

In this context, the United Nations (UN) provides a comprehensive overview on the identified Global issues and classifies them under different topics. Among the matters of concern, such as Atomic Energy, Human Rights, Refugees, Water, Health, and several others, there is only one topic to which the institution refers to as “one of the major challenges of our time”. And that is the Climate Change. The same institution, under its “Resolution adopted by the General Assembly on 3 June 2009”, emphasizes the need

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for "the protection of the global climate for present and future generations of mankind", and "calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response, in accordance with their common but differentiated responsibilities and respective capabilities and their social and economic conditions".

While Climate Change is repeatedly and with full justification referred throughout the world as one of the major problems humanity faces, such description, on a thorough and long-term approach and understanding, could very well be considered correct but not sufficient, diminishing the perception of what it truly is. As pleaded further on, Climate Change with all its direct and indirect implications (changes can have an impact on health, food production, increase of hazardous natural phenomena etc.), could very well be seen as the biggest threat humankind ever faced as a species.

While for all of the other issues, solutions seem to be not so far out of hand, viewing the positive time-frame on which science and technology evolve and manage to address them or to considerably reduce their impact, the possible political actions that could avoid catastrophes and see many concerns and problems solved, for the phenomena of Climate Change, there is no foreseeable evidence in the near future that the humankind will possess the means to fully control and eliminate its potentially devastating impact. Looking on a relatively small time-scale (e.g. the life expectancy of an average human), Climate Change, even with its visible consequences, can be seen a far off threat compared to many other burning issues. Nevertheless, when gradually increasing this time-scale, Climate Change starts to weigh more and more, up to the point, where all the other issues can be seen as irrelevant and obsolete.

It is not only the apocalyptic far away scenario of an uninhabitable Earth which poses a problem for humankind, but the relatively short and medium term increase in destructive natural phenomena (e.g. excessive drought, powerful storms, etc.), which can have unforeseeable consequences.

The global context regarding the issue is unfortunately under some negative influence from a large number of skeptics that industriously attempt to deny the signals, warnings and evidence coming from science communities all over the world, in regard to human influence over Climate Change and the potential effects these changes could have on human lives. Such actions and line of thought, built the foundation for unproductive political debates that only delayed and continue to delay measures and actions that should have already been in place. Either we talk about a big failure in the global educational system, lack of access to information, or about a hidden agenda, as causes for the scepticism on this matter, actions should not be dependent on groundless random opinions. Climate Change and the influence of human activities over the phenomena is not a subject that should be debated as an opinion, but rather as a clear and irrefutable scientifically demonstrated fact, since it is something that takes place independently of anyone's opinion.

Even if it could be seen in some cases as almost tardy and maybe with effects that could be interpreted as too soft and limited, viewing the importance of the issue, political decisions and international agreements draft the premises for a more convincing approach towards tackling the problem at its true dimension, at a global scale. As a recent example, the "Paris Agreement", brought together as of December 2016, 194 states and the European Union. Out of these 195 parties, 160 have ratified or acceded to the Agreement, most notably China, the United States (who, in 2017 expressed its intention to leave the agreement – this will only take place in November 2020, as the earliest effective withdraw date under the agreement's provisions) and India, three countries which alone are considered to be accountable for about 50% of the global greenhouse emissions. (Source: International Energy Statistics).

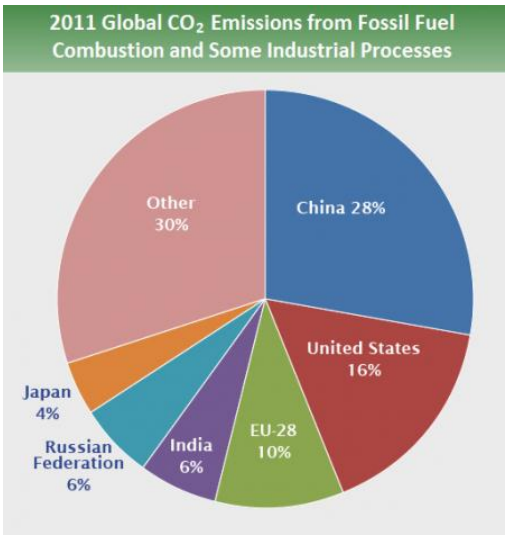

FIGURE 1 – GLOBAL CO2 EMISSIONS
(Source: U.S. Department of Energy, 2015)

The Paris Agreement is an important step but, because of its restrictive nature, the purpose for which it was created could evolve towards a volatile state of action, if not backed up by strong political will and sustained and efficient decisions and measures from all the parties. The restrictive nature referred to comes from the fact that the agreement does not impose a mechanism through which the parties can be forced by any means to set specific targets by specific dates, but rather to autonomously decide their own objectives, with the sole provision that these should be above previously set targets.

The increasing interest over Climate Change and human related influence, within the political and scientific spheres, can be seen as a positive catalyst for present and future actions on this matter. However, to fully engage on solving this problem, the awareness level should increase rapidly, Climate Change should be understood and further studied and all the social structures should actively participate in solving the related issues, of course, limited to their specific capabilities.

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The Climate Change effects can be seen in many places and can take many different forms but there is only one area with which it relates at a foremost visible manner, in terms of reciprocity and interchangeable causes and effects, in a "symbiotic" alike relationship.

Thus, in direct connection to human needs, activities, way of life and behaviour, which have a direct or indirect impact on Climate Change, the consequences of such phenomena can only be firstly perceived by the general public within their own habitat, the Urban Area.

2. GENERAL OVERVIEW

Throughout its approximately 4.54 billion years of history, Earth was subject to profound variations of its climate, going through at least five major ice ages and also, through periods of extreme heat. Therefore, the climate on Earth is naturally changing, with or without human interference. Nevertheless, human activity can dramatically influence the speed on which these changes occur, leading to rapid climate change, as further-on explained (van Bakker 1978)

For a better understanding, the "Climate" can be defined as the statistically determined average values for the weather parameters (e.g. precipitations, temperatures) of an area (e.g. overall planet, a region, a city) over a certain period of time (e.g. year, season, month, etc.). Therefore, the "Climate Change" of such an area implies the variation of the average values of its weather parameters (Hutter, 2017).

Studying the variation of these parameters, implementing a climate modelling approach and through other specific means, some progress was made for a better understanding of the past and future climate changes. As part of the climate modelling process, graphics and trends regarding climate change were generated. Such tools favoured a better understanding of the impact of certain human activities on the climate as main reason for obvious abnormalities and deviations from trends. It has been determined that the human activities with a relatively considerable impact on climate change are the ones that cause the release of greenhouse gases (GHG) into the atmosphere. Even if not the only GHG, CO2 is the main gas released into the atmosphere by human activities. A direct correlation could be made between the amount of CO2 that has been released into the atmosphere, starting with the Industrial Revolution and an abnormal increase of the annual average temperatures, which also influence precipitations and other natural phenomena. This increase and the statistically determined trend show unequivocally that the Earth is going through a "Global Warming" phase.

Since the late 19th century the planet's average surface temperature has risen more than 1 degree Celsius (NASA 2017), mostly due to "increased carbon dioxide and other human-made emissions into the atmosphere". At the same time, 2016 was "the warmest year on record" and, as shown in the graphic below, eight months in 2016 "were the warmest on record for those respective months"

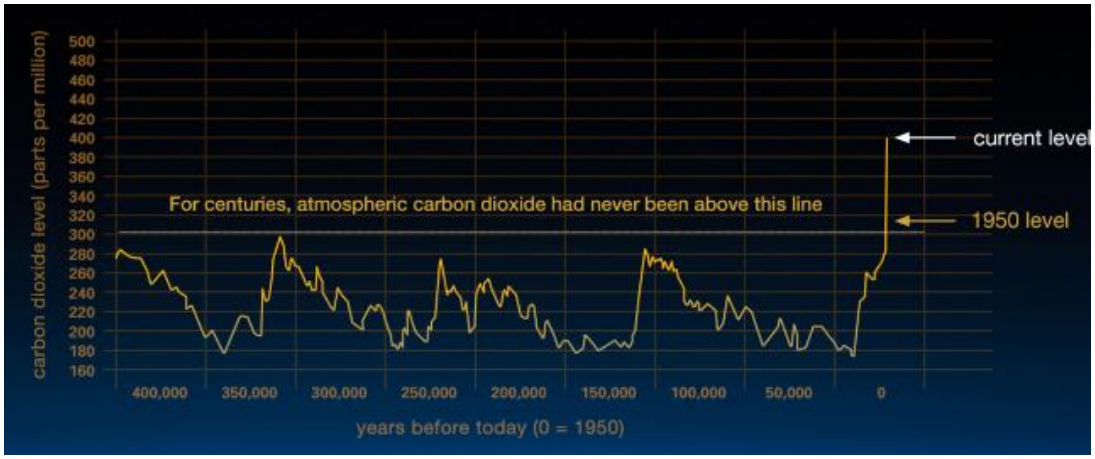

FIGURE - 2A - CARBON DIOXIDE LEVEL VARIATION OVER TIME
(Source: https://climate.nasa.gov/evidence/)

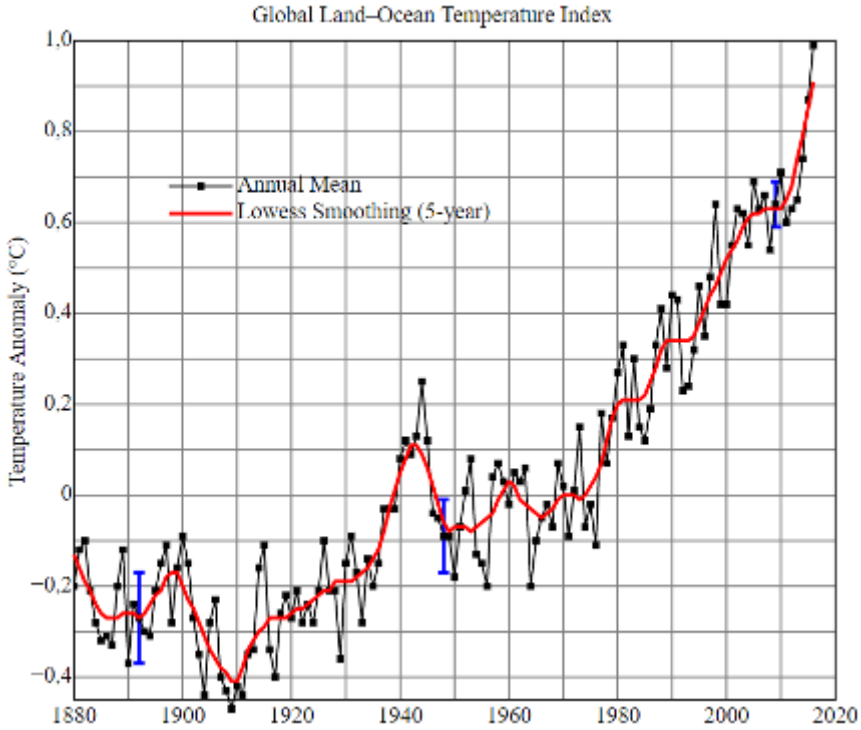

FIGURE - 2B - GLOBAL TEMPERATURE ANOMALY
(Source: GISTEMP Team, 2017)

"Land-ocean temperature index, 1880 to present, with base period 1951-1980. The solid black line is the global annual mean and the solid red line is the five-year lowess smooth, i.e. a non-parametric regression analysis that relies on a k-nearest-neighbor model. The blue uncertainty bars (95% confidence limit) account only for incomplete spatial sampling" (GISTEMP Team, 2017).

While comparing the two graphics (i.e. Fig. 2A and Fig. 2B), a connection can be made between the increase of CO2 levels in the atmosphere and the rise of global temperatures. Nevertheless, CO2 cannot be considered as the sole reason for Global Warming, as there are several other drivers for climate change, but also, its decisive role cannot be denied. As an argument for the important role of GHG on the

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Climate, it has been determined that “without naturally occurring greenhouse gases, Earth's average temperature would be near 0°F (or -18°C) instead of the much warmer 59°F (15°C)." (Ma, 1998). This shows a strong connection between GHG and temperatures and, implicitly, the influence they have over the global climate.

To further understand the importance of GHG and their decisive role in the Global Climate and Global Warming, it is necessary to apprehend the mechanism through which they interact with the environment. GHG are gases in an atmosphere that subject to their chemical and physical properties, accumulate and re-emit radiation to the ambient. This process fundamentally defines the greenhouse effect. The main greenhouse gases in Earth's atmosphere are: water vapour, carbon dioxide, methane, nitrous oxide and ozone.

The main GHG produced by human activities, the carbon dioxide, compared to other GHG, does not pose a threat only by its nature and greenhouse effect, but also by the fact that once it is released, it can affect the climate for a long number of years before it is removed from the atmosphere. (Archer, 2016). Even this “removal” can cause problems, since a large quantity of CO2 goes into the planetary waters, influencing the chemistry of the waters and leading to a potentially negative effect on the ecosystem. This alone can be seen as a sufficiently good reason for immediate action towards the reduction of CO2 emissions caused by human activities. Nevertheless, this process would never soak up enough CO2 to return atmospheric levels to what they were before industrialization (Tyrell, 2007).

3. CLIMATE CHANGE AND URBAN AREAS

As previously detailed, climate and climate change are specific and can refer to various areas, on a smaller or on a larger scale. When approaching the smaller scale, we enter into the field of what is called “Microclimate”, which can be defined as “the climate of a very small or restricted area, especially when this differs from the climate of the surrounding area" (Luca, 2017). Based on specific characteristics and observed differences of the climate, when referring to the main areas inhabited by humans, two general categories can be determined and differentiated: Urban areas and Rural areas.

When comparing Urban areas and nearby Rural areas, several differences can be observed in the small scale climate. The main parameter that seems to shape and interchangeably influence these climates, with a direct and indirect impact on human lives (e.g. levels of dust, precipitations, levels of humidity, health problems generated by the usage of cooling equipment, etc.) is the temperature, which is directly connected and driven by the built environment and the human activities in the two areas. It is observable that temperatures in “heavy developed” cities tend to be higher than the ones of the surrounding rural areas. The effect of increased temperatures, can have different causes and can be justified and influenced

by various factors, such as: the built environment (tall buildings that have glass effect facades that reflect and concentrate sunlight; large amounts of construction materials, such as concrete or asphalt, that absorb energy from the sun, heat up and re-radiate, having a gradual warming up effect on the ambient air); traffic; industry; any other human activity that produces GHG, or radiates heat.

The increased temperatures that characterize such urban areas, not only directly or indirectly affect the comfort and health of the inhabitants, but also set the premises for a negative action-reaction circle, in which, in order to increase their own comfort, people tend to use more and more often vehicles (also seen as sources of heat) for moving around the city, or tend to use more frequently various cooling equipment, leading to an increase of GHG within the atmosphere, either directly (CO2 produced by cars, or other activities) or indirectly (since the production of electrical energy is connected to emissions of GHG into the atmosphere). Knowing that GHG in the atmosphere accelerate climate warming, the previously mentioned circle can be drawn: as the temperatures rise, humans will try and tend to adapt by engaging more often in activities that will generate more GHG emissions into the atmosphere, which will lead to temperatures increases and accelerate global warming (both locally and at a global scale).

As the Rural areas lack, in a positive way, the previously mentioned drivers for increased temperatures, they are less vulnerable to local climate warming, up to the extent in which the nearby "heavy developed areas" and global warming do not have an extreme effect on them.

In order to portray a sensible picture of the importance and relevance that "heavy developed" Urban Areas pose in what the Global Climate Change and Global Warming are concerned, it is mandatory to fully understand the role of all the relevant factors and their magnitude of influence within this context.

3.1. Buildings, the built environment and related human activities

As previously described, buildings, along with the entire built environment, have different direct or indirect influences on the urban and global climate. While some influences cannot be practically quantified, some can be understood in a more "measurable" manner. For example, (Chalmers 2014) in 2010, 34% of global final energy use and 24% of energy GHG are coming from buildings. This helps understand the impact of buildings over the climate in direct connection to the energy usage and GHG emissions.

Recent research suggests methodology to define a detailed description of buildings for urban climate and building energy consumption simulations (Tornay et al, 2017) and also methodology (Palme et al, 2017) to incorporate the UHI effect in building performance simulation.

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3.2. Urban Transportation

Even if it is almost impossible to provide a worldwide global estimate for the ratio at which urban transportation alone counts in the overall transportation sector, except from limited study cases based on traffic analysis and statistical modelling for certain areas, a general overview on the Transportation Sector can be sufficient to draft a picture of its impact on the Climate. Recent analysis emphasized that 23% of CO2 emissions are produced by transportation sector, from fuel combustion and is increasing in a fast manner (Sims 2014).

Research in the field is heading towards improving air quality through use of electric vehicles (Incropera, 2016) but also through smart grid which is important to the transition to wind and solar generated electricity (Erikson et al, 2017).

3.3. Industries in Urban Areas

Several studies (Heede, 2014) claim that roughly two-thirds of the global GHG were caused by only 90 companies, from the beginning of the industrial era until today. Similar to the Transportation Sector, viewing the large number of models that describe urbanization in different areas and cultures, it is hard to establish a global and generally applicable conclusion on the exact Impact of Industries in Urban Areas, except from limited study cases that could be made on certain areas. Nevertheless, while the industrial activities that generate GHG outside of urban areas have a less visible immediate effect, it is highly perceivable that the industries within cities have a more direct and rapid impact on the urban climate.

3.4. The Built Environment and its role in Climate Change – Mitigation and Adaption

Considering the hypothesis from the beginning of the paper, that humankind is not able and will not be able anytime soon to fully control Climate Change, for the time being, the only possible approaches towards the reduction of the hazardous consequences of this phenomena are the mitigation of human impact on the climate and the adaption to changes. However, next steps and their consequent impact, are to be considered:

Mitigation of GHG emissions into the atmosphere caused by the built environment

Even if the report mentioned under the previous section (i.e. “Buildings and the built environment“) positively concludes that best practices and technologies would support stabilisation or fall of energy use in buildings, a deeper approach should be encouraged, in order to better describe, understand and action against the impact of the built environment, locally or globally, on the GHG levels in the atmosphere and Climate Change.

For this, it could be necessary to establish a thorough approach on the matter and to segregate the idea of impact, as proposed below:

1. Direct impact is related to the overall "climate cost" in terms of GHG released into the atmosphere, as required for the functioning and designated purpose of a construction object, during its lifespan.

The available know-how and technologies offer possibilities for low and even zero-energy buildings. This has a huge potential over the reduction of GHG emissions during the lifespan of buildings. However, it is a real challenge regarding the identification of the right mechanisms for encouraging the development of such buildings, not only for developed countries, but also and especially for underdeveloped communities, where urbanization can be seen as chaotic and distant from such an approach. Moreover, the existing buildings continue to use energy inefficiently and indirectly generate GHG. Not only this, but the buildings are only part of the human built environment, so for a higher efficiency towards tackling the issue of GHG emissions, the actions related to the Construction Industry should not be limited to buildings alone, but to cover the built environment as a whole. The indirect impact of the built environment seems to be insufficiently managed, with limited mechanisms regarding the encouragement of materials produced under low "climate costs" in terms of GHG emissions, or in aspects such as their effect of accumulating and re-radiating heat.

Nevertheless, legislation has to be developed and serious political action is required in order to encourage good practices in relation to activities that cause GHG emissions, among which, measures that would allow only the development of a healthy and environmentally friendly built environment.

2. Indirect impact

a. All the materials, equipment and plant that are part of the construction process require energy in order to function and/or to be produced. The production of energy is directly related to the GHG released into the atmosphere. Therefore, a direct estimation is needed, regarding the "climate cost" in terms of released GHG into the atmosphere for construction works, which should be seen as a whole.

b. "Climate cost" is also regarded in terms of released GHG into the atmosphere for dismantling, recycling and disposing of buildings or parts of the buildings after their lifespan.

All over the world, different measures are taken into discussion and even if there are several positive measures that could and should be implemented, this article, as final scope, proposes a potential approach towards the issue of GHG emissions and its mitigation, which could be further on debated and analysed.

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The conversion of GHG emissions into financial burden as "climate cost"

A full transparency in relation to the GHG emissions caused by the different energy producing companies should be enforced (e.g. energy bills should state the amount of GHG emissions and other harmful substances that were generated during the production process of the electrical energy the client had consumed in relation to the respective bill) and, subject to a profound analysis towards detailed implementation, the quantity of these emissions could be converted into a financial burden taking the form of taxation or of something similar. On an open market, where clients can choose their energy providers, this could lead to an efficient encouragement for companies to allocate resources towards researching new ways to reduce GHG emissions in their energy production process. Doing so, large scale producers of construction materials for example, or other industries which require high amounts of energy in their production line, could also choose lower cost energy providers (having reasons related financial or GHG emissions aspects, or both), in order to increase their own competitiveness.

Even more, either if we talk about the construction process or the final finite product, the built environment could be taxed on the amount of GHG emissions generated, directly or indirectly, following the previously described model. This could force developers and designers to take these additional costs effectively into account for their project/design, and, as a desired consequence, to search for a less environmentally harmful solution.

Depending on the form and dynamism of such a taxation system, presuming it manages to cover also the materials used for construction works and their final impact on the surroundings such as their effect of heat accumulation and re-emission to the ambient, research of advanced materials with limited impact on the environment could be encouraged within the private sector.

Of course, such a taxation system should not discourage investments and developers from starting and implementing their projects. It should only influence the decision making and help shape a more environmentally friendly sector of human activity.

Mitigation of the impact of the built environment on the surroundings and within urban areas

For direct mitigation and adaption to climate changes there are enlisted some of the actions that could be immediately implemented in relation to the built environment and the mitigation of its impact on the climate, as well as in relation to the enhancement of urban climate quality, as a matter of adaption to global warming:

1. Enhancement of the energy efficiency of the already built environment.

2. Maintenance, protection and extension of green spaces, even green infrastructure (Luca et al, 2015); installation of means (e.g. tall trees, suspended covers, etc.) that protect streets against sunlight, in order to encourage walking or cycling).
3. Development and installation of means and measures to regulate humidity and dust levels within the city.
4. Enforcement of legislation that allows only the construction of low or zero-energy buildings.
5. Development and implementation of a taxation system based on GHG emissions, as previously described.
6. Investment and funding for the research of environmentally friendly construction materials.
7. Investment and funding for the research of energy efficient production lines for construction materials (and not only).
8. Investment and funding for the enhancement of production lines for construction materials in terms of "climate cost" and GHG emissions.
9. International agreements and efforts for defining and enforcing general principles for urbanization on a global scale (including underdeveloped communities that are characterized by an accelerated chaotic urbanization), having environmental friendliness as fundamental principle.

Indirect mitigation

For a better understanding of the complex implications that the built environment can have on urban areas and its climate, it is necessary to understand that such an environment has, as primary scope, to facilitate activities in a satisfactory way and in direct response to the complex needs of its inhabitants. Depending on cultures, levels of education, capabilities, and many other factors, the needs can be acknowledged differently from case to case, and this is a direct reference to the way the need for a healthy environment is perceived by the general public.

One indirect effect of urbanization and the built environment is that it attracts traffic, which has a severe impact on CO2 emissions and other particles (Krzyzanowski et al, 2014). The amount of attracted traffic is in direct connection with the inhabitants needs, behaviour and culture that influence their own decision making in terms of preferred means of transportation. This is just an observable example of how the built environment can indirectly influence the climate and human lives. In view of the subject's complexity, a multidisciplinary approach is required (e.g. scientists from different fields, legal experts, economists that would have to assess different measures etc.), in order to better understand the urban area with its built

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environment, the climate (locally or generally) and the behaviours and needs of its inhabitants and also to properly understand the interdependency between all these factors. It can be presumed that the indirect impact of the built environment can go beyond the observable spectrum of one individual with the level of understanding relatively limited to its own profession and knowledge, and should be subject for a holistic approach, where all the individuals should understand the context of Climate Change, act accordingly and even bring their own personal input, as a generalized approach and involvement towards this subject. Therefore, in order to properly enhance the efficiency of the mitigation of human activities negative influence on the environment (including the built environment), at least on a long term, and to assure proper actions and decisions, at a smaller or a bigger scale, it is required to make the subject of Climate Change available to everybody by introducing it as a subject within the global educational system curricula.

3.5. Climate change in Romania

Romania occupied the 46th position in 2014 (Le Quéré et al, 2015) being accountable for 19090 of thousand metric tons of carbon (not CO2) emissions, representing only about 0.21% of the global emissions. Nevertheless, the high level of carbon emissions concentrated within higly congested urban areas can still pose a serious threat in terms of local urban climate and public health.

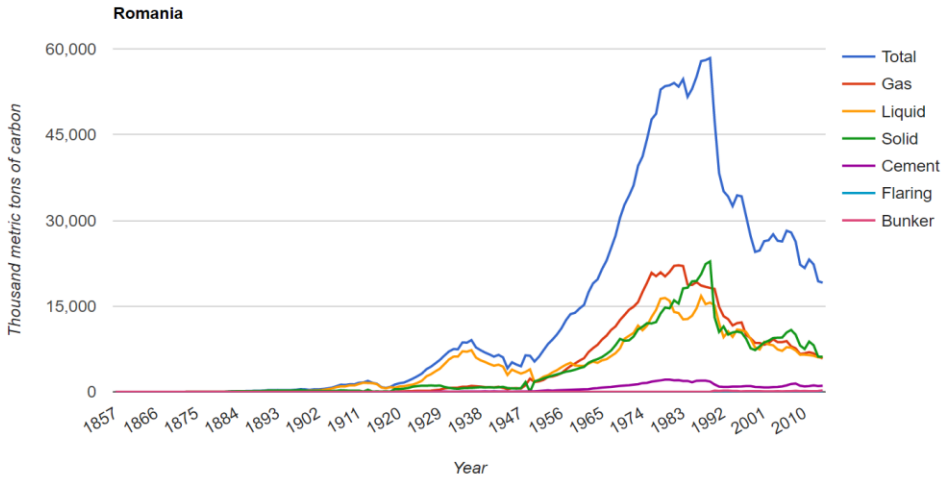

FIGURE 3 – CARBON EMISSIONS FROM 1857 TO 2014 IN ROMANIA
(Source: Carbon Dioxide Information Analysis Center)

Nevertheless, some results can be seen, as several projects such as Urban Climate Study of Bucharest -UCS, financed by Romanian-Swiss Research Programme between 2013-2016 or Urban Heat Island Monitoring under Present and Future Climate (2013-2015) - UCLIMESA, financed by STAR Programme, are starting the study of urban climate.

Project Urban Climate Study of Bucharest integrated basic research on the urban climate and air pollution of the Bucharest region, analysed the time series of spatially distributed data from satellites, the application of the results for urban and regional planning, and the transfer and implementation of methodologies and spatially distributed data for local planning authorities. The project results were largely disseminated and results are easy replicable.

Project UCLIMESA investigated the characteristics of the Urban Heat Island (UHI) over the city of Bucharest (Romania), both under the present climate conditions and in the long-term climate change perspective (2021-2050), by integrating data retrieved from satellite imagery, ground-based meteorological stations, and other sources (e.g. urban sensors, field experiments). The project detailed the potential of satellite remote sensing to investigate UHIs characteristics (e.g. magnitude, intensity, extension) in order to support the adequate monitoring and response to future climate challenges.

At the same time European projects including Romanian partners are implemented, such as Train-to-NZEB, financed by Horizon 2020, designed to establish a network of training and consultation centres, providing practical trainings, demonstrations and complex consulting services for the implementation of nearly-zero energy buildings (NZEB).

4. CONCLUSIONS

The subject of Climate Change becomes more and more relevant as its consequences and effects become more visible, both at a global level and especially in the isles of "heavy developed" urban areas. With the growing importance of the topic, the general public still has limited insight, knowledge and understanding of this subject and its importance. Even if there is plenty of information available, it is not as visible and effective as the political debates or the sceptical figures, which easily create confusion regarding such a complex matter, which requires some effort for a thorough understanding. This leads to ignorance, inefficient political action, lack of will for action, and continuous postponing of measures that should have been taken long time ago. Communities developed especially in terms of general education level will struggle to impose rules and will take measures for more eco-friendly urban areas, industries, and so on. In the meantime, the uneducated communities will continue to show a chaotic approach towards urbanization and development, towards noxious industries, without having the environment as main guideline of thought and decision making. This scenario should be avoided, strong and consistent political decisions should be enforced and efficient ways should be identified, so that at a global scale:

- climate Change (with deep reference to the impact of the built environment, industries, related human activities, etc.) becomes a subject in the worldwide educational systems even for the early stages (e.g. school, high-school);

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- climate Change becomes a relevant subject in higher-educational systems, as required by its multidisciplinary dimension;
- measures and actions, such as those described under "Direct mitigation and adaption to climate changes", are taken immediately.

REFERENCES:

Archer, D. (2016). *The long thaw: How humans are changing the next 100,000 years of earth's climate*. Princeton University Press.

Chalmers, P. (2014). *Climate change: Implications for buildings. Key Findings from the Intergovernmental Panel on Climate Change Fifth Assessment Report*.

Erickson, L. E., Robinson, J., Brase, G., & Cutsor, J. (Eds.). (2016). *Solar powered charging infrastructure for electric vehicles: A sustainable development.* CRC Press.

GISTEMP Team. (2017). GISS Surface Temperature Analysis (GISTEMP). *NASA Goddard Institute for Space Studies*. Retrieved August 15, 2017 from https://data.giss.nasa.gov/gistemp/.

Heede, R. (2014). Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854–2010. *Climatic Change*, 122(1-2), 229-241.

Hutter, B. M. (2017). *Risk, resilience, inequality and environmental law*. UK: Edward Elgar.

Incropera, F. P. (2016). *Climate Change: A Wicked Problem: Complexity and Uncertainty at the Intersection of Science. Economics, Politics, and Human Behavior*, Cambridge University Press, New York.

Krzyzanowski, M., Apte, J. S., Bonjour, S. P., Brauer, M., Cohen, A. J., & Prüss-Ustun, A. M. (2014). Air pollution in the mega-cities. *Current Environmental Health Reports*, 1(3), 185-191.

Le Quéré, C., Moriarty, R., Andrew, R. M., Canadell, J. G., Sitch, S., Korsbakken, J. I., ... & Houghton, R. A. (2015). Global carbon budget 2015. *Earth System Science Data*, 7(2), 349-396.

Luca, O. (2017). Considerations on climate strategies and urban planning: Bucharest case study. *Theoretical and Empirical Researches in Urban Management*, 12(1), 53.

Luca, O., Petrescu, F., Iacoboaea, C., Gaman, F., Aldea, M., & Sercaianu, M. (2015). Green structure in Romania: the true story. *WIT Transactions on Ecology and the Environment*, 193, 489-500.

Ma, Q., & Tipping, R. H. (1998). The distribution of density matrices over potential-energy surfaces: Application to the calculation of the far-wing line shapes for CO 2. *The Journal of chemical physics*, 108(9), 3386-3399.

NASA. (2017, January 18). 2016 warmest year on record globally, NASA and NOAA data show: Third record-breaking year in a row for average surface temperatures. ScienceDaily. Retrieved September 1, 2017 from www.sciencedaily.com/releases/2017/01/170118112554.htm

Palme, M., Inostroza, L., Villacreses, G., Lobato-Cordero, A., & Carrasco, C. (2017). From urban climate to energy consumption. Enhancing building performance simulation by including the urban heat island effect. *Energy and Buildings*, 145, 107-120.

Sims R., Schaeffer R., (2014). Transport. In Climate Change 2014, 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.), *Mitigation*

of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp 599 – 670). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press

Tornay, N., Schoetter, R., Bonhomme, M., Faraut, S., & Masson, V. (2017); GENIUS: A methodology to define a detailed description of buildings for urban climate and building energy consumption simulations. *Urban Climate*, 20, 75-93.

Tyrrell, T., Shepherd, J. G., & Castle, S. (2007). The long-term legacy of fossil fuels. *Tellus B*, 59(4), 664-672.

van Bakker, E. Z. (Ed.). (1978). *Antarctic Glacial History and World Palaeoenvironments* (Vol. 10). CRC Press.

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