Built Environment Life Cycle Process and Climate Change

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Abstract In order to design and realise an efficient built environment life cycle with focus on climate change mitigation and adaptation, it is necessary to carry out exhaustive investigations of all the decision and processes that form it. The efficiency level of the considered built environment life cycle depends on a great many micro, meso and macro factors. The authors of this paper participated in the different EU projects related with built environment and climate change [Linking European, Africa and Asian Academic Networks on Climate Change (LEAN CC), etc.]. One of the LEAN CC project's goals was to develop a Model and Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation. The presented Model and Intelligent System enables one to form up to 100 million alternative versions. Intelligent system allows one to determine the strongest and weakest points of each project and its constituent parts. In order to demonstrate the micro, meso and macro factors that influence the efficiency of the built environment in climate change mitigation and adaptation processes, the Model and Intelligent System will be considered as an example.

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1 Introduction

Climate change mitigation is action to decrease the intensity of radiative forcing in order to reduce the potential effects of global warming. In contrast, adaptation to global warming involves acting to tolerate the actual or expected effects of global warming (IPCC 2010). Most often, climate change mitigation scenarios involve reductions in the concentrations of greenhouse gases (GHGs), either by reducing their sources or by increasing their sinks (Molina et al. 2009).

Using data from 73 sites around the world, scientists have been able to reconstruct Earth's temperature history back to the end of the last Ice Age, revealing that the planet today is warmer than it has been during 70–80 % of the time over the last 11,300 years (Marcott et al. 2013).

Surface temperature reconstructions of the past 1,500 years suggest that recent warming is unprecedented in that time. Here, we provide a broader perspective by reconstructing regional and global temperature anomalies for the past 11,300 years from 73 globally distributed records. Early Holocene (10,000–5,000 years ago) warmth is followed by ~0.7 °C cooling through the middle to late Holocene (<5,000 years ago), culminating in the coolest temperatures of the Holocene during the Little Ice Age, about 200 years ago. This cooling is largely associated with ~2 °C change in the North Atlantic. Current global temperatures of the past decade have not yet exceeded peak interglacial values but are warmer than during ~75 % of the Holocene temperature history. Intergovernmental Panel on Climate Change model projections for 2100 exceed the full distribution of Holocene temperature under all plausible greenhouse gas emission scenarios (Marcott 2013).

The UN defines mitigation in the context of climate change, as a human intervention to reduce the sources or enhance the sinks of GHGs. Examples include using fossil fuels more efficiently for industrial processes or electricity generation, switching to renewable energy (solar energy or wind power), improving the insulation of buildings, and expanding forests and other 'sinks' to remove greater amounts of carbon dioxide from the atmosphere (GCCA 2012). The IAEA, an international organisation using the UN flag and reporting to the UN, asserts that nuclear power belongs to the set of options available to reduce greenhouse gas emissions in the power sector (IAEA 2008).

Scientific consensus on global warming, together with the precautionary principle and the fear of abrupt climate change (Schneider 2004) is leading to increased effort to develop new technologies and sciences and carefully manage others in an attempt to mitigate global warming. Most means of mitigation appear effective only for preventing further warming, not at reversing existing warming. The Stern Review identifies several ways of mitigating climate change. These include reducing demand for emissions-intensive goods and services, increasing efficiency gains, increasing use and development of low-carbon technologies and reducing fossil-fuel emissions (Stern 2007).

Residential sector carbon dioxide emissions originate primarily from: direct fuel consumption (principally, natural gas) for heating and cooking, electricity for cooling (and heating), appliances, lighting, and increasingly for television computers, and other household electronic devices. Energy consumed for heatir in homes and businesses has a large influence on the annual fluctuations in energ related carbon dioxide emissions. In the longer run, residential emissions a affected by population growth, income and other factors. From 1990 to 200 residential sector carbon dioxide emissions grew by an average of 1.3 % per yea U.S. population grew by an average of 1.1 % per year, per capita income (me sured in constant dollars) grew by an average of 1.7 % per year, energy efficienc improvements for homes and appliances have offset much of the growth in tl number and size of housing units. As a result, direct fuel emissions from petr leum, coal and natural gas consumed in the residential sector in 2008 were on 1.5 % higher than in 1990. Energy-related carbon dioxide emissions account f more than 80 % of U.S. greenhouse gas emissions (EIA report 2009). Oth countries have similar proportions of energy-related carbon dioxide emissions.

Global Carbon Cycle buildings in North America contribute 37 % of total CC emissions, while US buildings correspond to 10 % of all global emissions. Tl buildings sector of North America was responsible for annual carbon dioxic emissions of 671 million tons of carbon in 2003, which is 37 % of total Nort American carbon dioxide emissions and 10 % of global emissions. Options f reducing the carbon dioxide emissions of new and existing buildings incluc increasing the efficiency of equipment and implementing insulation and passiv design measures to provide thermal comfort and lighting with reduced energ Current best practices can reduce emissions from buildings by at least 60 % f offices and 70 % for homes. Technology options could be supported by a portfoli of policy options that take advantage of cooperative activities, avoid undul burdening certain sectors and are cost-effective (SOCCR 2008). Therefore, be practices utilisation is a key factor in productively executing a climate chang mitigation and adaptation in built environment project. The main purpose of th paper is to present the Model and Intelligent System of Built Environment Li Cycle Process for Climate Change Mitigation and Adaptation which the authors this paper have developed.

Sustainable material selection represents an important strategy in buildir design. Current building materials selection methods fail to provide adequa solutions for two major issues: assessment based on sustainability principles ar the process of prioritising and assigning weights to relevant assessment criteri Akadiri et al. (2013) proposes a building material selection model based on tl fuzzy extended analytical hierarchy process (FEAHP) techniques, with a view providing solutions for these two issues. Assessment criteria are identified base on sustainable triple bottom line (TBL) approach and the need of buildir stakeholders. A questionnaire survey of building experts is conducted to assess tl relative importance of the criteria and aggregate them into six independer assessment factors. The FEAHP is used to prioritise and assign importar weightings for the identified criteria. A numerical example illustrating tl implementation of the model is given. The proposed model provides guidance building designers in selecting sustainable building materials (Akadiri et al. 2013

The structure of this chapter is as follows: Sect. 2, which follows this introduction, describes the Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation. Section 3 analyses the micro, meso and macro factors that influence the efficiency of the built environment in climate change mitigation and adaptation processes. Section 4 describes Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation and Case Study 'Energy-Efficient House Decision Support Sub-system for Africa'. Certain concluding remarks appear in Sect. 5.

2 Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation

By modelling and forecasting future perspectives and trends of climate change mitigation and adaptation in built environment, it is possible to get ready to respond to the variation of micro-, meso- and macro-level variables. Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation suggested by this research is based on presumption that the efficiency of climate change mitigation and adaptation depends on many micro-, meso- and macro-level variables. The presence of specific micro-, meso- and macro-level variable factors right away imposes objective limitations for efficient climate change mitigation and adaptation in built environment.

Therefore, basing oneself on main worldwide development trends and best practices, it is possible to issue recommendations on the increase of efficiency of climate change mitigation and adaptation in built environment in specific country. When rational variable micro-, meso- and macro-level factors determine for specific country have been realised, they should create better and more favourable conditions for efficient realisation of climate change mitigation's projects would be created.

The research aim was to produce a Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation in specific country by undertaking a complex analysis of micro, meso and macro environment factors affecting it and to give recommendations on the increase of its competitive ability.

The research was performed by studying the main worldwide development trends and best practice, taking into consideration specific countries' history, development level, needs and traditions. Simulation was undertaken to provide insight into creating an effective environment for the climate change mitigation and adaptation in built environment by choosing rational micro, meso and macro factors. The most of stakeholders of climate change mitigation cannot correct or alter the micro-, meso- and macro-level variables, but they can go into the essence of their effect and take them into consideration when realising various activities. Stakeholders, knowing the micro-, meso- and macro-level factors affecting the activities being realised, can organise their present and future activities more successfully.

To design and achieve effective built environment life cycle with focus on climate change mitigation a complex analysis of its stages as well as stakeholders, their aims and potentialities are needed. The effect of micro, meso and macro environmental factors should also be taken into account.

Dozens of millions of built environment life cycle with focus on climate change mitigation and adaptation alternative versions can be obtained. The diversity of solutions available contributes to more accurate evaluation of economical, political, technological, emotional, climatic and other conditions, risk exposure, as well as making the project cheaper and better satisfying different stakeholder's requirements. This also leads to better satisfaction of the needs of all parties involved in the project design and realisation.

Various stakeholders are involved in the life cycle of a climate change mitigation, trying to satisfy their needs and affecting its efficiency. The level of the efficiency of life cycle of a climate change mitigation depends on a number of variables at three levels: micro, meso and macro level.

The problem is how to define an efficient built environment life cycle with focus on climate change mitigation and adaptation when a lot of various stakeholders are involved, the alternative project versions come to hundreds million and the efficiency changes with the alterations in the environment conditions and the constituent parts of the process in question. Moreover, the realisation of some objectives seems more rational from the economic perspective thought from the other qualitative perspectives they have various significance. Therefore, it is considered that the efficiency of a sustainable built environment life cycle depends on the rationality of its stages as well as on the ability to satisfy the needs of the stakeholders and the rational character of micro, meso and macro environment conditions.

Formalised presentation of the research shows how changes in the micro, meso and macro environment and the extent to which the goals pursued by various stakeholders are satisfied cause corresponding changes in the value and utility degree of a sustainable built environment life cycle. With this in mind, it is possible to solve the problem of optimisation concerning satisfaction of the needs at reasonable expenditures. This requires the analysis of built environment life cycle with focus on climate change mitigation and adaptation versions allowing to find an optimal combination of goals pursued and finances available.

The research object is a built environment life cycle with focus on climate change mitigation and adaptation, stakeholders striving to attain their goals and micro, meso and macro environment making an integral whole.

Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation was developed with the goal of integrating different quantitative and qualitative aspects of the process over the life of the climate change mitigation. This six-stage model is presented in brief heretofore (see Fig. 1):

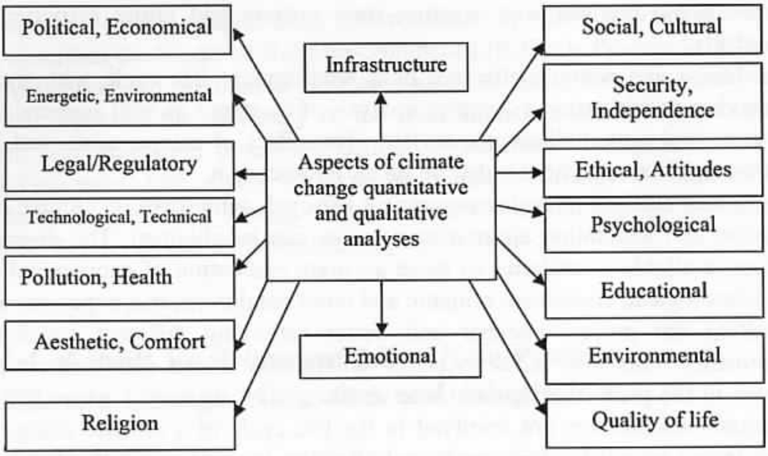


Fig. 1 Climate change mitigation and adaptation in built environment quantitative and qualitative analyses aspects

Stage 1. Comparative description of the climate change mitigation basing oneself on main worldwide development trends and best practices (see Fig. 1):

- Determining a system of criteria characterising the efficiency of a climate change mitigation by employing relevant literature and expert methods.
- Describing, per this system of criteria, the present state of the climate change mitigation in countries under consideration in conceptual (textual, graphical, numerical, virtual and augmented reality and such) and quantitative forms.

Stage 2. Comparison and contrast of the climate change mitigation in countries under consideration:

- Identifying the global development trends (general regularities) of the climate change mitigation.
- Identifying the differences in climate change mitigations in countries under consideration.
- Determining the pluses and minuses of these differences.
- Determining the best practice for the climate change mitigation in countries under consideration as per actual conditions.
- Estimating the deviation between the knowledge stakeholders have of worldwide best practices and their practice-in-use.

Stage 3. Development of certain general recommendations on how to improve the knowledge levels of stakeholders.

Stage 4. Submission of certain recommendations to stakeholders including several particular alternatives for each general recommendation proposed.

Stage 5. A multiple criteria analysis of the composite parts of a climate change mitigation and selection of the most efficient built environment life cycle with focus on climate change mitigation and adaptation—henceforth interlinking the received compatible and rational composite parts of a climate change mitigation into a full climate change mitigation process.

Section 4 'Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation. Case Study: Energy-Efficient House Decision Support Sub-system for Africa' illustrates a part of the Stage 5 'A multiple criteria analysis of the composite parts of a climate change mitigation' of the Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation.

Stage 6. Transformational learning and the redesign of mental and practical behaviour of different stakeholders.

3 Micro, Meso and Macro Factors that Influence the Efficiency of the Built Environment in Climate Change Mitigation and Adaptation Processes

In order to assure the efficiency of a project, it should be executed within certain bounds that are determined by the built environment. The fact is that these factors are different in each country, so also the possibilities for efficient realisation of projects (see Fig. 2) will also vary.

Figure 2 indicates diagrammatically the factors at micro, meso and macro level which may impinge upon the efficiency of the built environment. This means that to be efficient the built environment must operate within certain boundaries

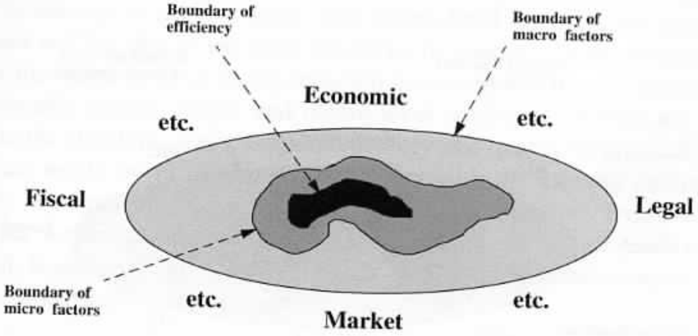


Fig. 2 Micro, meso and macro factors that influence the efficiency of the built environment in climate change mitigation and adaptation processes

imposed by the micro, meso and macro factors. Recognising that in each country the factors will be different, this diagram will vary accordingly. It is necessary to utilise knowledge and experience about the micro-, meso- and macro-level factors, so as to increase the efficiency level in each country under consideration. This will be done by analysing the worldwide experience, knowledge and best practices and applying this to specific country.

Using carbon tax as an example of this, it can be appreciated that if the level of carbon tax is high, national firms could either go bankrupt because of increased tax liabilities, or they could decrease efficiency in the face of a lack of competition from international companies who will not attempt to enter the local market. Similarly, if the carbon tax level is lowered, this may cause national firms to lose market share to international companies entering the local market, or to force them to increase efficiency in the face of such competition.

Such changes in taxation will alter the boundary of efficiency of the built environment. Similar built environment changes can shift this boundary (the area within boundary of efficiency expresses the total satisfaction level of needs of all stakeholders). For example, the specific country government (in order to solve the most important problems for specific country society) may abolish VAT on new residential passive houses in order to promote investment in passive housing. Thus, the boundary of efficiency is extended to include this new development from the former situation. After development of the specific country passive house sector, the boundary will alter again (Fig. 3 illustrate a revised level of efficiency as an example of how to take account of these alterations).

Figure 4 graphically illustrates interrelationships between macro level factors and the built environment. The area inside the ellipse represents the positive action of specific macro-level factors on the efficiency of the built environment. The area outside the ellipse represents the negative effect of the macro-level factors on the efficiency of the built environment, where the macro-level factors overlap a better environment for the built environment is created. In this case, the optimum environment for the built environment is when all four ellipse areas are overlapping (i.e. economic, fiscal, legal and market). The greater the common overlapping

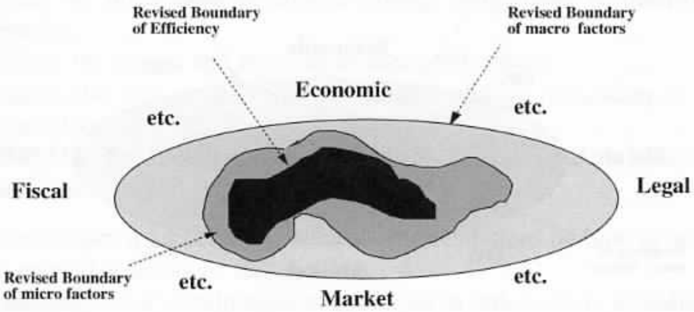


Fig. 3 Fluctuation of efficient boundary of micro, meso and macro environment

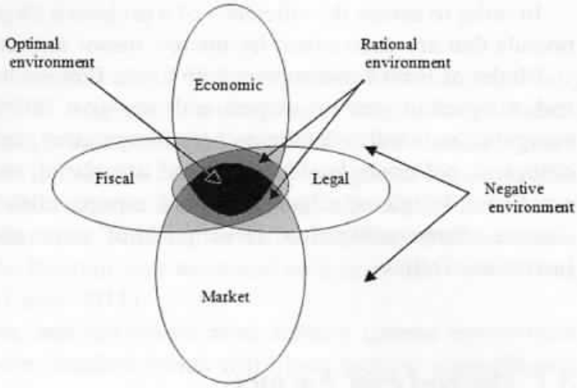


Fig. 4 Determination of optimal, rational and negative environment for the built environment

area (taking into account the significance of the factors), the greater will be the efficiency level of the built environment. Having investigated the effects of the micro, meso and macro variables affecting built environment by using best practices, differences have been identified between these and specific country. On the basis of these differences, the main implications for specific country can be identified. Studying only some worldwide experience, knowledge and best practices could lead to any inferences being purely subjective. However, by studying a number of countries any bias can be diminished. In other words, the presence of specific micro-, meso- and macro-level variable factors immediately imposes objective limitations on the efficient activities of stakeholders. The stakeholders, in the presence of these objective limitations, try to perform their activities in a more rational way.

Based on the above considerations, it is possible to propose a Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation on the basis of the performed search for a rational variable environment for specific country (i.e. seek to explore ways of harmonising the relationship between the specific country built environment and its micro, meso and macro environment). Upon completion of such a model, the stakeholders by taking into consideration existing limitations of micro-, meso- and macro-level environment and existing possibilities will be able to use their resources in a more rational manner.

One of the major tasks of an organisation is to carry out its activities under the most favourable micro-, meso- and macro-level conditions. Efforts are made to ensure that the structure, goals, output, efficiency and quality of production of the organisation would be in maximum conformity with the existing environmental conditions. The pursuit of impracticable goals, for instance, trying to realise projects that surpass the organisation's capabilities or the environment (economical, social, legal, political, competitive and technological conditions) is adverse, may cause undesirable consequences.

In order to assure the efficiency of a project, it should be executed within certain bounds that are determined by micro-, meso- and macro-level factors.

Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation was developed with the goal of integrating the environmental, energetic, political, economical, legal/regulatory, infrastructural, technical, technological, pollution, health, quality of life, social, cultural, ethical, psychological, emotional, religious, ethnic and other aspects of the process over the life of the climate change mitigation. Description of some above micro, meso and macro factors are follows.

3.1 Macro-Level Factors

The highest level at which factors may be considered is the macro-level factors. The level of efficiency and the scope of activities of the built environment depend on the next macro-level variable factors:

- a key economic indicators for the country as a whole,
- the global warming price,
- stakeholders,
- civil conflicts,
- human culture,
- religion,
- ethics,
- Easterlin paradox and happiness economics,
- intervention of government,
- physical infrastructure,
- Financial sector,
- interest rate,
- environment issues,
- unemployment,
- labour skill level,
- wages level,
- insurance,
- inflation,
- innovations,
- exchange rate,
- unofficial economy, etc.

A few examples regarding relations of climate change and macro-level factors (the global warming price, stakeholders, climate mobility social and civil conflicts, climate change and human culture, religion, ethics, easterlin paradox and happiness economics) are follows.

3.1.1 The Global Warming Price

The heated argument about economic costs, however, barely touched one vitally important issue: the costs of NOT taking action on climate. What if last summer's Russian heat wave and drought, which destroyed one-third of the country's wheat crop, or the catastrophic floods in Pakistan and China, or category 5 hurricanes like Katrina are just glimpses of future havoc from warming left unchecked? Certain events would have been extremely unlikely to have occurred without global warming and that includes the Russian heat wave and wild fires, and the Pakistan, Chinese, and Indian floods (Carey 2011).

Droughts, floods, wildfires, and hurricanes have already caused multibillion-dollar losses, and these extreme weather events will likely become more frequent and more devastating as the climate continues to change. Tourism, agriculture, and other weather-dependent industries will be hit especially hard, but no one will be exempt. Household budgets, as well as business balance sheets, will feel the impact of higher energy and water costs. Ruth et al. (2007) estimates what the United States will pay as a result of four of the most serious impacts of global warming in a business-as-usual scenario—that is, if we do not take steps to push back against climate change (Ruth et al. 2007):

- Hurricane damages: $422 billion in economic losses caused by the increasing intensity of Atlantic and Gulf Coast storms. In the business-as-usual climate future, higher sea-surface temperatures result in stronger and more damaging hurricanes along the Atlantic and Gulf coasts. Even with storms of the same intensity, future hurricanes will cause more damage as higher sea levels exacerbate storm surges, flooding and erosion. In recent years, hurricane damages have averaged $12 billion and more than 120 deaths per year. With business-as-usual emissions, average annual hurricane damages in 2100 will have grown by $422 billion and an astounding 760 deaths just from climate change impacts.
- Real estate losses: $360 billion in damaged or destroyed residential real estate as a result of rising sea levels. Our business-as-usual scenario forecasts 23 inches of sea-level rise by 2050 and 45 inches by 2100. If nothing is done to hold back the waves, rising sea levels will inundate low-lying coastal properties. Even those properties that remain above water will be more likely to sustain storm damage, as encroachment of the sea allows storm surges to reach inland areas that were not previously affected. By 2100, U.S. residential real estate losses will be $360 billion per year.
- Energy costs: $141 billion in increasing energy costs as a result of the rising demand for energy. As temperatures rise, higher demand for air conditioning and refrigeration across the country will increase energy costs, and many households and businesses, especially in the North, that currently do not have air conditioners will purchase them. Only a fraction of these increased costs will be offset by reduced demand for heat in Northern states. The highest net energy costs—after taking into consideration savings from lower heating bills—will fall on Southeast and Southwest states. Total costs will add up to more than $200

billion for extra electricity and new air conditioners, compared with almost $60 billion in reduced heating costs. The net result is that energy sector costs will be $141 billion higher in 2100 due to global warming.

- Water costs: $950 billion to provide water to the driest and most water-stressed parts of the United States as climate change exacerbates drought conditions and disrupts existing patterns of water supply. The business-as-usual case forecasts less rainfall in much of the United States—or, in some states, less rain at the times of year when it is needed most. By 2100, providing the water we need throughout the country will cost an estimated $950 billion more per year as a result of climate change. Drought conditions, already a problem in Western states and in the Southeast, will become more frequent and more severe.

3.1.2 Stakeholders

The Citizens' support for policies that aim to curb carbon emissions and energy use is often seen as informed by their values, attitudes and perceptions of the environmental problem in question. Fischer et al. (2011) argue that we also need to understand how people conceptualise policies and the governance approaches underpinning them to be able to judge the likely acceptance of policy change. Fischer et al. (2011) draw on qualitative interviews ($n = 202$) from five European countries to explore citizens' views on governance approaches to stimulate behavioural change in the field of resource use, including regulations, price changes, collective action, technological change and education. Fischer et al. (2011) found that many of our interviewees referred to generalised characteristics of humankind and contemporary society to back up their arguments for or against specific governance approaches. In particular, many interviewees concurred that people in general were so self-centred, driven by habit and money- and consumption-oriented that only strict regulations, drastic price changes and technological innovation could possibly achieve widespread behavioural change. As a consequence, such 'folk psychologies' can have substantial impact not only on public acceptance, but also on the success of policy measures that aim to reduce citizens' resource use (Fischer et al. 2011).

Climate change has been identified as potentially the biggest health threat of the twenty-first century. Canada in general has a well-developed public health system and low burden of health which will moderate vulnerability. However, there is significant heterogeneity in health outcomes, and health inequality is particularly pronounced among Aboriginal Canadians. Intervention is needed to prevent, prepare for, and manage climate change effects on Aboriginal health but is constrained by a limited understanding of vulnerability and its determinants. Despite limited research on climate change and Aboriginal health, however, there is a well-established literature on Aboriginal health outcomes, determinants, and trends in Canada; characteristics that will determine vulnerability to climate change. In this paper, Ford et al. (2010) systematically review this literature, using a vulnerability framework to identify the broad level factors constraining adaptive capacity and increasing sensitivity to climate change. Determinants identified include the following: poverty, technological capacity constraints, socio-political values and inequality, institutional capacity challenges, and information deficit. The magnitude and nature of these determinants will be distributed unevenly within and between Aboriginal populations necessitating place-based and regional-level studies to examine how these broad factors will affect vulnerability at lower levels. The study also supports the need for collaboration across all sectors and levels of government, open and meaningful dialogue between policy makers, scientists, health professionals, and Aboriginal communities, and capacity building at a local level, to plan for climate change. Ultimately, however, efforts to reduce the vulnerability of Aboriginal Canadians to climate change and intervene to prevent, reduce and manage climate-sensitive health outcomes will fail unless the broader determinants of socio-economic and health inequality are addressed (Ford et al. 2010).

In the United States, public support for federal, state and local efforts to reduce GHGs continues to be a crucial element of the political viability of these proposals. Shwom et al. (2010) present a detailed analysis of the reasons given by the general public of Michigan and Virginia for supporting or rejecting a number of policies that could be implemented to meet GHG reductions. The data allow us to analyse the relationships between reasons provided by respondents, social psychological and demographic characteristics and policy support. This analysis can provide policymakers pragmatic guidance in (1) developing tactics to engage the public that build on current concerns about climate change policies and (2) crafting and communicating policies that garner support from various segments of the public. This analysis also raises theoretical questions regarding the relationship between public discourse on environmental issues and the formation of public policy support. Shwom et al. (2010) suggest that future efforts to understand the U.S. dynamics of public support for climate change policies could benefit from understanding the public discursive and the reasoning processes that underlie public opinion formation (Shwom et al. 2010).

Anti-coal and some investment policies are widely justified with reference to global warming. Political analysis suggests that these policies are supported by the reinforcing interests of three powerful lobbies: scientific institutions engaged in atmospheric research and earth observation, energy corporations harmed by low fossil fuel prices or supplying 'clean' technologies, and numerous interlocking bureaucracies. Together they have succeeded in maintaining momentum in current climate negotiations (Boehmer-Christiansen 1997).

3.1.3 Climate Mobility Social and Civil Conflicts

The Climate change can increase societies' propensity to conflict by changes in socio-structural conditions (e.g. resource scarcity and migration). Climate change is expected to bring about major change in freshwater availability, the productive capacity of soils, and in patterns of human settlement. The direst predictions about the impacts of global warming warn about greatly increased risks of violent conflict over increasingly scarce resources such as freshwater and arable land (Raleigh and Urdal 2007). Raleigh and Urdal (2007) argue that our best guess about the future has to be based on our knowledge about the relationship between demography, environment and violent conflict in the past. Previous rigorous studies in the field have mostly focused on national-level aggregates. Raleigh and Urdal (2007) represent a new approach to assess the impact of environment on internal armed conflict by using georeferenced (GIS) data and small geographical, rather than political, units of analysis. It addresses some of the most important factors assumed to be strongly influenced by global warming: land degradation, freshwater availability, and population density and change. While population growth and density are associated with increased risks, the effects of land degradation and water scarcity are weak, negligible or insignificant (Raleigh and Urdal 2007).

Allouche (2011) looks at the interrelationship between water and food security. More specifically, Allouche (2011) examines the resilience and sustainability of water and food systems to shocks and stresses linked to different levels and intensity of conflict, global trade and climate change. Allouche (2011) makes four points: (1) that resource scarcity as a driver of conflict is inconclusive especially at regional and national levels (2) most insecurities surrounding water and food are explained by political power, social and gender relations; (3) global trade has enabled national food and water security but that is now threatened by increasing food prices, food sovereignty movements and land 'grabbing' (4) and that water and food security will face major challenges under conditions of climate change (Allouche 2011).

Climates more suitable for Eurasian agriculture are associated with a decreased likelihood of conflict, while freshwater resources per capita are positively associated with the likelihood of conflict. Moreover, positive changes in rainfall are associated with a decreased likelihood of conflict in the following year (Hendrix and Glaser 2007).

In climate change discourse, climate mobility is often characterised as the production of 'refugees', with a tendency to discount long histories of ordinary mobility among affected populations. The case of Tuvalu in the Pacific juxtaposes migration as everyday practice with climate refugee narratives (Farbotko and Lazrus 2012).

3.1.4 Climate Change and Human Culture

If solar variability affects human culture, it most likely does so by changing the climate in which the culture operates (Feynman 2007).

Geel et al. (2004) described hypothesis regarding climate change and the expansion of the Scythian culture after 850 BC. In southcentral Siberia, archaeological evidence suggests an acceleration of cultural development and an increase in the density of nomadic populations around 850 BC. Geel et al. (2004) hypothesise a relationship with an abrupt climatic shift towards increased humidity caused by a decline of solar activity. Areas that initially may have been hostile semi-deserts changed into attractive steppe landscapes with a high biomass production and high carrying capacity. Newly available steppe areas could be invaded by herbivores, making them attractive for nomadic tribes. The central Asian horse-riding Scythian culture expanded and an increased population density was a stimulus for westward migration towards southeastern Europe (Geel et al. 2004).

Tibetan culture and livelihoods depend on native plants for medicine, food, grazing, wood, as well as cash from market sales. The Medicine Mountains (part of the Hengduan Mountains) of the eastern Himalayas, with tremendous plant diversity derived from steep gradients of both elevation and precipitation, have traditionally been an important source of Tibetan medicinal plants (Salick et al. 2009). Salick et al. (2009) examine climate change in this area and vegetation patterns influenced by biogeography, precipitation and elevation. The Alpine environment has the highest plant diversity and most useful plants and is the most susceptible to climate change with impacts on traditional Tibetan culture and livelihoods—particularly Tibetan medicine and herding (Salick et al. 2009).

3.1.5 Religion

Biomass Different religion leaders call on all people and nations to recognise the serious and potentially irreversible impacts of global warming caused by the anthropogenic emissions of GHGs and other pollutants, and by changes in forests, wetlands, grasslands and other land uses. According to the New Scientist (2007), also religious leaders pray for cold weather to combat climate change. Leaders from world religions gather in Greenland to show unity on the problem of global warming and to pray for the planet (The New Scientist 2007). As example, we will present Vatican and Buddhism point of view regarding climate change.

A Vatican-appointed panel of scientists has reported what climate change experts have been warning for years: the Earth is getting warmer, glaciers are melting, and urgent measures are necessary to stem the damage. The scientists called for urgent reduction of carbon dioxide emissions and reductions in methane and other pollutants that warm the air, and for improved observation of mountain glaciers to better track their changes. The Pontifical Academy of Sciences, a Vatican advisory panel appeal to all nations to develop and implement, without delay, effective and fair policies to reduce the causes and impacts of climate change on communities and ecosystems, including mountain glaciers and their watersheds, aware that we all live in the same home (Vatican-appointed… 2011).

Buddhism is not a religion; it is a way of life. It teaches the moral and ethical conduct… for the happiness of oneself and the welfare of the community. The Buddhist doctrines… [analyse] human life and the intrinsic nature of things… based on reasoning and rational thinking… not based on an initial act of faith (Mendis 1993).

Firstly, Buddhism proposed that beliefs, values and ethics have a strong influence upon the behavioural outcomes that are manifest as the driving forces behind environmental pressures. Although this perspective underplays the role of structural forces that constrain human behaviour, the influence of beliefs and values can be seen to operate via their configuration of goals, wants, needs, intent and choices. Secondly, a more complete nexus with Buddhism requires an explicit shift in focus to human welfare as the key objective of both mainstream economic and policy prescriptions, and the Buddhist way of life (Daniels 2010a).

The Second Noble Truth reveals the source of this persistent dissatisfaction or disappointment. It comes from clinging or attachment to external, worldly phenomena in the belief that they will bring sustained and consummate satisfaction or happiness (French 2003). These objects of our desire include not just material goods or assets and the services they provide but people and other animate beings as well as ideas, social and economic roles, success and status (Webster 2005).

Desire for maximum consumption via material good accumulation, derived services, and control over people for self-satisfaction, drives economic and lifestyle choices and is the natural economic (if not the social) outcome of a belief system based on the principle that the external world is the ultimate source of happiness (Tideman 2001).

Buddhism makes to explain the 'double whammy' of the past 60 years of spectacular fossil-fuel-based economic growth where happiness levels within nations do not seem to be increasing (the 'Easterlin Paradox'), and yet resource use and degradation have reached unsustainable and possibly ecosphere catastrophe levels (Baucells and Sarin 2007; Daniels 2007). The relentless drive for the economic extraction and transformation of nature for economic wealth has not had the anticipated positive impact on subjective well-being. Indeed, craving for material wealth has not only failed to significantly reduce 'suffering' (increase well-being) but has increased environmental destruction and instability (Mendis 1993).

Daniels (2010a) examines how central Buddhist world views and themes can contribute to effectively addressing climate change by looking deep within the ethical, economic and ecological nature of consumer market economies. A persistent theme of Daniels (2010a) approach is the structured analysis of climate change in terms of the drivers, pressures, and responses that stem from societal beliefs and world views about human actions and choices, and their links to human goals and well-being. Buddhist notions of interconnectedness, dependent origination, and mindful consumption and production can help explain and reshape human motives and actions for climate and other forms of environmental sustainability. The mode of analysis of Buddhism has had much in common with ecological economics—with primary conceptual and methodological roles ascribed to ethics, the ecologisation of society, social capital and sustainability, and ultimate means and ends via an extensive consideration of well-being and the goals of human endeavour (Daniels 2010a).

Environmental, economic, ethical and cosmological dimensions of Buddhism are presented as a logical and practical basis for reducing the climate change pressures deriving from prevailing global modes of production and consumption

(Daniels 2010b). Daniels (2010b) presents an analytical framework and philosophical base for understanding the causes and refining the goals behind human and societal endeavour. Buddhist notions of interconnectedness, dependent origination and mindful consumption and production can help explain and reshape human motives and actions for climate and other forms of environmental sustainability (Daniels 2010b).

3.1.6 Ethics

Climate change raises many questions with strong moral and ethical dimensions that are important to address in climate-policy formation and international negotiations (Wardekker et al. 2009).

The emotional and embodied practice of narrative ethics is offered as one possible response to the overemphasis on technical rationality within our society and its institutions (Willis 2012). Willis (2012) argues that the development of practical wisdom (phronesis) is essential to addressing issues such as climate change, which are not simply technical problems but are fundamentally rooted in the human condition.

Ecoethics is an emerging discipline that trains moral attention and critical reflection on the vastly expanded range of human productive and consumptive powers that are causing increasing and perhaps irreparable damage to many of Earth's ecosystems and the human communities and non-human species who depend on those ecosystems' well-being. Ecoethics ponders the significance of how the rapidly rising human population is so widely transforming natural ecosystems that increasing numbers of animal and plant species are being pushed via habitat destruction into endangerment or extinction. Likewise, ecoethics ponders the fate of both humanity and that of all other species as it confronts rising worries about anthropogenic or human-caused global warming or climate change trends (French 2008).

3.1.7 Easterlin Paradox and Happiness Economics

The Easterlin Paradox is a key concept in happiness economics. It is named for economist and USC Professor Richard Easterlin who discussed the factors contributing to happiness in the 1974 paper 'Does Economic Growth Improve the Human Lot? Some Empirical Evidence'. Easterlin found that within a given country people with higher incomes are more likely to report being happy. However, in international comparisons, the average reported level of happiness does not vary much with national income per person, at least for countries with income sufficient to meet basic needs. Similarly, although income per person rose steadily in the United States between 1946 and 1970, average reported happiness showed no long-term trend and declined between 1960 and 1970. The implication for government policy is that once basic needs are met, and policy should focus not on economic growth or GDP, but rather on increasing life satisfaction or Gross national happiness (Wiki). There is no evidence of a marked increase in life satisfaction in China of the magnitude that might have been expected based on the fourfold increase in the level of per capita consumption during that period. In its transition, China has shifted from one of the most egalitarian countries in terms of distribution of life satisfaction to one of the least egalitarian. Life satisfaction has declined markedly in the lowest-income and least-educated segments of the population, while rising somewhat in the upper SES stratum (Easterlin et al. 2012).

Moreover, the life satisfaction pattern in China fits with the historical context. The factors shaping life satisfaction in China appear to be essentially the same as those in the European transition countries—the emergence and rise of substantial unemployment, dissolution of the social safety net, and growing income inequality. The failure of China's life satisfaction to increase despite its differing output experience—a rapid increase versus the collapse and recovery of output in the European countries—suggests that employment and the social safety net are critically important factors in determining life satisfaction. One may reasonably ask how it is possible for life satisfaction not to improve in the face of such a marked advance in per capita GDP from a very low initial level? In answer, it is pertinent to note the growing evidence of the importance of relative income comparisons and rising material aspirations in China, which tend to negate the effect of rising income. These findings are consistent with the view common in the happiness literature that the growth in aspirations induced by rising income undercuts the increase in life satisfaction related to rising income itself (Easterlin et al. 2012).

Moreover, there is more to life satisfaction than material goods. Other factors include home life and the need for a secure job to support it, health, friends and relatives, and the like. It is possible that the lack of a marked uptrend in overall life satisfaction in China might reflect an adverse impact on life satisfaction of changes in such factors as these, as has been true of the transition experience of East Germany, for which data on such circumstances are available (Easterlin 2010).

The GDP measure registers the spectacular average improvement in material living conditions, whereas the measure of life satisfaction demonstrates that among ordinary people, especially the less-educated and lower income segments of the population, life satisfaction has declined noticeably as material aspirations have soared and concerns have arisen about such critical matters as finding and holding a job, securing reliable and affordable health care, and providing for children and the elderly. Clearly, life satisfaction is the more comprehensive and meaningful indicator of people's life circumstances and well-being (Stiglitz et al. 2008).

It would be a mistake to conclude from the life satisfaction experience of China, and the transition countries more generally, that a return to socialism and the gross inefficiencies of central planning would be beneficial. However, our data suggest an important policy lesson that jobs and job and income security, together with a social safety net are of critical importance to life satisfaction. In the last few years, the government of China has begun serious efforts to repair the social safety net. These efforts are an encouraging portent for the future life satisfaction of the Chinese population, particularly for the least advantaged segments (Vodopivec and Tong 2008).

3.2 *Micro- and Meso-Level Factors*

The second-level factors may be considered as the micro level and these depend upon those at the macro level.

It is obvious that in order to design and realise a high-quality passive house project, it is necessary to take care of its efficiency from the initial brief to the end of maintenance. The entire process must be planned and executed taking into account the specific goals of the participating parties. The designing and planning procedure must include multiple criteria optimisation, not only of the separate processes and decisions, but also of the whole life cost of the passive house. This must take into account the needs expressed by the parties involved in the project.

In order to efficiently design and implement projects in the built environment, it is necessary to investigate as many of the possible alternative solutions for each variable and to select the most rational one. The selected variables are then combined into one efficient project. Hence, the efficiency of a project will depend to a very great extent not only on the selected variables, but also on micro, meso and macro factors affecting them.

The level of efficiency and the scope of activities of the built environment depend on the next micro variable factors:

- information system of built environment,
- building's life cycle energy analysis,
- energy use in the built environment,
- pollution and health in cities,
- real estate losses as a result of sea-level rise,
- education and training,
- types of contracts,
- briefing process,
- design process,
- manufacture process,
- construction process,
- maintenance process,
- facilities management,
- holiday travels,
- festivals,
- etc.

As an example, further on we shall briefly discuss some above-mentioned micro-level factors (building's life cycle energy analysis, energy use in the built environment, pollution and health in cities, real estate losses as a result of sea-level rise, holiday travels, Cherry blossom festivals).

3.2.1 Building's Life Cycle Energy Analysis

Buildings demand energy in their life cycle right from its construction to demolition. Studies on the total energy use during the life cycle are desirable to identify phases of largest energy use and to develop strategies for its reduction. Ramesh et al. (2010) presented a critical review of the life cycle energy analyses of buildings resulting from 73 cases across 13 countries. The study includes both residential and office buildings. Results show that operating (80–90 %) and embodied (10–20 %) phases of energy use are significant contributors to building's life cycle energy demand. Life cycle energy (primary) requirement of conventional residential buildings falls in the range of 150–400 kWh/m^2/year and that of office buildings in the range of 250–550 kWh/m2/year. Building's life cycle energy demand can be reduced by reducing its operating energy significantly through use of passive and active technologies even if it leads to a slight increase in embodied energy. However, an excessive use of passive and active features in a building may be counterproductive. It is observed that low-energy buildings perform better than self-sufficient (zero operating energy) buildings in the life cycle context. Worldwide, 30–40 % of all primary energy is used for buildings, and they are held responsible for 40–50 % of green house gas emissions. It is therefore essential for the building built environment to achieve sustainable development in the society. Sustainable development is viewed as development with low environmental impact, and high economical and social gains. To achieve the goals of sustainability, it is required to adopt a multidisciplinary approach covering a number of features such as energy saving, improved use of materials including water, reuse and recycling of materials and emissions control. Life cycle energy analysis of buildings assumes greater significance for formulating strategies to achieve reduction in primary energy use of the buildings and control emissions (Ramesh et al. 2010).

Life cycle energy analysis is an approach that accounts for all energy inputs to a building in its life cycle. The system boundaries of this analysis) include the energy use of the following phases: manufacture, use and demolition. Manufacture phase includes manufacturing and transportation of building materials and technical installations used in erection and renovation of the buildings. Operation phase encompasses all activities related to the use of the buildings, over its life-span. These activities include maintaining comfort condition inside the buildings, water use and powering appliances. Finally, demolition phase includes destruction of the building and transportation of dismantled materials to landfill sites and/or recycling plants (Ramesh et al. 2010).

A large variety of materials are being used in building construction. Some of them may have a life-span less than that of the building. As a result, they are replaced to rehabilitate the building. In addition to this, buildings require some regular annual maintenance. The energy incurred for such repair and replacement (rehabilitation) needs to be accounted during the entire life of the buildings. It is the energy required for maintaining comfort conditions and day-to-day maintenance of the buildings. It is the energy for heating, ventilation and air conditioning (HVAC), domestic hot water, lighting and for running appliances. Operational energy largely varies on the level of comfort required, climatic conditions and operating schedules. At the end of buildings' service life, energy is required to demolish the building and transporting the waste material to landfill sites and/or recycling plants (Ramesh et al. 2010).

3.2.2 Impact of Climate Change on Energy Use in the Built Environment

Work on the subtropical climates had revealed an increasing trend of temperature and summer discomfort over the past decades, and it was found that the anticipated temperature rise could result in more cooling demand. More electricity use for air conditioning would lead to larger emissions, which in turn would exacerbate climate change and global warming. Even in regions with severe cold climates where the decrease in heating energy use could, in terms of final or delivered energy, outweigh the increase in cooling, the impact of climate change on the overall primary energy requirement and the environment would remain uncertain. This is because heating is usually provided by oil- or gas-fired boiler plants, whereas cooling relies on electricity-driven chillers (except gas-fired absorption systems). In terms of carbon footprint, electricity tends to have a much lower overall efficiency and higher CO_2 emissions per unit energy consumption. From a nationwide energy and environmental perspective, it is important to be able to estimate the magnitude of the likely changes in heating and cooling energy requirements due to climate change in different climate zones. Broadly speaking, there are two main approaches (Li et al. 2012):

- Degree-days method. The degree-days concept is widely used for measuring the influence of climate on heating and cooling requirements. Hekkenberg et al. (2009) argues that socio-economic changes may alter the temperature dependence pattern of energy demand in future years. However, to a good approximation heating and cooling energy requirements can be assumed to be proportional to the HDDs and CDDs, respectively. In recent years, this method has been used to assess the impact of climate change on regional energy demand as well as energy consumption in the built environment in different parts of the world. Pilli-Sihvola et al. (2010) chose five countries along the north–south gradient: Finland, Germany, the Netherland, France and Spain. Their main findings were as follows: in central and north Europe, the decrease in heating due to climate warming would dominate, and in southern Europe climate warming and the consequential increase in cooling and electricity demand would outweigh the decreasing need for space heating.
- Building energy simulation technique. There had been a number of studies on the impact of climate change on the built environment using sophisticated building energy simulation tools to perform hour-by-hour computation of the heating/cooling loads and corresponding energy use. Building energy simulation is an acceptable technique for assessing the dynamic interactions between the

external climates, the building envelope and the HVAC system and the corresponding energy consumption. It has played an important role in the development of simple design tools and building energy efficiency codes. This technique has also been used by a number of researchers to assess the impact of climate change on energy use in buildings. Gaterell and McEvoy (2005) assessed the impact of projected climate changes on the thermal performance of the built environment and the measures implemented to improve such performance. The air temperatures were raised by 2 and 2.9 °C to reflect the climate in 2050, and by 2.3 and 5.9 °C in 2100 in a study by Radhi (2009) to investigate the potential impact of global warming on residential buildings in United Arab Emirates. It was concluded that global warming was likely to increase the energy used for cooling by 23.5 % with a 5.9 °C increase in the ambient temperature. It was also found that energy design measures, such as thermal insulation and building thermal mass, were important to cope with global warming.

3.2.3 Climate Change, Pollution and Health in Cities

Excess morbidity and mortality related to extremely hot weather and poor air quality are found in cities worldwide. This is a major public health concern for cities now and looking towards the future, because the interactions of global climate change, urban heat islands and air pollution are predicted to place increasing health burdens on cities. The proposed mitigation and adaptation strategies in cities' climate risk management plans may produce health co-benefits by reducing emissions and cooling temperatures through changes in the built environment. There are challenges, however, to implementing the plans and the most widely documented beneficial policy to date is the adoption of heat warning and air quality alert systems to trigger emergency responses (Harlan and Ruddell 2011).

As the largest developing country, China has been changing rapidly over the last three decades and its economic expansion is largely driven by the use of fossil fuels, which leads to a dramatic increase in emissions of both ambient air pollutants and GHGs. China is now facing the worst air pollution problem in the world and is also the largest emitter of carbon dioxide. A number of epidemiological studies on air pollution and population health have been conducted in China, using time-series, case-crossover, cross-sectional, cohort, panel or intervention designs. The increased health risks observed among Chinese population are somewhat lower in magnitude, per amount of pollution, than the risks found in developed countries. However, the importance of these increased health risks is greater than that in North America or Europe, because the levels of air pollution in China are very high in general and Chinese population accounts for more than one-fourth of the world's totals. Meanwhile, evidence is mounting that climate change has already affected human health directly and indirectly in China, including mortality from extreme weather events; changes in air and water quality; and changes in the ecology of infectious diseases. If China acts to reduce the combustion of fossil fuels and the resultant air pollution, it will reap not only the health benefits associated with improvement of air quality but also the reduced GHG emissions. Consideration of the health impact of air pollution and climate change can help the Chinese government move forward towards sustainable development with appropriate urgency (Kan et al. 2012).

Urban centres in Latin American often face high levels of air pollution as a result of economic and industrial growth. Decisions with regard to industry, transportation, and development will affect air pollution and health both in the short term and in the far future through climate change. Bell et al. (2006) investigated the pollution health consequences of modest changes in fossil-fuel use for three case study cities in Latin American: Mexico City, Mexico; Santiago, Chile; and São Paulo, Brazil. Annual levels of ozone and particulate matter were estimated from 2000 to 2020 for two emissions scenarios: (1) business-as-usual based on current emissions patterns and regulatory trends and (2) a control policy aimed at lowering air pollution emissions. The resulting air pollution levels were linked to health endpoints through concentration–response functions derived from epidemiological studies, using local studies where available. Results indicate that the air pollution control policy would have vast health benefits for each of the three cities, averting numerous adverse health outcomes including over 156,000 deaths, 4 million asthma attacks, 300,000 children's medical visits, and almost 48,000 cases of chronic bronchitis in the three cities over the 20-year period. The economic value of the avoided health impacts is roughly $21 to $165 billion (US). Sensitivity analysis shows that the control policy yields significant health and economic benefits even with relaxed assumptions with regard to population growth, pollutant concentrations for the control policy, concentration–response functions and economic value of health outcomes. Bell et al. (2006) research demonstrates the health and economic burden from air pollution in Latin American urban centres and the magnitude of health benefits from control policies (Bell et al. 2006).

The contribution of the road transportation sector to emissions of air pollutants and GHGs is a growing concern in developing countries. Emission control measures implemented within this sector can have varying counteracting influences. In the city of Durban, South Africa, the growing dependence on privately owned motor vehicles and increasing usage of roads for freight transport have all resulted in significant air pollution and greenhouse gas emissions. In this study, an emissions inventory was developed for the road transport sector and was used as a basis to explore intervention opportunities that are likely to reduce simultaneously, air pollution and greenhouse gas emissions in this sector. It was found that reducing the vehicle kilometres travelled by privately owned motor vehicles and improving the efficiency of road freight transport offered the greatest potential for achieving co-benefits (Thambiran and Diab 2011).

Bollen et al. (2009) present the findings of a combined cost-benefit analysis of local air pollution and global climate change, two subjects that are usually studied separately. Yet these distinct environmental problems are closely related, since they are both driven by the nature of present energy production and consumption patterns. Bollen et al. (2009) also demonstrate that the discounted benefits of local air pollution reduction significantly outweigh those of global climate change mitigation, at least by a factor of 2, but in most cases of our sensitivity analysis much more. Still, Bollen et al. (2009) do not argue to only restrict energy policy today to what should be our first priority, local air pollution control, and wait with the reduction of greenhouse gas emissions. Instead, Bollen et al. (2009) propose to design policies that simultaneously address these issues, as their combination creates an additional climate change bonus. As such, climate change mitigation proves an ancillary benefit of air pollution reduction, rather than the other way around (Bollen et al. 2009).

3.2.4 Real Estate Losses as a Result of Sea-Level Rise

The effects of climate change will have severe consequences for low-lying U.S. coastal real estate. If nothing is done to hold back rising waters, sea-level rise will simply cause many properties in low-lying coastal areas to be inundated. Even those properties that remain above water will be more likely to sustain storm damage, as encroachment of the sea allows storm surges to reach inland areas that were not previously affected. More intense hurricanes, in addition to sea-level rise, will increase the likelihood of both flood and wind damage to properties throughout the Atlantic and Gulf coasts. To estimate the value of real estate losses from sea-level rise, we have updated a detailed forecast of coastal real estate losses in the 48 states developed by the Environmental Protection Agency (EPA). In projecting these costs into the future, Ackerman and Stanton (2008) assume that annual costs will be proportional to sea-level rise and to projected GDP. Ackerman and Stanton (2008) calculate the annual loss of real estate from inundation due to the projected sea-level rise, which reaches 45 inches by 2100 in the business-as-usual case. These losses amount to $360 billion by 2100, or 0.35 % of GDP (Ackerman and Stanton 2008).

No one expects coastal property owners to wait passively for these damages to occur; those who can afford to protect their properties will undoubtedly do so. But all the available methods for protection against sea-level rise are problematic and expensive. It is difficult to imagine any of them being used on a large enough scale to shelter all low-lying U.S. coastal lands that are at risk under the business-as-usual case. Elevating homes and other structures is one way to reduce the risk of flooding, if not hurricane-induced wind damage. A Federal Emergency Management Agency (FEMA) (1998) estimate of the cost of elevating a frame construction house on a slab-on-grade foundation by two feet is $58 per square foot, with an added cost of $0.93 per square foot for each additional foot of elevation (FEMA 1998). This means that it would cost $58,000 to elevate a house with a 1,000-square foot footprint by two feet. It is not clear whether building elevation is applicable to multi-storey structures; at the least, it is sure to be more expensive and difficult (Ackerman and Stanton 2008).

3.2.5 Holiday Travels and Cherry Blossom Festivals

Whilst much effort has been made to communicate to the public the importance of reducing carbon footprints in the home, one area where emissions are growing rapidly and little attempt has been made to increase consumer understanding of the impacts is holidays, particularly those involving air travel. Using focus group research, this paper explores tourists' awareness of the impacts of travel on climate change, examines the extent to which climate change features in holiday travel decisions and identifies some of the barriers to the adoption of less carbon-intensive tourism practices. The findings suggest that many tourists do not consider climate change when planning their holidays. The failure of tourists to engage with the climate change impact of holidays, combined with significant barriers to behavioural change, presents a considerable challenge in moving the tourism industry onto a sustainable emissions path. The findings are discussed in relation to theoretical perspectives from psychology and sociology (Hares et al. 2010).

Most global climate change models predict serious ecological and social problems. In Japan, biologists have found climate change is affecting species and ecosystems, including the earlier flowering time of cherry trees that are an important cultural symbol in Japan. Cherry blossom festivals are also important to local economies. This study explored the perceptions of Japanese residents regarding climate change impacts on culturally significant events such as flower timing of cherry trees. Sakurai et al. (2011) conducted interviews of stakeholders of three cherry blossom festivals, including sixteen organisers of festivals and 26 managers of festival-dependent businesses, to understand their awareness, attitudes and behaviours towards global climate change and impacts on cherry blossom festivals. Most organisers of the festival in Kakunodate were concerned about global warming and its impact on cherry blossom times while organisers of festivals in Nakano and Komoro felt it was unimportant if flower timing affected the festival schedule. Most (92 %) managers of festival-dependent businesses mentioned that global warming is occurring and affecting the flower timing of cherry trees, but there were diverse perceptions of global warming impacts on their business. Managers more dependent on income from cherry blossom festivals indicated greater concern for the effects of climate change (Sakurai et al. 2011).

As example, micro-level factors are more exhaustively described in the following sub-chapter (see Energy-Efficient House Decision Support Sub-system for Africa).

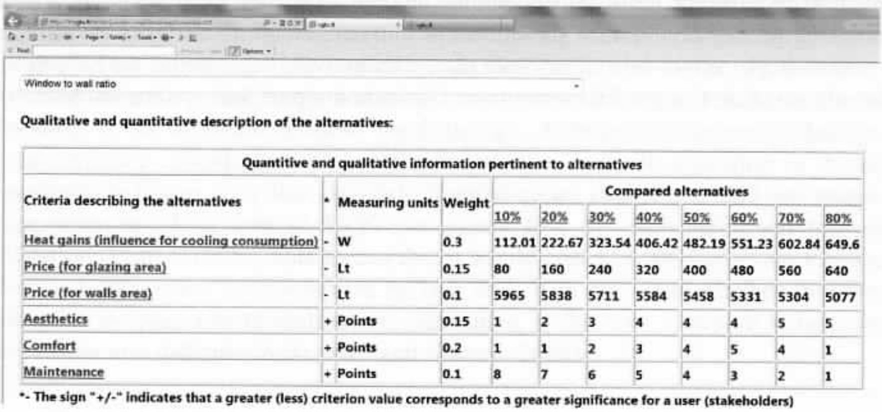
4 Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation. Case Study: Energy-Efficient House Decision Support Sub-System for Africa

Based on the analysis of existing intelligent systems a Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation (IS-BELCP-CCMA) consisting of a database, database management system, model-base, model-base management system and user interface was developed.

The following tables make IS-BELCP-CCMA database:

- Initial data tables. These contain general facts about the built environment and climate change considered. The reasons of regenerating of built environment and their significance as well as the money intended to be spent on it are also given.
- Tables assessing refurbishment of built environment solutions. They contain quantitative and conceptual information about alternative of built environment refurbishment solutions [as examples see Equity and Climate Change (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=390), Climate Change Policies (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=391), Operationalising a Resilience to Uncertain Climate Changes (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=392), Climate change and resilience management in built environment (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=409), Energy-Efficient House Decision Support Sub-system for Africa (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=428) (window to wall ratio: Table 1; orientation: Table 2; shading: Table 3)].
- Tables of multi-variant design. They provide quantitative and conceptual information on the interconnection of the elements of built environment to be

Table 1 Fragment of a grouped decision-making matrix of window to wall ratio alternative's multiple criteria analysis. Qualitative and Quantitative description of the alternatives



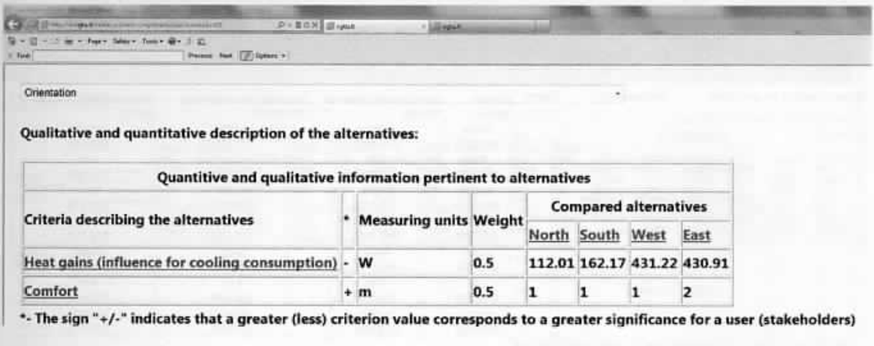
Window to wall ratio

Qualitative and quantitative description of the alternatives:

Quantitive and qualitative information pertinent to alternatives											
Criteria describing the alternatives	*	**Measuring units**	**Weight**	**Compared alternatives**							
				10%	20%	30%	40%	50%	60%	70%	80%
Heat gains (influence for cooling consumption)	-	W	0.3	112.01	222.67	323.54	406.42	482.19	551.23	602.84	649.6
Price (for glazing area)	-	Lt	0.15	80	160	240	320	400	480	560	640
Price (for walls area)	-	Lt	0.1	5965	5838	5711	5584	5458	5331	5304	5077
Aesthetics	+	Points	0.15	1	2	3	4	4	4	5	5
Comfort	+	Points	0.2	1	1	2	3	4	5	4	1
Maintenance	+	Points	0.1	8	7	6	5	4	3	2	1

*- The sign "+/-" indicates that a greater (less) criterion value corresponds to a greater significance for a user (stakeholders)

Table 2 Fragment of a grouped decision-making matrix of orientation alternative's multiple criteria analysis. Qualitative and Quantitative description of the alternatives



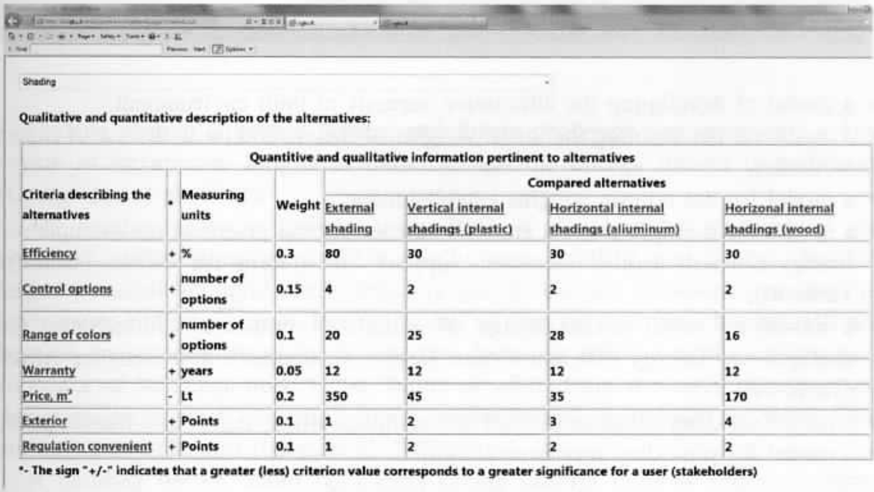
Orientation

Qualitative and quantitative description of the alternatives:

Quantitive and qualitative information pertinent to alternatives							
Criteria describing the alternatives	*	Measuring units	Weight	Compared alternatives			
				North	South	West	East
Heat gains (influence for cooling consumption)	-	W	0.5	112.01	162.17	431.22	430.91
Comfort	+	m	0.5	1	1	1	2

*- The sign "+/-" indicates that a greater (less) criterion value corresponds to a greater significance for a user (stakeholders)

Table 3 Fragment of a grouped decision-making matrix of shading alternative's multiple criteria analysis. Qualitative and Quantitative description of the alternatives



Shading

Qualitative and quantitative description of the alternatives:

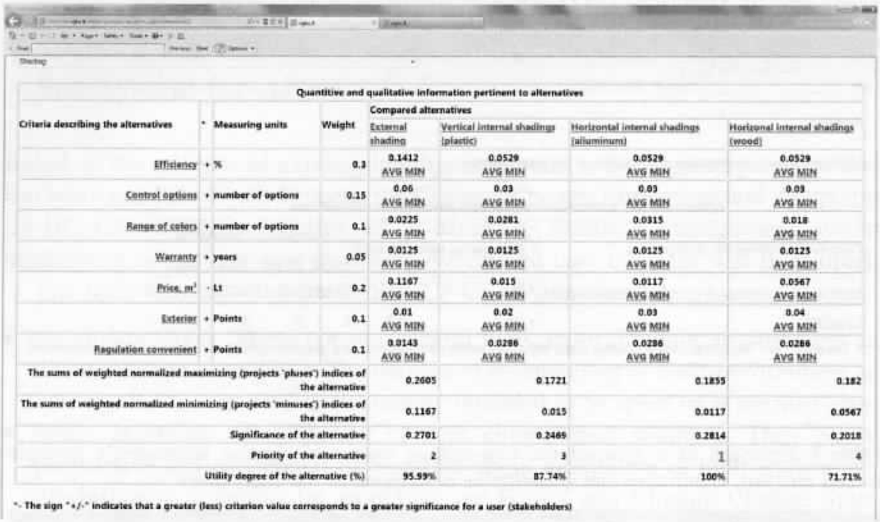
Quantitive and qualitative information pertinent to alternatives							
Criteria describing the alternatives	*	Measuring units	Weight	Compared alternatives			
				External shading	Vertical internal shadings (plastic)	Horizontal internal shadings (aliuminum)	Horizonal internal shadings (wood)
Efficiency	+	%	0.3	80	30	30	30
Control options	+	number of options	0.15	4	2	2	2
Range of colors	+	number of options	0.1	20	25	28	16
Warranty	+	years	0.05	12	12	12	12
Price, m^2	-	Lt	0.2	350	45	35	170
Exterior	+	Points	0.1	1	2	3	4
Regulation convenient	+	Points	0.1	1	2	2	2

*- The sign "+/-" indicates that a greater (less) criterion value corresponds to a greater significance for a user (stakeholders)

regenerated, their compatibility and possible combinations as well as data on complex multivariant design of built environment.

Since the efficiency of a built environment refurbishment variant is often determined taking into account quantitative and qualitative factors a model-base of the IS-BELCP-CCMA should include models enabling a decision maker to do a comprehensive analysis of the variants available and make a proper choice. The following models of model-base are aimed to perform this function:

Table 4 Shading alternative's multiple criteria analysis results



Quantitive and qualitative information pertinent to alternatives

Criteria describing the alternatives	*	Measuring units	Weight	Compared alternatives			
				External shading	Vertical internal shadings (plastic)	Horizontal internal shadings (aluminum)	Horizontal internal shadings (wood)
Efficiency	+	%	0.3	0.1412 AVG MIN	0.0529 AVG MIN	0.0529 AVG MIN	0.0529 AVG MIN
Control options	+	number of options	0.15	0.06 AVG MIN	0.03 AVG MIN	0.03 AVG MIN	0.03 AVG MIN
Range of colors	+	number of options	0.1	0.0225 AVG MIN	0.0281 AVG MIN	0.0315 AVG MIN	0.018 AVG MIN
Warranty	+	years	0.05	0.0125 AVG MIN	0.0125 AVG MIN	0.0125 AVG MIN	0.0125 AVG MIN
Price, m²	-	Lt	0.2	0.1167 AVG MIN	0.015 AVG MIN	0.0117 AVG MIN	0.0567 AVG MIN
Exterior	+	Points	0.1	0.01 AVG MIN	0.02 AVG MIN	0.03 AVG MIN	0.04 AVG MIN
Regulation convenient	+	Points	0.1	0.0143 AVG MIN	0.0286 AVG MIN	0.0286 AVG MIN	0.0286 AVG MIN
The sums of weighted normalized maximizing (projects 'pluses') indices of the alternative				0.2605	0.1721	0.1855	0.182
The sums of weighted normalized minimizing (projects 'minuses') indices of the alternative				0.1167	0.015	0.0117	0.0567
Significance of the alternative				0.2701	0.2469	0.2814	0.2018
Priority of the alternative				2	3	1	4
Utility degree of the alternative (%)				95.99%	87.74%	100%	71.71%

*- The sign "+/-" indicates that a greater (less) citation value corresponds to a greater significance for a user (stakeholders)

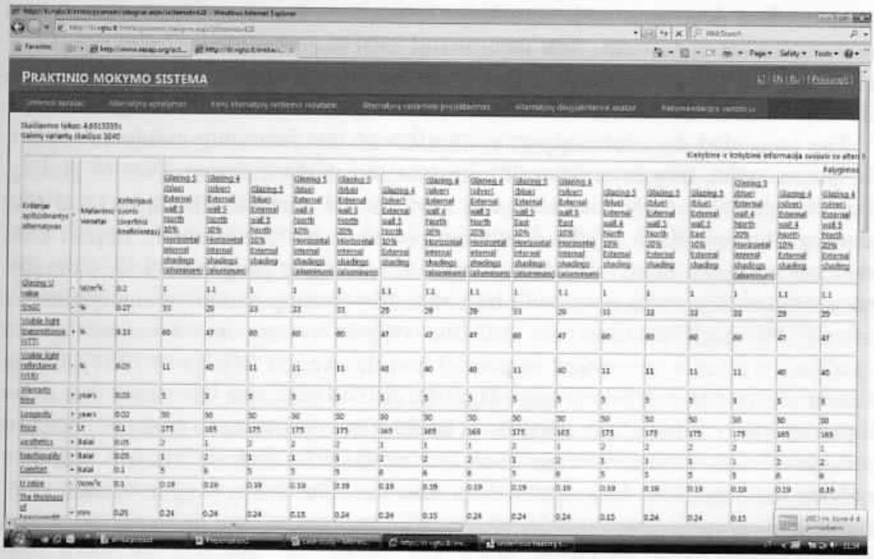
- a model of developing the alternative variants of built environment,
- a model for determining the initial weights of the criteria (with the use of expert methods),
- a model for the criteria weights establishment,
- a model for multiple criteria analysis and setting the priorities (as example see Energy-Efficient House Decision Support Sub-system for Africa (shading: Table 4)),
- a model for multi-variant design of a built environment refurbishment [as example see Energy-Efficient House Decision Support Sub-system for Africa (Table 5)],
- a model for determination of built environment utility degree and market price,
- a model for providing recommendations.

Based on the above models, the IS-BELCP-CCMA system can make until 100 million built environment refurbishment alternative versions, performing their multiple criteria analysis, determining utility degree, market price and selecting most beneficial variant without human interference. Case study of the IS-BELCP-CCMA (Energy-Efficient House Decision Support Sub-system for Africa) is presented below. Energy-Efficient House Decision Support Sub-system for Africa is analysing only microfactors.

Energy-Efficient House Decision Support Sub-System for Africa

The Case Study illustrates a part of Stage 5 "A multiple criteria analysis of the composite parts of a climate change mitigation" of the Model of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation.

Table 5 Multivariant design of energy-efficient house in Africa



Climate change is both a present and future challenge and represents a key reason to incorporate long-term thinking into the energy design of buildings (Georgiadou et al. 2012).

The building sector contributes up to 30 % of global annual green house gas emissions and consumes up to 40 % of all energy [UNEP], that is why—has the largest potential for significantly reducing greenhouse gas emissions compared to other major emitting sectors. Buildings able to respond to future changes will not become prematurely obsolete; hence, key decisions relating to the energy performance of buildings need to be 'future-proofed' from the early planning and design stages against long-term social, technological, economic, environmental and regulatory changes (Mora et al. 2011).

A building design based on energy-saving criteria reduces economic costs throughout the useful life of the building because of its lower energy consumption, and this more than compensates for the greater initial investment. Since there are also fewer CO_2 emissions into the atmosphere throughout the building's life cycle, this benefits society as well (Pacheco et al. 2012). So the building design optimised at the early planning and design stage therefore, make it possible to construct not only energy efficient, but also eco-friendly buildings.

The decision support system (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=428) presented here will facilitate the sustainable building design process and will make it possible to assess any alternatives against a range of criteria. In this particular case, the analysis of building envelope alternatives is adjusted for Johannesburg, a city in South Africa.

During the conceptual design phase of a building, the design team often has to make critical decisions with significant impact on the energy performance and indoor comfort conditions. The design and selection of facades, fenestration systems and their control plays a key role in determining building performance (Tzempelikos et al. 2007).

The presented decision support system covers the following groups of objects: six glazed units, five external-wall constructions, eight different areas of glazing, four orientations of the main façade towards the cardinal directions, and four shading devices. Each of these alternatives makes a considerable impact on a building's energy demands, indoor comfort, aesthetic properties and, naturally, price. Hence, the alternatives will be defined by both quantitative and qualitative criteria. For each criterion, the decision support system sets a measuring unit (qualitative criteria are scored in points) and the weight [e.g. price (0.1)]. Bigger weight means the criterion is more significant. The indicator '±' shows that either higher or lower value of the criterion is better. One by one, each group of objects is considered, its alternatives are analysed against the defined criteria and their weights, and then, the best option is picked out. The utility degree of each alternative is then considered and the alternatives are ranked as a first priority, second priority and so on.

Some indicators were determined theoretically (such as the thermal transmittance coefficient, inertia, etc.), some were obtained from the manufacturers of the materials (such as optical and thermal properties of windows, prices, etc.). Two software applications helped determine the balance of heat gains and the values of quantitative indicators to be used in the assessment of the life cycle of materials:

- Proclim. This application created a reference model of a single-zone building (7 × 5 × 2.6 m) in Johannesburg (South Africa). By varying wall constructions, optical and thermal properties of glazed units, building's orientation towards the cardinal directions and the glazed area, the software determined typical daily gain balances. Since a universal assessment much depends on the intensity of gain variations, this figure will be included as a quantitative indicator defining the alternatives in question, as it is important in their assessment. The assessment trends of the properties of building's windows and walls correspond to the recommendations laid out in South Africa Fenestration & Insulation Energy Rating Association (SAFIERA).
- SimaPro. It is one of the most popular applications designed to assess the life cycle of building materials. Two methods—IPCC 2007 and Cumulative Energy Demand (CED)—were selected to assess each material used in the construction of walls. IPCC 2007 GWP 100a method lists the climate change factors of IPCC with a timeframe of 100 years. Here, the total amount of carbon dioxide equivalent emissions over the production life cycle (kg CO_2-Eq/kg) was determined for each structural material in its production phase.
- The CED represents the direct and indirect energy use in units throughout the life cycle. In our case, CED. Renewable and CED. Non-renewable were determined to assess the external-wall materials in their production phase.

The objective in this analysis was to reach energy efficient, cost-effective, eco-friendly building design, without considering on comfort and aesthetics.

As cooling is dominating in hot climate countries, so here the main intention was to reduce the solar heat gains and cooling demand. The application of life cycle analysis (LCA) lets us compare the alternatives of construction materials in order to find the environmental friendly building design.

Eco-friendly, green building is one of the best strategies for meeting the challenge of climate change. Greenhouse gas emissions from buildings primarily arise from their consumption of fossil-fuel-based energy, both through the direct use of fossil fuels and through the use of electricity that has been generated from fossil fuels. Significant greenhouse gas emissions are also generated through construction materials, in particular insulation materials, and refrigeration and cooling systems [UNEP].

It is fundamental to apply the life cycle vision and take into account both the economic and environmental costs when identifying the most eco-efficient technology. Often, products that are presented as cheap in the medium term can have high maintenance or waste management costs and highly technological products can have very high production costs that are never recouped. Contrarily, it maybe that when we consider the whole life cycle, materials with significant CO_2 emissions, such as concrete, can see their emissions reduced by giving them a second life as a filler material in infrastructure, with a double effect: the reduction of emissions compared with obtaining filler materials from quarries and the absorption of CO_2 due to the recarbonation processes (Zabalza et al. 2011).

The decision support system has an object group titled 'External wall' (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=428), which includes five alternatives of concrete and wooden walls defined by 15 criteria—13 quantitative and two qualitative.

The group of quantitative indicators (with their weights) included the U-value of wall constructions (0.1), the thickness of heavyweight layer (0.05), insulation thickness (0.05), density (0.05), estimated inertia of constructions (0.16) and price (0.1). The application SimaPro and the aforesaid methods assessing the life cycle of materials produced other criteria to define the alternatives: carbon footprint (0.1) and the CED, which comprises non-renewable, fossil (0.05), non-renewable, nuclear (0.05), non-renewable, biomass (0.05), renewable, biomass (0.03), renewable, wind, solar, geothermal (0.03), renewable, water (0.03). The application estimated the values of carbon footprint and CED for each structural material—concrete, timber, thermal insulation materials, etc.—in its manufacturing phase. The qualitative indicators for wall constructions were aesthetic properties (0.1) and maintenance (0.05).

In this instance, the most significant indicator was the inertia of wall constructions with a weight of 0.16. A more massive construction is slower to react to temperature variations, which is a highly important factor in countries with hot climates.

Once the weights of the criteria had been considered, the system produced results indicating 'External wall 4' as the best wall construction. The parameters of the alternatives in question show that this construction has the lowest thermal transmittance coefficient, one of the highest inertia values and one of the highest prices. Since the price variation was minor, this criterion was not too determining a factor in the overall assessment.

The group titled 'Glazing' (http://iti.vgtu.lt/imitacijosmain/simpletable.aspx?sistemid=428) comprised six standard, sun protecting, reflecting or tinned glazed units defined by ten criteria—seven quantitative and three qualitative.

Glazed surfaces have an impact on the energy demand for lighting, heating and cooling of buildings (Da Silva et al. 2012), so the optical and thermal properties of glazed units are of particular importance in hot climates. Higher energy demand for cooling, leads to larger emissions, which in turn would exacerbate climate change and global warming.

The alternatives in this group were defined by the following criteria: thermal transmittance (U-value), solar heat gain coefficient (SGHC), visible light reflectance (VLR), price, warranty time, longevity, functionality, comfort and aesthetics. All of the quantitative criteria were available in the specifications produced by manufacturers. The qualitative indicators were scored in points by a group of experts.

In this particular case, the assessment trends of optical and thermal properties correspond to the requirements laid out in SAFIERA: the lower the U-value, the lower the SGHC value and the higher the visible light transmittance (VTT) value. Here, the lower the U-value, the greater a window's resistance to heat flow and the better its insulating value. The lower the SHGC value, the better glazing is at blocking unwanted heat gain. The higher the VTT value, the more light is transmitted into the room and, in turn, the better is the visual comfort indoors. The biggest weights in this group were, therefore, attributed to SGHC (0.27) and U-value (0.2).

The system's results indicated 'Glazing 5' as the best option among the glazing alternatives. This glazing unit has the best thermal properties with its U-value at 1 W/m^2 K., some of the best optical properties with SHGC = 33 %, but the highest price at 175 LTL/m^2. Since the optical and thermal properties have far higher weights—SGHC 0.27 and U-value 0.2—than price (0.1), the latter indicator was not the determining one.

Besides the properties of glazed units, other factors that contribute to a building's energy efficiency—such as glazed area, orientation towards the cardinal directions and shading devices—also play an important role in hot climates. The factors ought to be considered in early designing phases to find an optimal and energy-efficient architectural solution.

Ouedraogo et al. (2012) shown that it is possible to achieve significant a 31 % cooling load reduction by reducing the building total glazing surface area. Shading devices can produce a cooling load reduction of up to 40 % depending on their type and location. For East and West facing facade, the reduction in cooling load is up to 49 % when shading devices are installed.

So our next group of objects is, therefore, eight alternatives of glazed areas [window to wall ratio (WWR %)] (Table 1), four orientations of the main façade towards the cardinal directions (Table 2) and four shading devices (Table 3).

The application ProClim analysed the variation of heat gains for the following groups of alternatives: façade glazing area (WWR %) varying between 10 % and 80 %, and the orientation of the main façade towards either north, south, east or west. Heat gains were used as a quantitative indicator to assess the alternatives.

Naturally, the bigger the glazed area, the higher heat gains, which means higher cooling costs. On the other hand, larger windows may improve a building's aesthetic properties, but may also make the maintenance of transparent surfaces a more difficult task. The biggest weights in the group titled 'Window to wall ratio' (WWR %) were thus attributed to the following criteria: heat gains (0.3) and comfort (0.2). As the glazed area becomes bigger, the area of other wall constructions shrinks, which is why, in terms of a higher price, 'price of glazing' (0.15) has bigger weight than 'price of wall construction' (0.1). The group of qualitative indicators includes such indicators as aesthetics (0.15) and maintenance (0.1). The best option determined by the above weights was the smallest possible glazed area.

Likewise, the façade orientation towards the cardinal directions (Table 2) was assessed against two criteria: heat gains (0.5) and comfort (0.5). Heat gains were estimated by the application ProClim, but it is a relative figure, which, in our case, shows the trends in gain variation determined by different orientation. Comfort was scored in points. In this particular case, the best façade orientation is northward.

Shading devices are one of the simplest ways to block unwanted sun gains.

Shading devices may control solar gains, block direct sunlight and transmit diffuse daylight in the room and eliminate glare and high contrast. Fixed shading devices are usually employed in the building envelope to exclude solar radiation in the summer and admit it during the winter (Tzempelikos et al. 2007).

The decision-making matrix in the group titled 'Shading' (Table 3) analyses four types of blinds: internal vertical plastic blinds, internal horizontal wooden blinds, internal horizontal aluminium blinds and external blinds. At any rate, since blinds are mounted on glazed surfaces, their efficiency to block solar gains, price, control options and the ease of use, the warranty term, are not the only factors, the choice of colour and appearance are also important. All quantitative details were submitted by the manufacturers of shading devices.

In this particular case, the biggest weights were attributed to efficiency (0.3), price (0.2) and control options (0.15).

The best alternative in this group was internal horizontal aluminium blinds. At 30 %, these blinds had the same efficiency as all other options of internal blinds, but the lowest price. The efficiency of external blinds to block solar gains is up to 80 %, but the price had one of the biggest weights in the decision support system and, therefore, it appears to have been the determining criterion in the overall assessment.

Another feature of the system is multivariate design (Table 5). It might prove useful when one needs to make an integrated assessment of all structural and architectural combinations. The method involves the assessment of the alternatives from all groups of objects at once considering all weighted criteria defining each of the alternatives. A possible combination takes one alternative from each group, which are glazing, external wall, orientation, WWR % and shading. The system produces 3,840 possible combinations defined by 40 criteria.

Multivariate design is different from the assessment of individual alternatives by its ability to make an integrated assessment of the entire combination's efficiency. As a result, it may happen that one of the most efficient combinations is not necessarily a combination of the best alternatives from each group of objects. It is a way, then, to pick out a combination of alternatives with maximum efficiency by all possible criteria.

5 Conclusion

In the past there has been no intelligent approach to learning from climate change mitigation and adaptation in built environment projects once they are completed. Now, however, the built environment is adapting concepts of tacit and explicit knowledge management to improve the situation. Top managers generally assume that professionals in enterprises already possess tacit and explicit knowledge and experience for specific types of projects. Such knowledge is extremely important to organisations because, once a project is completed, professionals tend to forget it and start something new. Therefore, knowledge multifold utilisation is a key factor in productively executing a climate change mitigation and adaptation in built environment project. The main purpose of this paper is to present the Model and Intelligent System of Built Environment Life Cycle Process for Climate Change Mitigation and Adaptation which the authors of this paper have developed.

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