A STUDY ON THE ENERGY EFFICIENCY CRITERIA OF GREEN CAMPUS WITH A MULTI-SCALE APPROACH: METU CAMPUS

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ABSTRACT

A STUDY ON THE ENERGY EFFICIENCY CRITERIA OF GREEN CAMPUS WITH A MULTI-SCALE APPROACH: METU CAMPUS

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Reducing fossil fuel demand has become a more critical issue within the sustainable development agenda due to the rising concerns about recent climate change. Urban areas currently consume over two-thirds of the world's energy and account for more than 75% of the anthropogenic emissions. In today’s context, tackling climate change and minimizing its impacts require to act urgently and effectively towards reducing energy-related emissions in urban areas.

As microcosms and living labs, university campuses are the best possible settings for exploring and practicing sustainability issues. In this respect, an increasing number of universities are committed to a more ‘‘green campus’’ to be primarily upon the energy issue by applying a variety of actions and strategies to their campuses. Literature, however, shows that the trend of transition into an energy-efficient campus for universities still lacks the core leading. The interventions and strategies applied by universities are generally framed by the Campus Sustainability Assessment (CSA) tools. Yet, the energy criteria of CSA tools limited to achieving energy savings with retrofit technics in building scale, green building certification, and green technology usage. Therefore, further research, the involvement of different disciplines, and the integration of energy-efficient design measures; all these are waiting for further promotion.

To that end, the study has two primary objectives: (1) based on the literature review to provide a multi-scale evaluation tool to investigate campus operations upon energy efficiency first as an organization and second as a physical settlement with a multi-scale approach, namely on building scale, on building configuration scale, and campus-scale (2) to evaluate the Middle East Technical University (METU) Campus greenness over energy efficiency with the generated assessment chart. The major contributions of this study are extending the understanding of the green campus concept in terms of energy efficiency and presenting a methodology that can be used to enrich the criteria of the CSA tools.

Keywords: Green Campus, Campus Sustainability Assessment Tools, Energy Indicators, Energy Efficient Design

ÖZ

ÇOK ÖLÇEKLİ BİR YAKLAŞIMLA ENERJİ VERİMLİ YERLEŞKE KRİTERLERİNİN SAĞLANMASI ÜZERİNE BİR ÇALIŞMA: ODTÜ YERLEŞKESİ

Apaydın, Özgü
Yüksek Lisans, Kentsel Tasarım
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Fosil yakıtı kullanım miktarının azaltılması konusunun sürdürülebilirlik gündemindeki önemi mevcut iklim değişimi konusunda artan endişelere paralel olarak artmaktadır. İklim değişiminin temel nedeni olan ve şehirlerin toplamda %75'inden fazla oranda nedeni olduğu insan kaynaklı sera gazı salınımları, kentlerde enerji dönüşümünün hızlı ve etkin bir şekilde gerçekleşmesini gerektirmektedir.

Küçük ölçekli kentler ve yaşayan laboratuvarlar olarak üniversite kampüsleri sürdürülebilirlik yaklaşımlarının organizasyonal ve mekansal düzeyde yürütülmesine örnek olabilecek en uygun alanlardır. Bu bağlamda günümüzde artan sayıda üniversite özellikle enerji dönüşümü konusunda ''yeşil kampüs'' olma yolunda hedefler belirlemektedir. Fakat ilgili yazında belirtildiği üzere; birçok üniversiteye yol gösteren enerji verimliliği kriterlerinin daha kapsamlı bir yaklaşımla ele alınmasına ihtiyaç duyulmaktadır.

Bu sorundan yola çıkan çalışma iki temel amaca sahiptir: (1) yeşil kampüs değerlendirme araçlarının enerji kriterleri, üniversitelerin kurumsal boyutunun kampüs sürdürülebilirliği ile ilgili süreçlere etkisi ve enerji verimli tasarım konuları üzerine yazın taraması yaparak yeşil kampüs enerji verimliliği uygulamaları için kampüsü stratejik ve mekansal açıdan kapsamlı şekilde değerlendirebilecek çok ölçekli bir değerlendirme aracı geliştirmek (2) ODTÜ kampüsünü tasarlanan bu araçla enerji verimliliği açısından değerlendirmek. Çalışmanın beklenen katkısı yeşil kampüs kavramının enerji kriterlerini genişletebilecek bir çalışma ve bu kavramı mekansal bakış açısıyla zenginleştirmek adına örnek olabilecek bir yöntem sunmaktır.

Anahtar Kelimeler: Yeşil Kampüs, Yerleşke Sürdürülebilirlik Değerlendirme Araçları, Enerji İndikatörleri, Enerji Verimli Tasarım

To the METU Campus...

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TABLE OF CONTENTS

ABSTRACT v

ÖZ vii

ACKNOWLEDGEMENTS x

TABLE OF CONTENTS xi

LIST OF TABLES xv

LIST OF FIGURES xvii

CHAPTERS

1. INTRODUCTION 1

1.1. Background 1

1.2. Objectives and Rationale 3

1.3. Main Premises 7

1.4. Research Questions 7

1.5. Methodology 9

1.5.1. Research Methodology to Define Multi-Scale Energy Criteria of Green Campus 10

1.5.2. Data Collection Methodology to Evaluate the Energy Transition on the METU Campus 10

1.6. Configuration of the Research 11

2. ENERGY TRANSITION & GREEN CAMPUS 15

2.1. Research Context: Sustainable Development Challenge 16

2.1.1. Background on Sustainable Development 16

2.1.2. The Theoretical Understanding of Sustainable Development 17

2.1.2.1. Growth and Development 17
2.1.2.2. Weak and Strong Sustainability 21
2.1.3. Urban Expansion and Population Growth 24
2.1.4. Climate Change as an Additional Layer of Sustainable Development Challenge 28
2.1.5. Energy and Environment 33
2.2. Research Context: Green Campus 36
2.2.1. Background on Sustainability in Higher Education 37
2.2.2. The Framework for Sustainable Campuses 44
2.3. The Overview of the Campus Assessment and Rating Systems in terms of Energy Criteria 50
2.3.1. The Sustainability Tracking and Assessment Rating System (STARS) Framework 50
2.3.2. Green Metrics (GM) Ranking Framework 51
2.3.3. The Evaluation of the Energy Criteria of the Sustainability Tracking and Assessment Rating System (STARS) and Green Metric (GM) Ranking Frameworks 52
2.4. Concluding Remarks 56
3. RESEARCH CONTEXT: A-MULTI SCALE APPROACH TO THE ENERGY CRITERIA OF GREEN CAMPUS 59
3.1. University Campuses towards Energy Transition as Organizations 59
3.1.1. Principles of Transformative Practice 60
3.1.1.1. Leadership & Vision 62
3.1.1.2. Social Network 63
3.1.1.3. Participation 64

3.1.1.4. Education, Learning & Research 65
3.2. University Campuses towards Energy Transition as Physical Settlements 67
3.2.1. Social Dimension of Campus Settlement: Learning Hubs 67
3.2.2. Physical Dimension of Campus: Green-Eco Design 69
3.2.3. Energy & Built Environment 71
3.2.4. Spatial Energy Efficiency Variables at Multi-Scale 72
3.2.4.1. Campus Climate Contribution to the Energy Transition....................74
3.2.4.2. Land Use Planning Contribution to the Energy Transition................78
3.3. Concluding Remarks 80
4. A MULTI-SCALE ENERGY EFFICIENCY EVALUATION: METU CAMPUS 83
4.1. The METU Campus 83
4.2. Data Collection 87
4.3. Multi-Scale Energy Efficiency Evaluation of the METU Campus 91
4.4. Insights related to the Energy Transition on the METU Campus 96
4.4.1. The METU Campus towards Energy Transition as an Organization 96
4.4.1.1. Leadership & Vision 96
4.4.1.2. Social Network...98
4.4.1.3. Participation 99
4.4.1.4. Learning 100
4.4.2. The METU Campus towards Energy Transition as a Physical Settlement 101
4.4.2.1. Building Scale 101
4.4.2.2. Building Configuration Scale...103

4.4.2.3. Campus Scale 104
5. CONCLUSION 109
5.1. Discussion on the METU Campus 110
5.2. Limitations 114
5.3. On Future 116
REFERENCES 117
APPENDICES
A. The Sustainability Tracking, Assessment & Rating System (Stars) Evaluation Criteria..127
B. The Green Metric (GM) Ranking Tool Criteria..131
C. Previous Studies of Sustainability Assessment Tools in HE...........................133

LIST OF TABLES

TABLES

Table 2.1. Patterns of ‘Ecological Succession’ (Source: Benyus, 1977) 19
Table 2.2. Ecosystem Services (Source: Millenium Ecosystem Assesment, 2005) ..20
Table 2.3. Comparison of Weak and Strong Sustainability (Source: Ehrenfeld, 2010) 23
Table 2.4. Problems Expected to Intensify with the Population Growth in Cities and Possible Mitigation Strategies (Source: Riffat et al., 2016).....................................27
Table 2.5. Comparison of the Declarations Concerning Different Themes (Source: Lozano et al., 2011: p.14)..42
Table 2.6. Definitions and Qualitative Aspects of Green/ Sustainable University Campus, Proposed by the Author...47
Table 2.7. The STARS & GM Ranking Tools, General Comparison, Proposed by the Author 53
Table 2.8. The STARS Evaluation Criteria over Energy (Source: STARS, 2019) ...54
Table 2.9. The GM Ranking Evaluation Criteria over Energy 54
Table 3.1. Transformative Processes: Leadership & Vision....................................63
Table 3.2. Transformative Processes: Social Network 64
Table 3.3. Transformative Processes: Participation...65
Table 3.4. Transformative Processes: Learning & Research 66
Table 3.5. Social Dimension of Campus..69
Table 3.6. Structural Variables at Different Scales from the Building Scale to Individual Settlement (Source: Owens, 1986) 73
Table 3.7. Energy Efficiency in Urban Scale, (Source: Kang Ko, 2012) 76
Table 3.8. Climate & Energy Efficiency Criteria 77
Table 3.9. Renewable Energy Criteria 78
Table 3.10. Land Use & Energy Efficiency...80

Table 4.1. Campus Scale Green Campus Approaches Considered in the Çinici Plan (Source: Çinici, 1964; ACDM, 2012; MSGK, 2016) 86
Table 4.2. University Stakeholders involving the Research 88
Table 4.3. Research Themes & Data Resource 90
Table 4.4. The Multi-scale CSA Assesment Criteria over Energy & the Evaluation of the Metu Campus Greenness over Energy 91

LIST OF FIGURES

FIGURES

Figure 1.1. The Number of Studies Published on ‘‘Green Campus’’ in Different Fields (Source: Web of Science, 2019).....5
Figure 1.2. Green Campus Radar Map Presented by Professor Hong-wei Tan (Source: Wang et al., 2017).....6
Figure 1.3. Main Research Questions.....8
Figure 1.4. Methodology of Research.....9
Figure 1.5. Research Design.....13
Figure 2.1. Sustainable Development by Brundtland, Source: Cornet et al., 2015.....18
Figure 2.2. left: Intersected ‘Venn Diagram’, right: ‘Nested’ Diagram.....22
Figure 2.3. Cities with 1 Million Inhabitants or More for the Years 2018 and 2030 (Source: UNDESA, 2018).....25
Figure 2.4. Schematic Framework Representing Relations Belonging Current Climate Change, Proposed by the Author.....29
Figure 2.5. The Projected Increase in Average Temperatures in Europe between 2071 and 2100 Compared with the Temperature in the Years 1961-1990 under Significant Behavioral Change/Successful Mitigation (B2 scenario, left) and under Largely Unchanged Behavior (A2 scenario, right) (Source: Regions 2020, 2009).....31
Figure 2.6. Schematic Framework Showing the Linkage between Climate Change Drivers, Vulnerabilities and Responses (Source: IPCC, 2007b).....32
Figure 2.7. The Comparison of Countries by Primary Energy Intensity (Source: IEA, 2017).....35
Figure 2.8. Significant Conferences, Summits & Declarations Held Internationally to Promote Sustainable Development in the Higher Educational Institutions. (Source: Lozano et al. 2013).....38
Figure 2.9. The Nexus between SD and HE (Source: Beynaghi et al., 2014).....41

Figure 2.10. Different Classes of Problems Related to Current Sustainability Framework Development and Adoption (Source: Sonetti et al., 2014) 45
Figure 2.11. Egg of Sustainability (Source: Cole, 2003).. 48
Figure 2.12. Integrating Domains of Campus Sustainability (Source: Beth et al., 2013) 49
Figure 2.13. Author's Conceptualization.. 56
Figure 3.1. The Graz Model for Integrative Development (Source: Mader, 2013)... 61
Figure 3.2. Area Scales of Climatic Investigation, (Source: Oliver and Hidore, p.163) 74
Figure 3.3. Author's Conceptualization 81
Figure 4.1. The METU Campus, Initial settlement (Source: Arkiv, nd) 84
Figure 4.2. Altuğ-Behruz Çinici Plan (1961) (Source: Çinici, 1964)........................ 85
Figure 4.3. The Natural Gas Consumption of the Buildings on the METU Campus 102
Figure 4.4. The Electricity Consumption of the Buildings on the METU Campus 103
Figure 5.1. A Number of Short Term, Mid Term & Long Term Strategies for the Energy Transition of the METU Campus... 114

CHAPTER 1

INTRODUCTION

1.1. Background

"An enduring environmental ethic will aim to preserve not only the health and freedom of our species, but access to the world in which the human spirit was born."

"The Diversity of Life"

E.O. Wilson

The earth faces intensifying environmental challenges caused by urbanization and industrialization processes from water and air contamination to deforestation in recent decades. Current climate change as one of the most potent environmental phenomena of our time is also a product of these processes -*anthropogenic*[1], differently from the previous climatic variations, which depend on low changes in Earth's orbit or the Sun itself (IPCC, 2007a; NASA, 2016).

The magnitude of current climate change is primarily correlated with the change in the natural atmospheric greenhouse. The dramatic increase in the concentration of GHGs within the atmosphere causes to trap the heat radiating from Earth toward space; thus, the earth becomes warmer[2]. Burning fossil fuels -coal, petroleum, and natural gas for the electricity, heating and transportation are the largest driving forces

[1]Referring to environmental alterations resulting from the human presence or activity. In IPCC 5^{TH} Assessment Report, 1,300 independent scientist agreed upon that human activities over past 50 years is the main contributor of global warming (IPCC,2018).

[2] The records show that the recent escalation in atmospheric greenhouse gases (GHGs) is unprecedented in the past 800,000 years (Luthi et al., 2008; IPCC, 2018).

of the global warming as they release high amount of GHGs-water vapor, carbon dioxide and methane during their combustion (IPCC, 2007b).

Tackling climate change effectively and minimizing its impacts require effective mitigation and adaptation strategies in urban areas. As they dominate the energy demand and by extension responsible for the 75%-80% GHG emissions rate, urban areas are the main contributor to climate change (Stern, 2006; IPCC, 2018). On the other hand, they are particularly vulnerable to climate change effects (IPCC, 2012). A range of direct impacts of climate change with the changes in average and extreme temperature and precipitation concentrated in urban areas are observable on many urban systems. Moreover, climate change adds additional stresses into the existing sustainability challenges of urban areas, and therefore leads to far-reaching problems for both the earth and human systems.

In the light of these daunting challenges, the efforts related to the sustainable development have been much more centered on the success of energy transition recently. Energy efficiency and clean energy source usage constitute two basic pillars of energy transition required for effective mitigation in urban areas. Nevertheless, the complex nature of the problem also makes necessary systemic, holistic, and interdisciplinary approaches for urban areas that evaluates the transition more than technological fixes and produces both demand-side and supply-side solutions. In this sense, the primary energy-efficient solutions such as energy conservation in buildings and transportation energy demand decrease call for the spatial integration of economic, institutional, and social processes.

As the fountain of innovation and research, universities indubitably have great significance in providing ideas and solutions for global environmental challenges. Moreover, they offer one of the best possible settings for practicing and exploring sustainability. Consequently, their approach to current environmental challenges is also expected to be more than knowledge production and transfer, and reflected in ‘‘campus planning, design, construction and renovation; transport and engagement with the wider community'' (UNEP, 2014, p. 15). In this respect, an increasing number of universities strive both to decrease their environmental footprint and make their campuses canvases to experience the paradigm shift, namely: to be 'greener' campuses.

The efforts to define the key role of the Higher Educational Institutions in sustainable development dates back 1970s; yet, 'green campus' is still an emerging concept. The concept of 'green campus' connotes the path towards sustainability of universities, with particular reference to the environmental pillar of sustainability and places emphasis on that education and operations on the campuses combine to promote environmental friendly practices.

Nevertheless, different classes of problems exist in the framework development for 'green campus'. As there is no core leading for green campus framework, the evaluators (the Campus Sustainability Assessment tools) are seen as the main agents for 'effective translation into practice' phase towards truly green campuses. Therefore, the criteria determined by these tools not only evaluate the campuses, but also guide them on their future campus operations and plans. Yet, as the literature suggests, the green campus criteria of evaluators are needed to be advanced in a comprehensive and systematic manner to bridge the gap between theory and practices.

By supporting the transformative role and unique identities of the university campuses, the study mainly focuses on energy transition in university campuses and designs a criteria list to evaluate campuses over energy transition.

1.2. Objectives and Rationale

This study mainly departs from the concerns over the inadequate energy efficient and sustainable practices in urban areas. In today's context, the energy transition is urgently needed in the whole world, and it is only possible with the transition into low carbon energy supply technologies in urban areas together with minimizing the energy demand of urban mass.

While urban areas are the main responsible of climate change, they are also the key places where the capacity for successful mitigation created. They can offer the solution to reduce fossil fuel dependency. At this point, it is vital to have holistic and interdisciplinary approaches and; therefore, take into consideration the spatial, infrastructural, and behavioral efficiency measures in cities (Pacala and Socolow, 2004; Krewitt et al., 2007). In this sense, urban planning and design tools such as stakeholder management, design and planning at different scales, and development management have significant potential.

As aforementioned, many aspects of the campuses make them ideal places to produce and practice transformative solutions and approaches for the environmental problems. Moreover, they can be considered 'experiment plots' and 'demonstration areas' for *'green' city* construction (Yang, 2015). On one hand, university campuses are small scale urban systems. The diversity of the involving functions, high intensity of people and material flows similar with urban areas. On the other hand, university campuses are governed from one place and they are more controllable settlements comparing to cities.

Nevertheless, the energy criteria of 'green campus' and; thus, the solutions many universities adopted in their campus operations can be criticized to be technology-oriented and to evaluate the campus as the sum of green buildings. More specifically, the energy criteria of green campus presented in green campus evaluation tools remain limited to retrofit technics in building scale, green building certification, and green technology usage. Therefore, the criteria are needed to be extended with further research, the involvement of different disciplines, and the integration of energy-efficient design measures.

Additionally, whereas an increasing number of universities commit to going 'greener' recently and apply to the Campus Sustainability Assessments[3] with this purpose, the studies published on 'green campus' in the literature low in number, particularly in the urban domain. The following Chart (figure 1.1) represents the number of studies published on 'Green Campus' in different fields between the years 1990-2019.

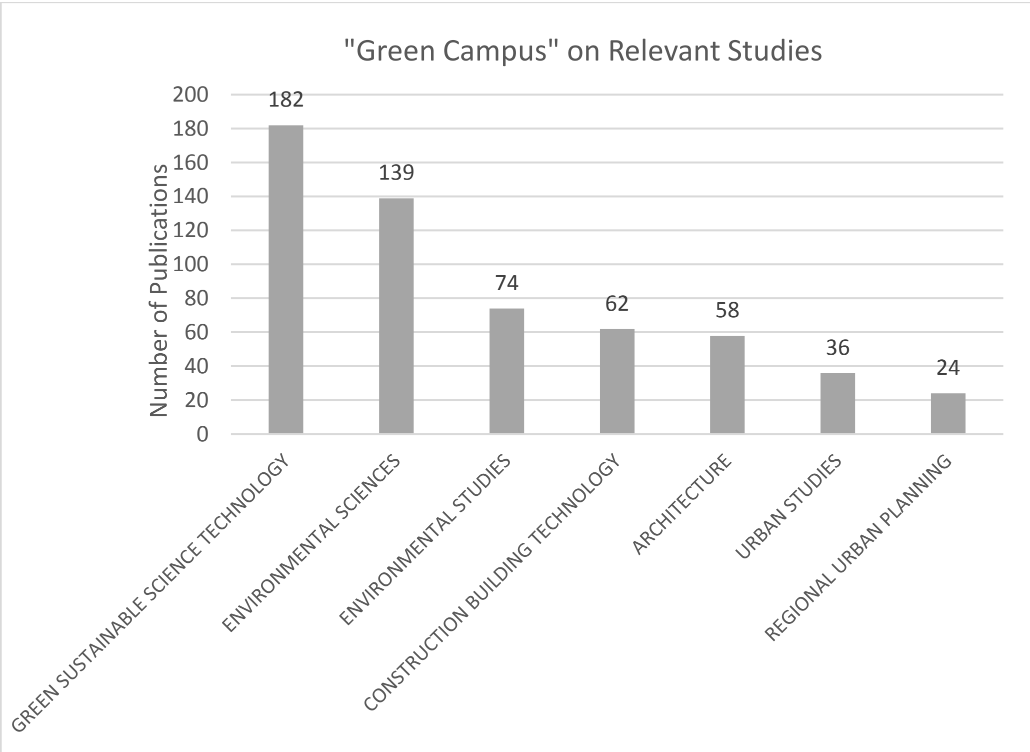

Figure 1.1. The Number of Studies Published on ''Green Campus'' in Different Fields (Source: Web of Science, 2019)

Similar to the approach presented in the Campus Sustainability Assessment tools, the previous research related 'green campus' also mainly concentrate on the technological aspect of the concept. Contrarily, the Radar Map presented by Professor Hong-wei Tan, Secretary-General of China Green University Network, demonstrates that

[3] The number of the universities which applied the assessment tools analyzed in this study will be indicated in chapter 2.

‘organizational structure and green planning’ as the most significant pillars of Green Campus (figure 1.2).

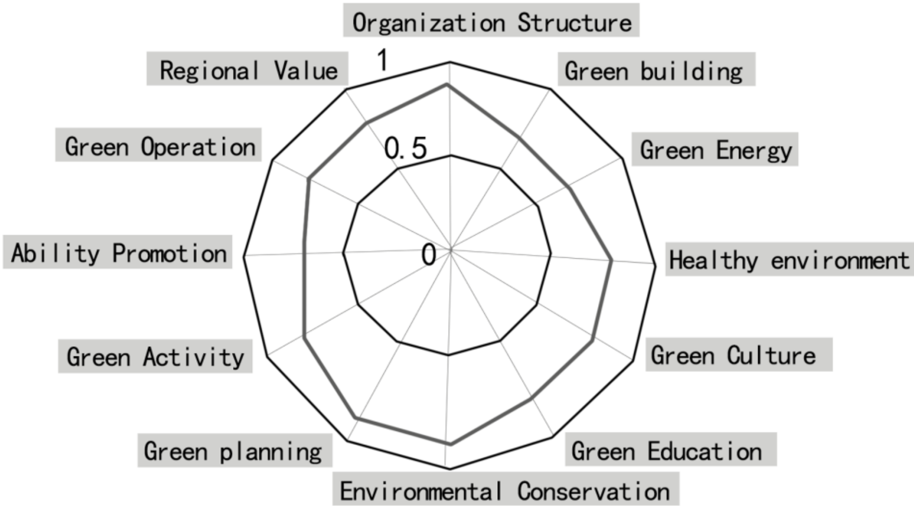

Figure 1.2. Green Campus Radar Map Presented by Professor Hong-wei Tan (Source: Wang et al., 2017)

A very limited number of studies in the literature point out the significance of outdoor physical environment elements of green campus upon energy. Literature review made by Wang et al. (2017) focuses on the relevant literature, and underlies three aspects of ‘the outdoor physical environment design of green campuses’ with reference to the energy efficiency which are ‘green planning’, ‘green landscape’ and 'green building’. The same study conceptualizes the campus as outdoor and indoor environments, which both consist of physical and cultural environments to cover different dimensions of ‘greenness’. Yang (2015) also indicates that ‘‘the demonstrative value of green buildings never lies in the accumulation of advanced energy-saving technologies –but in the adaptable combination of them’’ (p.220). He adds that it is significant to consider for any development within the campus ‘the relationship between buildings and surrounding sites’; and ‘the interaction with surrounding building groups’ for the energy efficiency.

In this respect, the study was designed to address two goals. In the first phase of the study, the study focuses on exploring and broadening the energy criteria of 'green campus' by covering two main constituents of university campuses: the organizational and spatial, and aims to generate a multi-scale energy evaluation criteria for university campuses. In the second phase, the study aims to examine the METU Campus with the generated criteria list as a case study. At the very end, this thesis expected to present both an approach and an applicable criteria list that can be used to evaluate the energy transition of university campuses, and a guide for the METU Campus that can be used in a Green METU Campus initiative.

1.3. Main Premises

The present research was grounded on three main premises:

-Climate change and environmental degradation issues require an urgent and effective energy transition in urban areas.

-The role of the Higher Educational Institutions to have successful energy transition is highly significant; particularly in terms of bridging the gap between theory and practice in urban areas.

-The green campus criteria determined by the Campus Sustainability Assessments are limited to evaluate the energy transition in the campuses in a holistic and interdisciplinary way; therefore; a more comprehensive approach is needed for the evaluation of the campuses in their energy transition.

1.4. Research Questions

The following research questions are mainly applicable to the research design explored in this thesis:

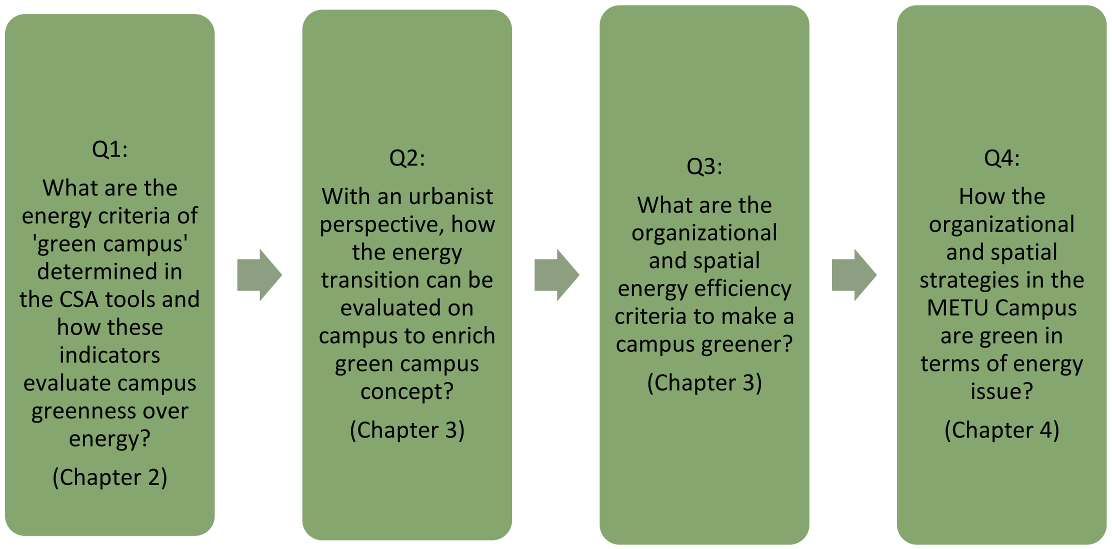

Figure 1.3. Main Research Questions

To answer these main questions, the following sub-questions are also explored throughout the research.

- Why are more comprehensive and interdisciplinary approaches in urban areas needed to tackle climate change? (Chapter 2)
- What is the context and significance of 'green campus' with reference to today's environmental problems? (Chapter 2)
- What are the attempts and issues related to campus sustainability framework development? (Chapter 2)
- What are the most commonly applied CSA's, how do they evaluate the campuses upon energy issue, and to what extent do they cover the domains of the campus sustainability? (Chapter 2)
- What are the principles of 'transformative practice', how they can be integrated into green campus evaluation criteria? (Chapter 3)
- What are the spatial energy efficiency variables in cities, and how they can be integrated into the green campus evaluation criteria? (Chapter 3)

- What are the current physical and organizational green operations, organizational perceptions and future plans upon energy transition in the METU? (Chapter 4)

1.5. Methodology

The objectives of the research first to formulate a multi-scale evaluation criteria for the energy transition of campuses inferring from the literature review and then to evaluate the METU Campus with the designed tool. In order to achieve these aims, the research was made in two phases: 1) research to outline a knowledge background and an operational framework for multi-scale energy criteria (Subsection 1.5.1), 2) data collection to evaluate the METU Campus on energy (Subsection 1.5.2).

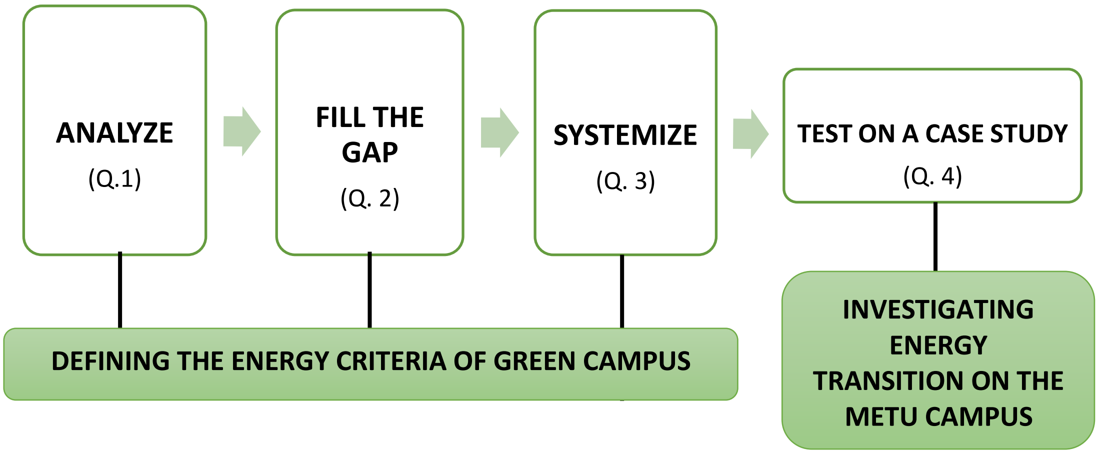

Figure 1.4. Methodology of Research

1.5.1. Research Methodology to Define Multi-Scale Energy Criteria of Green Campus

As aforementioned, this research approaches the 'green campus' concept considering the organizational and spatial aspects of university campuses. With the aim of covering these two domains of the campuses, data were gathered from multiple sources. The published documents including official sustainability reports of universities; the webpages of green campus initiatives, the Green Building Certification Systems and the Campus Sustainability Assessments (hereafter CSA) were thoroughly analyzed in this research to constitute a basis for the evaluation criteria. Namely, existed energy criteria of green campus are identified with deduction method.

To fill the gap, the energy criteria comprising both the organizational and spatial constituents of the campuses aimed to be investigated from the relevant literature. More specifically, the principles of transformative practices and the energy variables in spatial structure at different scales were studied separately.

To formulate a multi-scale energy criteria tool, the obtained criteria were re-organized by adding new concepts for the organizational and spatial criteria. The spatial scales were determined as building scale, building configuration scale, and campus-scale for the spatial energy criteria of university campuses while the organizational criteria were re-classified with the aim of covering the campus domains at a transformative level.

1.5.2. Data Collection Methodology to Evaluate the Energy Transition on the METU Campus

The designed evaluation tool was aimed to be tested. To do this, a case study approach was chosen. Yin (1984) defines case study approach "as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used'' (p.23).

In this sense, the intention of this study regarding the METU Campus, on the one hand, to evaluate the METU Campus with the designed energy criteria, and on the other hand, to present a guide to the METU Campus for the needed energy transition. To accomplish these objectives, the research was used a qualitative method. . In constructing the research method, the importance was given to reveal the organizational and multi-scale spatial energy efficiency considerations, future plans, and the strengths, opportunities, weaknesses and threats towards energy transition on the METU Campus; and thus, to conduct a comprehensive case study. Document analysis and semi-structured interviews were used as the research tools in the data collection part related to the METU Campus energy evaluation.

1.6. Configuration of the Research

This thesis is organized into five sections, as can be seen in the Figure 1.5. Chapter 1 is the introductory part of the study. It contains the background, objectives and rationale, main premises, research questions, and the research and data collection methodology, which is applied for the study.

Chapter 2 focuses the need of urgent energy transition in urban areas and the 'green campus' concept. The chapter begins by outlining the conceptual and contextual challenges for sustainability. It presents a background related to the energy issue within the context of sustainable development and climate change. Then, the chapter studies the evolution of the sustainability concept in Higher Education and the framework development attempts and current challenges. Lastly, it presents the Sustainability Tracking Assessment and Rating System (hereafter STARS) and Green Metric (hereafter GM) tools and analyzes their evaluation criteria.

Chapter 3 reviews the literature to set forth a comprehensive energy criteria list on university campuses. Firstly, the chapter discusses the organizational aspects of sustainability at transformative level. It presents 'the Graz Model' and studies each concept within the model to achieve transformative practices in university campuses. Secondly, the chapter presents campus-wide energy criteria which can be applicable for university campuses. To achieve this, the chapter focuses two spatial factors in the campuses: land and campus climate contribution to the energy efficiency and enhances the spatial criteria by using Owen's schematization for 'the energy variables in spatial structure at different scales'.

Chapter 4 studies the generated evaluation criteria which can be used to set transformative strategies and practices at multi-scale on university campuses and it evaluates the METU Campus with the evaluation criteria. The chapter starts with presenting the METU Campus background and continues with the methodology of the research. Research themes and tools, university stakeholders involving the research, ways of analyzing thematized data are specified. Lastly, the research presents the conducted research.

Finally, Chapter 5 critically discusses the research results. The data gathered with the evaluation criteria tool are transformed into a SWOT analysis for the METU Campus in this chapter. The chapter also presents the limitations and suggests a number of problems for a future investigation related to the conducted study.

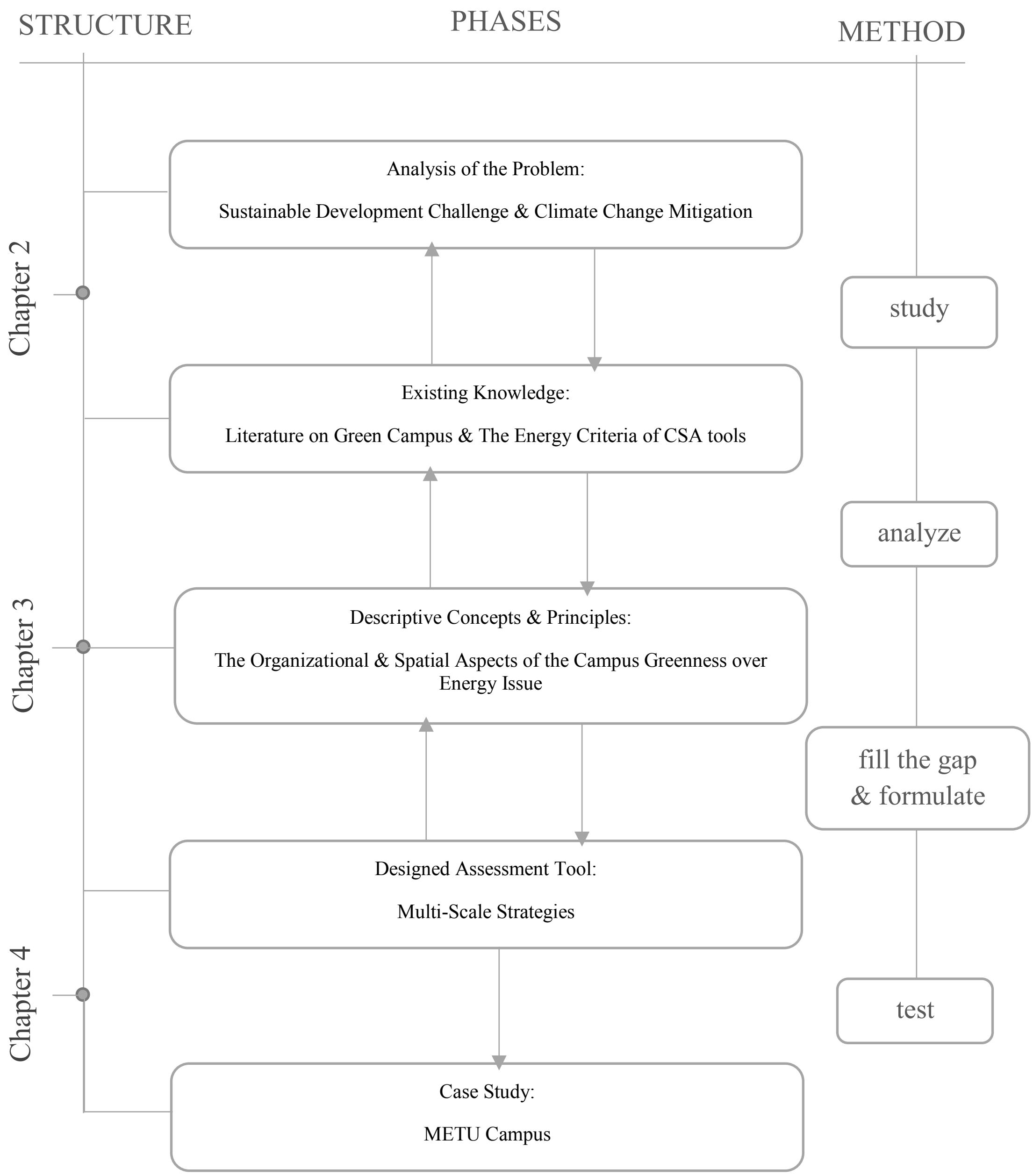

Figure 1.5. Research Design

CHAPTER 2

ENERGY TRANSITION & GREEN CAMPUS

This chapter aims at having the necessary background information in the context of the stated problem and related issues. Understanding the dynamics and complex relations of sustainable development challenge & climate change, and discussing the energy transition within this context are essentials to justify the need for comprehensive energy criteria for the 'green campus' concept. To that end, this chapter firstly outlines the historical background of sustainable development and presents ongoing discussions about the concept. It also investigates the problems in cities that are expected to intensify with the recent trends in urbanization, and the recent climate change as an additional layer of the sustainable development challenge.

Secondly, this chapter investigates 'green campus' concept. The evolution of the concept with time and its place to tackling with today's sustainability problems are studied within the chapter. Also, different classes of problems existed in the framework development for green campuses are examined to understand the role and issues related the CSA tools.

Lastly, the chapter analyzes the approach presented in two CSA tools on the energy issue: the Green Metric (GM) and the Sustainability Assessment, Tracking and Rating System (STARS). The energy criteria and evaluation methods of these tools are presented.

2.1. Research Context: Sustainable Development Challenge

2.1.1. Background on Sustainable Development

When investigating the historical evolution of sustainable development, many conferences have been held internationally and many declarations have been signed by the nations until now. The initial statement on sustainable development was *the Stockholm Declaration*, the product of the United Nations Conference on the Human Environment (UNCHE). The conference was convened to address issues concerning the environment and sustainable development. Then, UNCHE, also known as the Stockholm Conference, linked environmental protection with sustainable development (UNESCO, 1997). With this declaration, the idea of balanced development for cities was also acknowledged for the first time.

T*he Brundtland Report*, also called *Our Common Future,* published by the World *Commission* on Environment and Development (WCED) in 1987. It stated the importance of economic growth by preserving environmental sources. Within this report, the environmental degradation issue also started to be accepted for the first time as a global problem that requires global action.

In 1992, Rio Conference or the Earth Summit was held in Rio de Janeiro. In this summit, the decision for the establishment of the Commission on Sustainable Development was taken, and more than 100 nations committed to sustainable development (UNESCO, 1997). The Earth summit published *Agenda 21*, a detailed plan to achieve sustainable development in 21. Century. *Agenda 21* stated that the quality of human settlements should be improved by considering the social, economic, and environmental quality altogether. Additionally, the report underlined the importance of land use policies and promoting sustainable energy and transportation systems. *The United Nations Framework Convention on Climate Change* (UNFCCC) to take action on the greenhouse effect and *the Convention on Biodiversity* were the two significant accomplishments of the Rio Conference in terms of empowering the environmental sustainability paradigm.

In 1997, the UN General Assembly (Rio+5), and in 2002, The World Summit on Sustainable Development (Rio+10) meetings were held to evaluate the progress related to Agenda 21. Rio +10 meeting also provided *the Johannesburg Plan of Implementation* to monitor sustainable development. After twenty years from Rio Conference, in 2012, the United Nations Conference on Sustainable Development (Rio+20) was held. The conference set a global sustainability agenda and produced an institutional framework for sustainable development (UN CSD, 2012).

Above mentioned efforts are significant initiations regarding their influence on the production of sustainable development paradigm, which gives weight to environmental and social issues as well as economic growth. These initiations help the transition process from a mechanicist to an ecological and systemic paradigm (Elizabete et al., 2005). However, despite the increasing global efforts to achieve sustainable development internationally, there is an ongoing failure towards 'strong' sustainable development. Today, human and earth systems face intensifying sustainability problems, especially in urban areas. Therefore, it is still essential to reveal the dynamics and relations to broaden the sustainability concepts and put successful models on different scales into practice.

2.1.2. The Theoretical Understanding of Sustainable Development

2.1.2.1. Growth and Development

A common acceptance for the explanation of sustainable development is that: ''a development that meets the needs of the present without compromising the ability of future generations to meet their own needs'' (Brundtland, 1987, p. 43). Development here indicates a notion different from growth. In 1848, the liberal economist and philosopher John Stuart Mill expressed his concern regarding the environmental degradation as a result of economic growth with the statement of ''people would be content to be stationary, long before necessity compels them to it''(Mill, 1900:264). Since that time, many scholars have argued that further growth is 'inconsistent with the environment' and the physical expansion should be limited when 'steady state' is reached (Vermes 1990, Daly 2007:27). Whereas growth implies the physical or quantitative expansion of the economic system, development is a qualitative concept that is interested in ecological, cultural, social, and economic progress (Newman and Kenworthy, 1999). In this sense, sustainable development can be possible where social, economic, and environmental objectives are in unity (MacDonald, 2000).

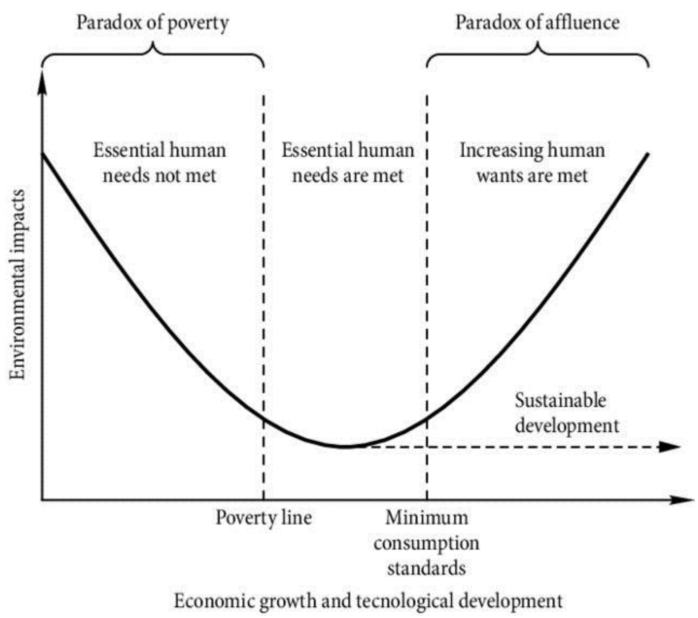

Figure 2.1. Sustainable Development by Brundtland, Source: Cornet et al., 2015

The Brundtland Report also stresses this difference by associating growth with its environmental impacts as shown in Figure 2.1. Similarly, in the book '*Biomimicry: Innovation inspired by* nature', Janine Benyus (1997) presents insights related 'pattern of ecological succession[4]' that can further our understanding regarding the relationship of human systems with natural systems in terms of growth. She highlights the contrast between 'pioneer species' in which energy and material usage are

[4] Explains maturation into a species that lives in harmony with the rest of nature (Benyus, 1997).

paramount and ‘climax community ‘where the production shifts from quantity to quality.

Table 2.1. Patterns of ‘Ecological Succession’ (Source: Benyus, 1977)

Ecosystem Attributes	Developing Stages	Mature Stages
Species diversity	Low	High
Body size	Small	Large
Life cycles	Short, simple	Long, complex
Growth strategy	Emphasis on rapid growth	Emphasis on feedback control
Production	Quantity	Quality
Internal symbiosis	Undeveloped	Developed
Nutrient conservation	Poor	Good
Niche specialization	Broad	Narrow
Stability	Poor	Good
Entropy (energy lost)	High	Low
Information (feedback loops)	Low	High

Table 2.1. illustrates the comparison between the developing stages (pioneer species) and the mature stages (climax community). Their growth strategy differences in many ways show similarity with the difference between growth and development. Whereas long term survival is not considered in pioneer species and entropy is high, climax community functions more stable with more information and feedback mechanism.

Although the understanding presented within the Brundtland Report regarding the relationship between economic growth and environmental impacts reflects a similar idea (Figure 2.1) with the ecological attributes of ‘climax community’, it is certain that sustainability-related problems have continued to intensify with the elements comprising ‘multiple crisis syndrome’ (Selby et al., 2015). Measured ‘ecological footprint’ of our economic activities indicates that it has been already exceeded the 'carrying capacity' of the world with 'disproportional resource consumption' (Wackernagel et al., 2005).

According to atmospheric chemist Paul Crutzen the ecological footprint of human activities has brought humanity in a new era called 'Anthropocene[5]'. With a rate 10.000 times higher than the natural extinction rate, between 30-50 percent of the Earth's species are expected to extinct until the mid-century. Moreover, according to UN Millennium Ecosystem Assessment[6] (2005), 60 percent of the Ecosystem Services including provisioning, regulating, cultural and supporting services were damaged or currently being used in an unsustainable way.

Table 2.2. *Ecosystem Services (Source: Millenium Ecosystem Assesment, 2005)*

PROVISIONING SERVICES	REGULATING SERVICES	CULTURAL SERVICES
The "products" obtained from ecosystems	*Benefits obtained from the regulation of ecosystem processes*	*Nonmaterial benefits obtained from ecosystems*
Foods Fibers Ornamentals Medicines Biofuels Fresh water Genetic resources	Climate regulation Flood prevention Erosion control Pest control Pollination Seed dispersal Disease regulation	Educational Recreational Sense of place Spiritual Cognitive development Stress relief Gardening

SUPPORTING SERVICES
Services necessary for the production of all other ecosystem services
Biodiversity Nutrient recycling Primary productivity

[5] defines Earth's most recent geologic period as being human activities dominant on Earth's geology and ecosystems
[6] Gathered data by 1300 international experts

At this point, the difference between development and growth starts to be more distinguishable and significant. *The Brundtland Report* explanation also left enough space for different interpretations of the term ‘sustainability’. Therefore; the sustainability debate also moves forward intensively in the frame of weak (environmental economics) and strong sustainability (ecological economics) continuum (Redcliff, 2005). The next subsection discusses these two interpretations of sustainability briefly.

2.1.2.2. Weak and Strong Sustainability

The concept of *triple bottom line* which represents three legs of sustainability coined by John Elkington in 1994. The triple bottom line (TBL) also called the three *Ps – people, planet, prosperity* is depicted initially by the ‘Venn diagram’. The diagram illustrates the balancing significance of three aspects of sustainability. In this respect, the diagram consists of and represents three dimensions of sustainability explained in *the Brundtland Report* with three intersected equal circles. Although the diagram reflects the basic idea of sustainable development; it is criticized for being nonhierarchical and that’s why for encouraging trade-offs in practice (Gibson, 2006). Taking into consideration the limitations of the Venn diagram, ‘the nested model’ –a model emphasizing the needed shift from economic orientation clearly- was proposed later to describe how these three aspects work together towards sustainability.

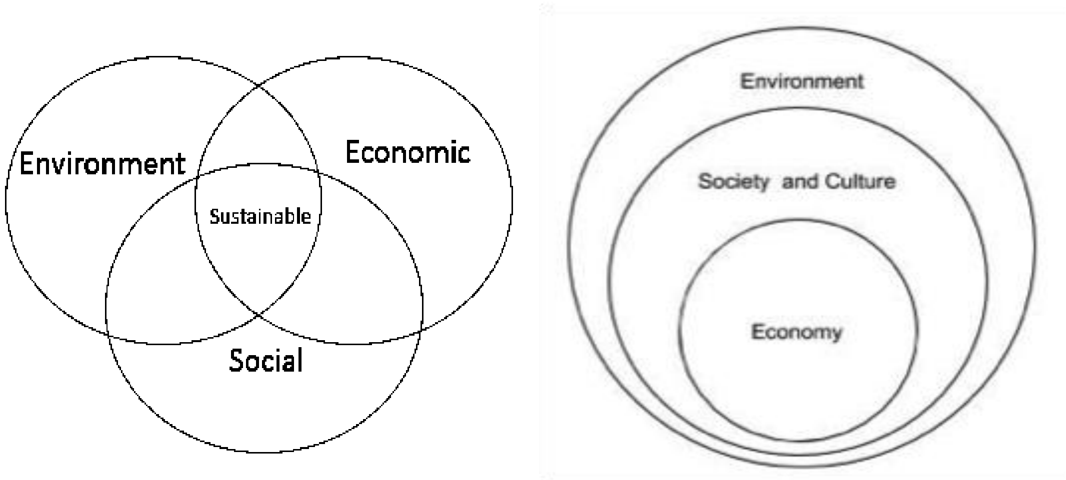

Figure 2.2. left: Intersected 'Venn Diagram', right: 'Nested' Diagram

The nested model depicts economic sustainability within the social one and the resulting socio-economic circles are in turn nested within the environmental one. The model portrays the idea that a healthy economy requires a healthy society, both of which depend on a healthy environment. The model also puts forward that an economic system cannot operate without the ecological systems that nature provides (Giddings et al.,2002).

In this respect, the nested model is associated with the 'strong sustainability continuum' while the intersected model is associated with the 'weak[7]' one (Hopwood et al., 2005, p. 40). Week sustainability with an environmental economics approach continues to focus on largely market without recognizing scale, whereas the strong one (ecological economics) looks at humans embedded in the 'ecological systems'. 'Weak sustainability' also represents some qualities of the modernity paradigm that can explain the main reasons behind today's failure in sustainability (Costanza, 2010).

The following table includes a comparison of weak and strong sustainability in terms of the differences in their focus.

[7] In weak sustainability continuum it is observed that 'human capital' can substitute 'natural capital' (Ekins et al. 2003).

Table 2.3. *Comparison of Weak and Strong Sustainability (Source: Ehrenfeld, 2010)*

Weak sustainability/ modernity paradigm	*Strong sustainability/ sustainability paradigm*
Status quo	Transformation
Technological fix with minor or no changes to lifestyle choices	Fundamental reassessment of values and lifestyle choices
Prioritise economic issues; deal with environmental issues as needed	Integrated, holistic approach to three dimensions
Technical progress and optimism	Technological scepticism and precautionary principle
Perfect substitution of natural and manmade capital	Limited substitution of natural and manmade capital
Manage business risk within existing free-market system	Transform market system

As with the failure of the triple bottom point of view, ‘weak sustainability’ continues not to be dominated with ecological concerns. Rather, it engages with environmental issues as needed. Moreover, it remains depended on ‘technological fixes’ without an integrated holistic approach and fundamental changes (Ehrenfeld, 2010). However, technological fixes solely do not guarantee an absolute decrease in environmental degradation. Also, many technology-oriented fixes that lack a comprehensive approach can have a ‘rebound effect’ as Alcott (2005), Sorrell, (2007) explained in their studies and they, therefore, result in an inadequate transformation towards sustainability without a holistic perspective.

On the other hand, even if the nested model reflects a more accurate representation of ‘strong sustainability’, both two representations are criticized for leaving some dimensions and the connections external and remaining in the ‘weak sustainability continuum’ in practice. For instance, Elizabete e. al. (2005) signifies that there are two missing and equally important dimensions of sustainability, namely ‘cultural’ and ‘spatial’. Fischer et al. (2007) also point out that it is highly essential to determine ‘the hierarchy of considerations’ beyond the hierarchy of dimensions of sustainability and making ‘transdisciplinary research’ for progress.

Although sustainable development has become a far more salient issue at an international level, the modernity paradigm still fails in many aspects in the line of weak sustainability (Fischer et al. 2007; Ehrenfeld 2010). Many scholars find that ‘strong sustainability’ is the only ‘legitimate interpretation of sustainability (Ekins, 2005; Biely et al., 2016). On the other hand, having different interpretations of ‘what is sustainability’ makes the perception blurred regarding what is sustainable. In other words, the current economy is naturally promoted in practice as a drawback (Pearce, 1992).

Urban areas place in the center of these discussions with the high number of people in which they accommodate and the environmental, social, economic impacts they have. Raising sustainability concerns within the urban areas with the population growth and uncontrolled urban expansion which will be mentioned briefly next section indicates the level of urgency to shift into more systematic, integrated, and holistic approaches in cities.

2.1.3. Urban Expansion and Population Growth

Sustainable development concerns are highly related to the magnitude and speed of urban expansion and population growth. In 1960, the percentage of the people who live in urban areas was only 34%; however, today, more than half of the world population live in urban areas (UNDESA, 2014). The United Nations Population Division projected that with an urban influx of 2.5 billion people, more than two-thirds of the population would be live in urban by 2050 (UNDESA, 2018). With the projected influx, the number and the size of the world cities are expected to increase by 2030, as shown in Figure 2.3.

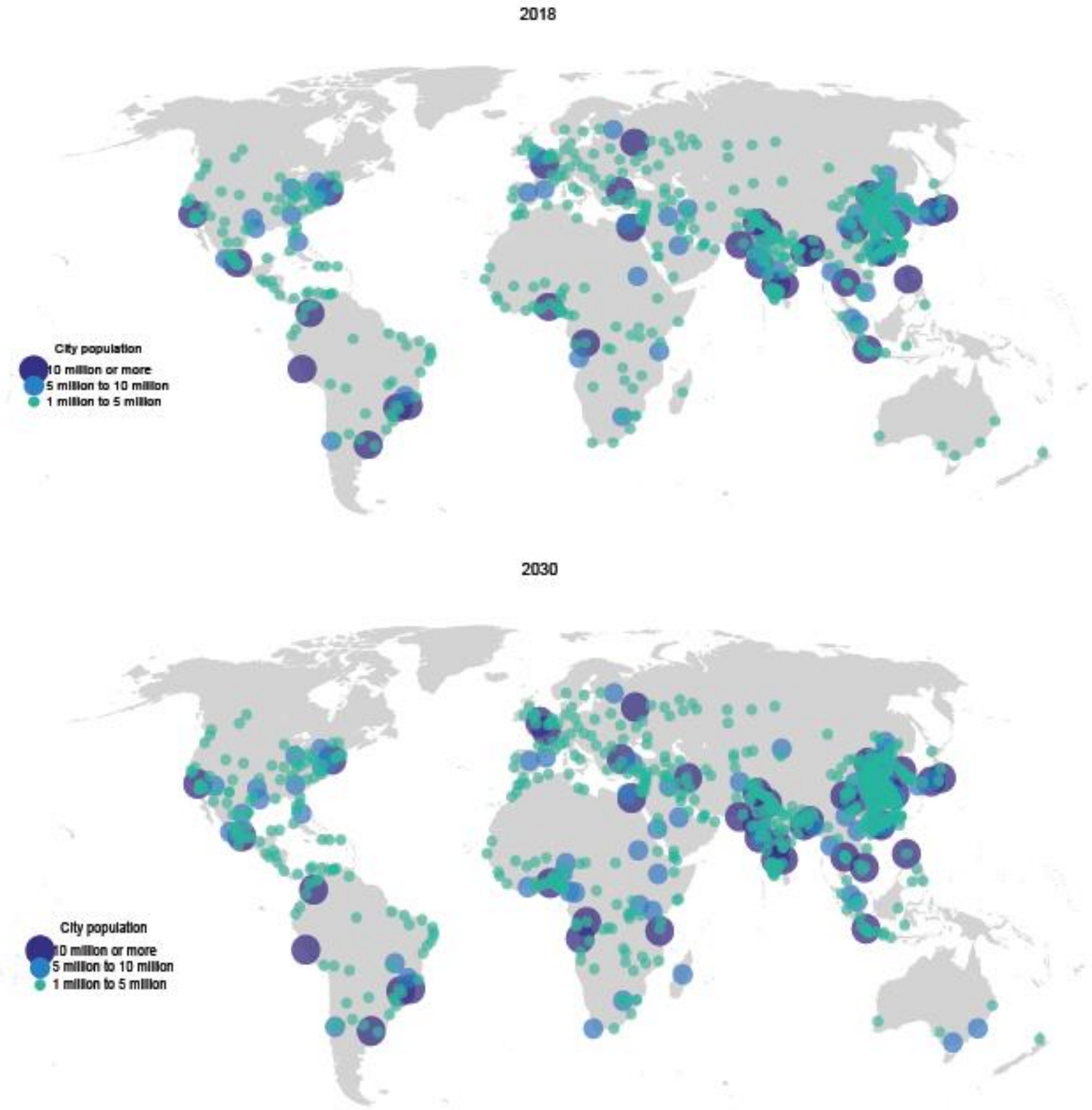

Figure 2.3. Cities with 1 Million Inhabitants or More for the Years 2018 and 2030 (Source: UNDESA, 2018)

United Nations (2018) projected that the number of cities with at least 1 million inhabitants will rise to 706 by 2030, whereas the current number of such cities sums up to 548. The same study shows that in 1970, across the globe, there were only three cities with at least 10 million inhabitants, termed as 'mega-cities', but by the year 2030, it is projected that the number of mega-cities will rise to 41 along with the increase in population (UN, 2018).

Urbanization with the above-mentioned rates has already put pressure on existing environmental sustainability challenges globally. However, the severity of the situation is reinforced by the fact that the trends in urbanization in developing countries have notably higher rates. In other words, the projected urban growth will mostly take place in developing nations, where urban productivity rates[8] are low (UNDESA, 2014). Therefore, many environmental problems we face in urban areas are expected to intensify correlated with the population and size growth, especially in the cities of developing world countries. The main issues expected to increase with population increase and size growth in future cities, and possible mitigation strategies are summarized in Table 2.3.

[8] The correlation of the rate of urbanization with economic growth

Table 2.4. Problems Expected to Intensify with the Population Growth in Cities and Possible Mitigation Strategies (Source: Riffat et al., 2016)

Impacts of Global Urbanization	*Mitigation Strategies*
High traffic recycling	✓ Efficient public transport ✓ Compact city design
Urban warming	✓ Increasing green space, ✓ Using reflective materials
Increasing energy consumption	✓ Using renewable sources, ✓ Achieving low energy buildings, ✓ Increasing efficiency of devices/processes
Increasing air pollution	✓ CO_2 capture, ✓ Filtering exhaust gases, ✓ Increasing efficiency of industrial processes/vehicles
Lack of biodiversity/natural habitat	✓ Increasing green space, ✓ Developing animal/plant protection areas
Sinking water resources	✓ Water purification ✓ Desalination ✓ Rainwater harvesting
Land shortage for housing	✓ Constructing multifunctional buildings ✓ Creative architectural designs
Weak social cohesion	✓ Improving socio-cultural environment ✓ Increasing the number of organizations events that bring people together
High amount of waste	✓ Recycling

Sustainable urban development gains more importance with the rising environmental concerns mentioned in the table. The success of future cities primarily relies on the success of the strategies tackling these problems. Moreover, urban areas are particularly expected to be under the threat of climate change-related problems. Climate Change Vulnerability Index (CCVI), illustrates that the cities with high urbanization rates will also be the ones most affected by the climate change issue over the next 30 years (Verisk Maplecroft, 2018). Therefore, it is highly significant to produce comprehensive and systematic approaches today to tackle the intensifying problems of urban areas.

2.1.4. Climate Change as an Additional Layer of Sustainable Development Challenge

Climate change refers to a significant change in the 'constituent elements of average weather' namely temperature, precipitation, or wind (Romm, 2016). It may result from internal or external dynamics of the climate system; yet, it basically depends on the change in the radiation balance of the Earth. This change is possible with three ways: 1) 'changes in natural factors' namely changes in the Earth's orbit or the Sun's intensity, 2) 'Changes in the natural processes' within the climate system due to the fraction of solar radiation and, 3) with the 'alteration of the radiation' from the Earth towards space (Nasa, 2016). The third one explains the current change within the climate. Human activities, namely burning fuels and the changes in land surface increase the greenhouse gas trapping within the atmosphere and thus, the climate system responds directly or indirectly to these changes with its feedback mechanisms (Nasa, 2016; IPCC, 2018). The following schematic framework represents the relations between the climate system and the excessive use of fossil fuels.

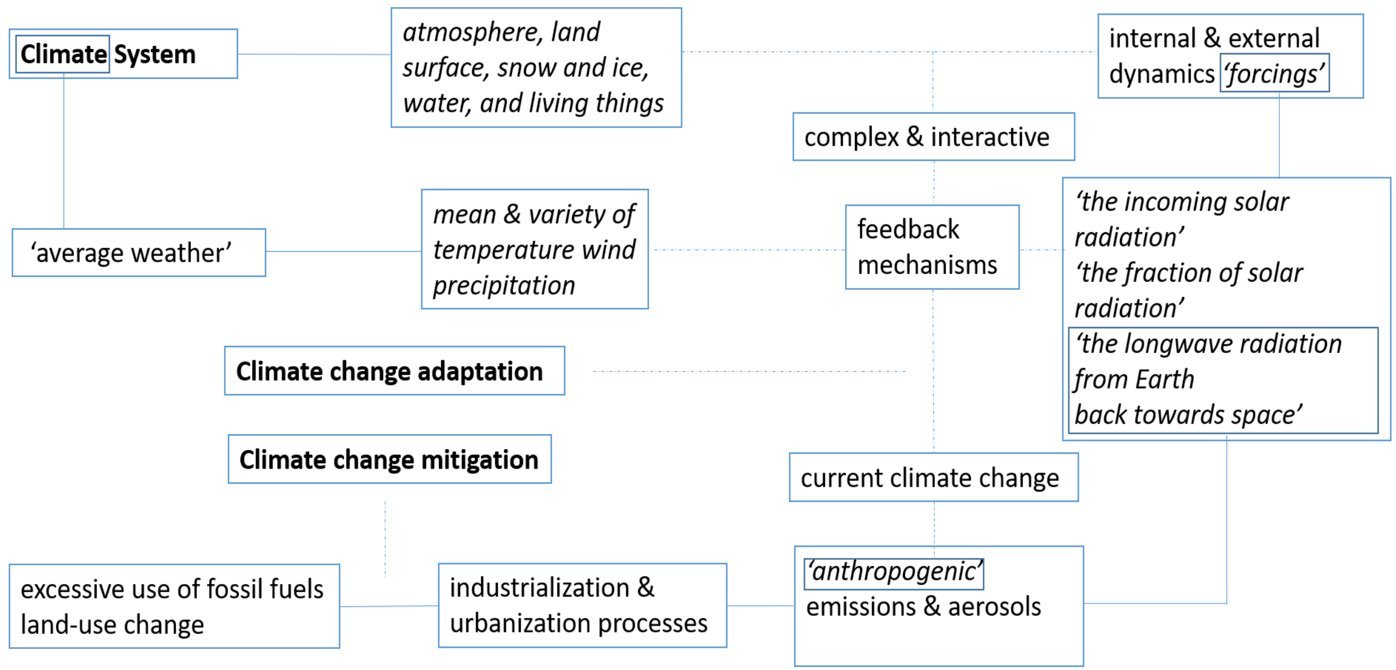

Figure 2.4. Schematic Framework Representing Relations Belonging Current Climate Change, Proposed by the Author

Joseph Fourier firstly mentioned the critical role of the atmosphere in the climate system in the year of 1826. Svante Arrhenius addressed the role of carbon-based energy production with respect to carbon dioxide accumulation in the atmosphere in the year 1896 and also implied that this accumulation would increase the earth temperature significantly (Denhez, 2007). Today, more than 97% of the published research expresses a position that climate change is happening and it is mainly caused by human activities (Cook et al., 2016).

Nations firstly acknowledge the climate change issue within the context of sustainable development nearly one century later under the agreement of *the United Nations Climate Change Environmental Agreement* (UNCCEA). In order to decrease the anthropogenic stress on climate, after UNCCEA, the nations agreed upon the legal regulations with *the Kyoto Protocol* (KP) in 1997. The KP entered in force after eight years with the sign of Russia in 2005. The KP introduced the need for a decrease in the current emissions to promote sustainable development all around the world. Moreover, the protocol contains binding targets; therefore, it is pivotal in terms of achieving the targeted emission decrease until 2012.

In 2007, to set an international climate change policy for the post-Kyoto period, *the Bali Action Plan* was also ratified. This plan is also the basis of *Cancun Agreements*, which involves a series of political decisions to combat climate change. *The Bali Action Plan* has significance since it stresses a need for a paradigm shift that ensures the creation of a low-carbon society to combat climate change.

Lastly, *the Paris Agreement* entered into force in 2016 by the involvement of 55 Parties of *the Convention on Climate Change* (UNFCC) whose total emissions cover more than %55 of the total global greenhouse gas emissions. Today, 127 out of 197 Parties of the Convention signed *the Paris agreement*.

The Paris Agreement aims to limit of global average temperature increase below 2 Celsius degrees compared to pre-industrial levels. However, the global average surface temperature has already changed by about 1,5 degrees Celsius from the beginning of the 20th century. This amount of increase affects the earth systems significantly considering that the difference between efficient climate and an ice age is only 5 Celsius degrees (Denhez, 2007). With about 1,5 degrees Celsius of warming, we have already experienced extreme weather events, a change in sea levels, or disaster-related deaths (IPCC,2018).

The anthropogenic stress on climate has brought many direct and indirect ecological, social, and economic consequences globally. The Intergovernmental Panel on Climate Change projects within the range of 1,5 to 5,8 degrees Celsius averages temperature difference by the year 2100 (IPCC,2018). Figure 2.4. represents different projections for the different emission scenarios for Europe covering the 21st century.

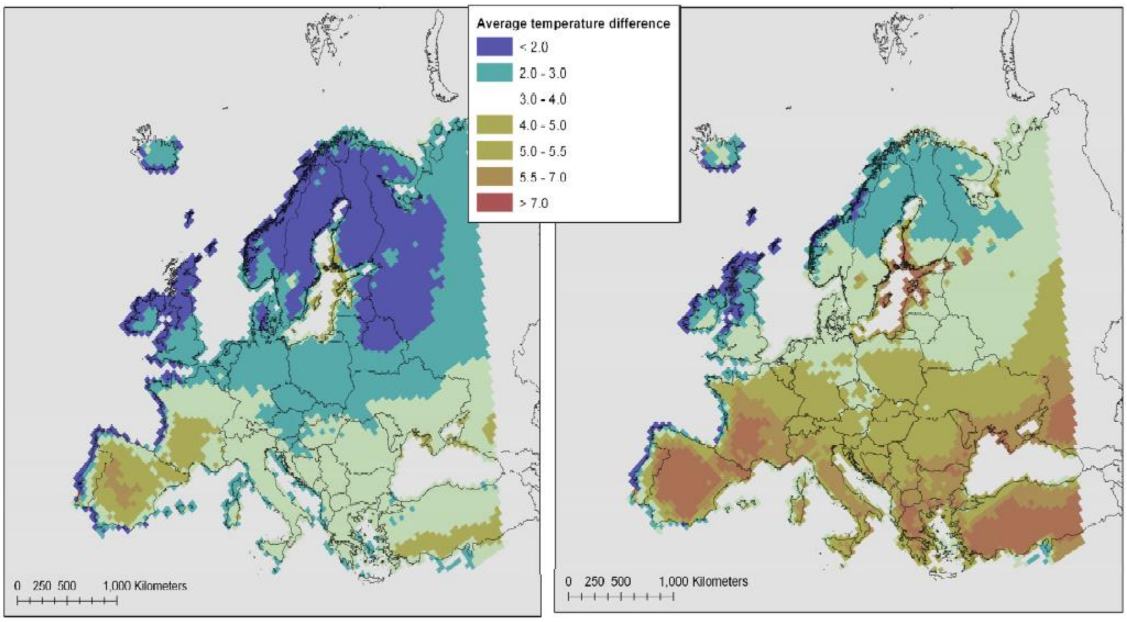

Figure 2.5. The Projected Increase in Average Temperatures in Europe between 2071 and 2100 Compared with the Temperature in the Years 1961-1990 under Significant Behavioral Change/Successful Mitigation (B2 scenario, left) and under Largely Unchanged Behavior (A2 scenario, right) (Source: Regions 2020, 2009)

The IPCC Fourth Assessment Report (2007a) underlines that in order to keep the global average surface temperature increase below 2-2.5 degrees Celsius, the global emissions will have to be reduced by 50-85% by 2050. According to the same report, a successful mitigation scenario with the targeted decrease (B2 scenario), requires system transitions in energy, land & ecosystem, urban & infrastructure, and industrial issues (IPCC,2007a).

Two fundamental responds to combat climate change are mitigation and adaptation strategies. Whereas the mitigation strategies focus on reducing anthropogenic greenhouse gases and, they are, therefore, aiming at stabilizing the heat-trapping greenhouse gases in the atmosphere, adaptation strategies engage with adjusting natural and human systems to decrease the adverse effects caused by climate change. The schematic framework (Figure 2.5.) presented in the IPCC report illustrates the linkages between climate change drivers, vulnerabilities and responses.

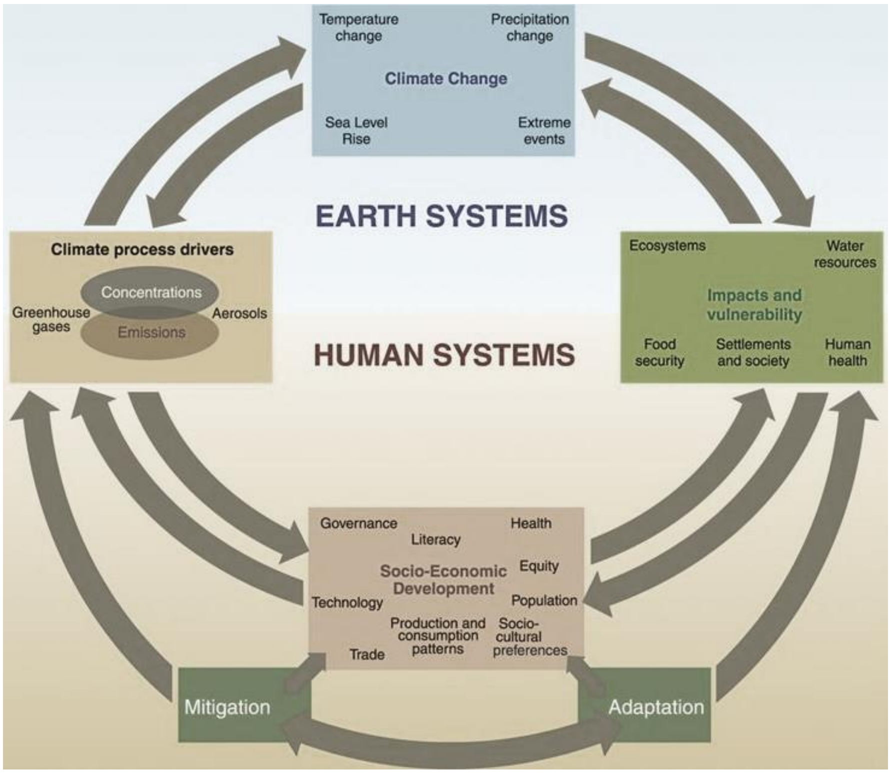

Figure 2.6. Schematic Framework Showing the Linkage between Climate Change Drivers, Vulnerabilities and Responses (Source: IPCC, 2007b)

The schematic framework represents that negative changes in the climate system are stressors for socio-economic processes. On the other hand, the framework provides two-way linkages that reveal the significance of climate adaptation and mitigation responses to decrease impacts and vulnerabilities. The rate and magnitude of the problem strongly associated with the quality of these responses. Therefore, well understanding of the linkages and building sustainable development integrated mitigation, and adaptation responses becomes highly crucial. Yet, the opportunities for the positive synergies between these linkages may decrease with time, especially if mitigation is delayed (IPCC, 2014).

As aforementioned, excessive use of carbon-based energy sources in cities are the main reason for climate change and global warming. Therefore, climate change entails us to contemplate our sustainable development approaches over energy. Implicit in the goals of *the Paris agreement* low carbon energy transition is an urgent need to mitigate climate change in the cities (IEA, 2018).

2.1.5. Energy and Environment

The need for energy to support human activities has increased over time, especially with the process of industrialization and urbanization. With these trends, the use of fossil fuels was accelerated. Both the extraction and usage process of fossil fuels damages the environment by polluting water and air, consuming clean water resources and increasing greenhouse gases. Currently, the energy sector accounts for more than two-thirds of the total greenhouse gas emissions and cities responsible for 75-80% carbon emissions (IEA, 2018). Moreover, the current trends show that the demand for energy continues to increase. With the urgency of climate change mitigation, in order to decrease anthropogenic greenhouse gases, concepts for energy transition for urban areas start to gain vital significance and meaning.

According to the data provided by The International Energy Agency (2018), about 50% of the global energy consumption is used in the construction phase and the usage period of the buildings. In the EIA analysis, buildings are in second place in the 'sectoral distribution of energy consumption' following industrial consumption and the end-use of energy usage in buildings is mostly for heating, cooling, and lighting purposes (EIA, 2018). Furthermore, 'the transportation of goods and people' accounts for 25% of global energy consumption according to the EIA data. Even if there is a considerable variation on the use of modes of transportation in countries, 'on-road passenger travel' accounts for the highest share of transport energy globally (EIA, 2018).

Considering Turkey, the energy demand of the urban population in recent years has also increased parallel with the urbanization and population growth in Turkey. Moreover, 'the self-efficiency rate in energy' is very low in the country, and 'non-renewables' mainly provide the energy need of cities. Turkey is still a Party to *the United Nations Framework Convention on Climate Change*, and a Party to *the Kyoto Protocol* from the year of 2009. Turkey also signed *the Paris Agreement* in 2016. In this respect, Turkey has responsibilities to decrease emissions and develop related measures over energy.

Nevertheless, energy demand increase records of OECD countries shows that Turkey has the fastest growth in energy demand among the member countries with an annual growth rate of 5,5% since 2002 (EIA, 2018). According to the same study, the energy use of the country is expected to increase by 50% over the next decade. Figure.2.4. shows the primary energy intensity[9] of Turkey.

[9] Energy depletion per unit of GDP

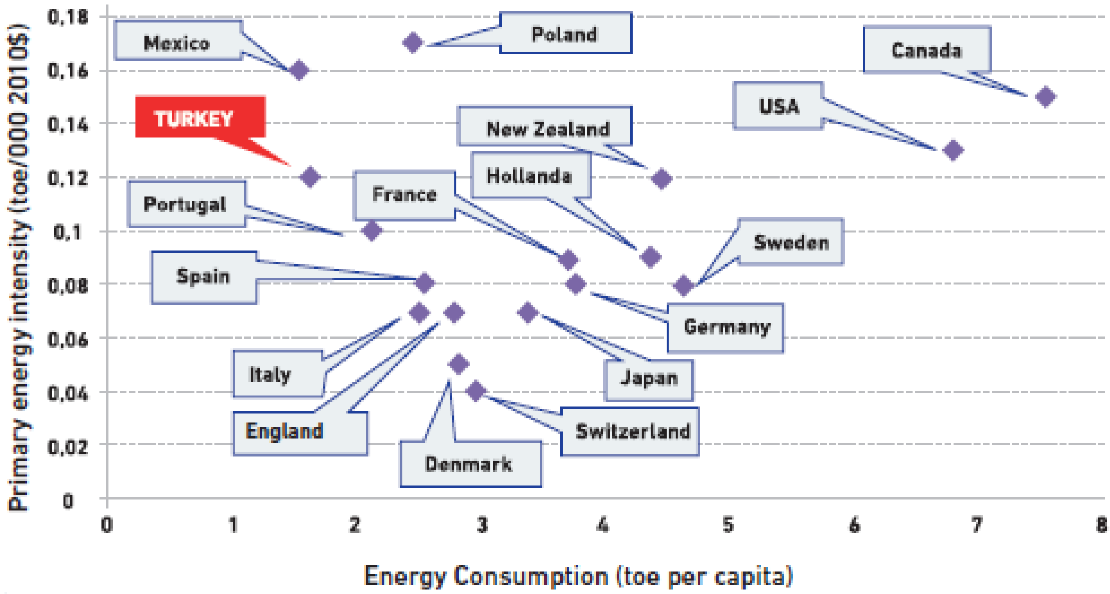

Figure 2.7. The Comparison of Countries by Primary Energy Intensity (Source: IEA, 2017)

With the aforementioned international efforts, countries determine strategies to reduce their energy consumptions. In the period 2005-2015, many countries showed a level of decrease in their energy consumptions. Japan decreased its energy consumption 3.3 unit while France achieves a reduction of 1.1 unit and Germany 0.7 unit; however, in the same period, the energy consumption of Turkey increased 0.7 unit (NEEAP, 2017).

Turkey prepared *the Strategic Energy Efficiency Plan (SEEP)* in 2013 and then *the National Energy Efficiency Action Plan (NEEAP)* in 2017 with the aim of providing a decrease in the energy consumption of the country. The plans set the strategic aim of reducing carbon emissions and the energy demand of buildings (SEEP, 2013; NEEAP, 2017). If the NEEAP would be fully accomplished, the emissions would be decreased at least 14% by 2030 in the country. On the other hand, the country's greenhouse gas reduction commitment is also categorized as ‘critically insufficient’ which means if the other states follow Turkey's current approach, global warming would reach at least 3-4 degrees Celsius by 2100 (Climateactiontracker, 2019).

2.2. Research Context: Green Campus

Urban areas need effective solutions to combat above-mentioned environmental challenges. In particular, recent climate change entails urban mass to minimize its fossil fuel demand urgently. Higher Educational Institutions have responsibilities to critically explore and exemplify sustainability and thus, bring society closer to a more sustainable future. Therefore, they also have key positions in the energy transition of urban areas.

The sustainability paradigm in Higher Educational Institutions has evolved with time and shifted from ‘sustainability in higher education’ to ‘higher education for sustainability’. Thus, beside the educational function of universities, campus operations has started to gain significance to promote environmental-friendly practices. In this sense, recently, an increasing number of universities committed to be *‘green campus’* by applying a variety of actions and strategies on their campuses.

The attributes of the sustainable university have discussed since the 1970s; however there are still different classes of problems for framework development for sustainable campuses. Many universities are guided by the evaluation criteria of the CSA tools to decrease their environmental impact. Nevertheless, the competency of the criteria belonging to these tools can be also criticized to remain limited in different ways.

The following sub-sections explore the paradigm shift in Higher Educational Institutions from Sustainable Development in Higher Education to Higher Education for Sustainable Development, the challenges and attempts related to the framework development for green university campuses.

2.2.1. Background on Sustainability in Higher Education

A sustainable university is generally defined as a higher education institution addressing, promoting and involving activities for 'the seek of the minimization' of negative economic, environmental and societal issues on a regional or global level (Hordijk,2014: p.810).

Velazquez et al. also defines the sustainable university in a similar way by highlighting its functions as:

"*a higher educational institution, as a whole or as a part, that addresses, involves and promotes, on a regional or a global level, the minimization of negative environmental, economic, societal, and health effects generated in the use of their resources in order to fulfill its functions of teaching, research, outreach, and partnership, and stewardship in ways.''* (Velazquez et al., 2006: p.812)

The expanded and refined definition associated with the functions of HE Institutions has emerged by the time of progress. The definition has matured with the help of many international events and declarations signifying the role and potentials of HE Institutions for sustainability.

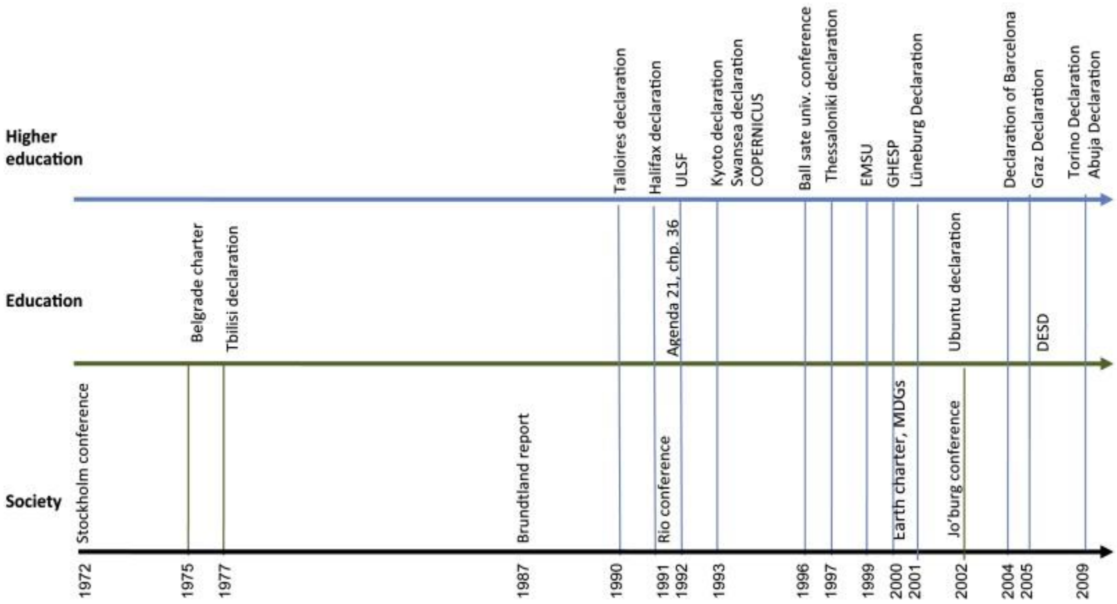

Figure 2.8. Significant Conferences, Summits & Declarations Held Internationally to Promote Sustainable Development in the Higher Educational Institutions. (Source: Lozano et al. 2013)

The role of higher education in promoting sustainability was firstly mentioned in the Stockholm Conference on the Human Environment (1972). Parallel to the increasing environmental concerns in the 1970s, the Higher Education Institutions have begun to take sustainability issue into their agendas. In 1977, the Intergovernmental Conference on Environmental Education was held in Tbilisi and the conference provided a framework for environmental education with *the Tbilisi Declaration* (UNESCO,1977).

With *the Brundtland report* (1987), there has been rising international attention in the role of higher education to promote sustainability concept. In 1990, to express the concerns on the sustainability-related issues and the significant role of the universities for a sustainable future, *the Declaration of Talloires* (TD) was made by 22 higher education institutions.

The declaration of Talloires defined the central role of the universities for sustainable future as:

"*Universities educate individuals most responsible for developing and organizing social institutions. For this reason, universities have a huge responsibility to raise awareness, knowledge, technology, and development tools needed to create an environmentally sustainable future*" (The Talloires Declaration, 1990, p.1).

The Talloires Declaration (TD) also presented an action plan for higher education institutions. With the TD, 350 higher education institution over 40 countries committed for the following issues:

''1. *Increase Awareness of Environmentally Sustainable Development*

2. Create an Institutional Culture of Sustainability

3. Educate for Environmentally Responsible Citizenship

4. Foster Environmental Literacy for All

5. Practice Institutional Ecology

6. Involve All Stakeholders

7. Collaborate for Interdisciplinary Approaches

8. Enhance Capacity of Primary and Secondary Schools

9. Broaden Service and Outreach Nationally and Internationally

10. Maintain the Movement." (The Talloires Declaration, p.1)

The paradigm shift from 'Sustainability in HE' to 'HE for sustainable development' was fostered with the presented action plan in the TD. Moreover, the importance of sustainable campus operations was firstly introduced with the statement of ''Practice Institutional Ecology'' in this declaration (Bartlett & Chase, 2004).

After the TD, the term ‘‘HE for sustainable development’’ emerged clearly out of the United Nations Conference on Environment and Development (the Earth Summit) in Rio de Janeiro in 1992. Its action plan *Agenda 21* also gave strong reference to the place of HEI’s in building a sustainable future (Beynaghi, 2014). Chapter 36 of the Agenda 21, on “Promoting Education, Public Awareness and Training,” states that “education is critical for promoting sustainable development and improving the capacity of the people to address environment and development issues” (United Nations Conference on Environment and Development (1992, 36.3). Also, it stressed most of the significant aspects of SD in HE today: ‘curriculum development on sustainability’, ‘multidisciplinary research’, ‘outreach and collaboration activities for promoting environmental awareness and sustainable development’, and ‘network formation’. Figure 2.9 presents the nexus between sustainable development and higher education, and also the aspects of the changing paradigm of the role and significance of the HE towards sustainability with time.

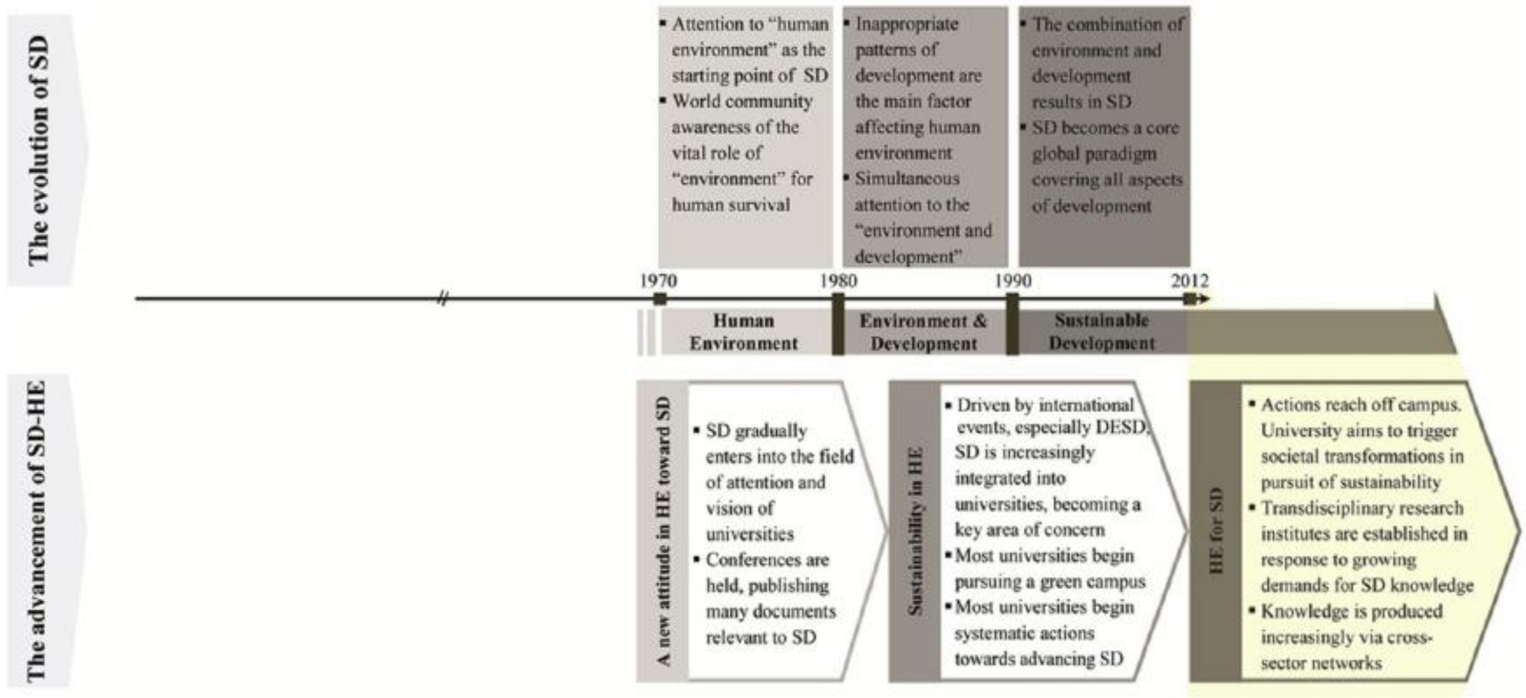

Figure 2.9. The Nexus between SD and HE (Source: Beynaghi et al., 2014)

After the Earth Summit, there has been significant growth in international attention to HEIs for sustainable development. The declarations have contributed to have a more expanded understanding regarding the different aspects of HEIs towards sustainable development; therefore, to the framework development. In his study, Lozano (2011) presents the most influential declarations with the major themes covered within.

Table 2.5. *Comparison of the Declarations Concerning Different Themes (Source: Lozano et al., 2011: p.14)*

	Curricula	Research	Operations	Outreach & Collaboration	Universities Collaboration	Assessment & Reporting	Trans-disciplinary	Institutional framework	SD through campus experiences	Educate the educators
Talloires	+	+	+	+			+		+	
Halifax	+		+	+						
Kyoto	+	+	+	+	+					
Swansea	+	+	+	+	+					
Copernicus				+	+		+		+	½ (+)
GHESP	+	+	+	+	+	+	+		+	+
Lüneburg	+	+		+						+
Barcelona	+	+		+		½ (+)	+	+	+	
Graz	+	+		+	+		+			
Turin	+	+		+			+			
Abuja	+	+	+	+	+		+			

Considering the connection with this study, *the Kyoto Declaration* (1993) has a significant place due to its emphasis on 'campus operations' by stating " HE Institutions not only promote sustainability through environmental education but also through the physical operations" (Wrighy, 2002: p. 208). With this statement of *the Kyoto Declaration,* the statement of the TD regarding the sustainable campus operations extended. On the other hand, whereas many declarations after the TD highlighted the significance of campus operations and transdisciplinary; only two of them the COPERNICUS and the GHESP stressed the importance of campus experiences.

Moreover, according to the study of Lazano, until the 2000s, only *the Global Higher Education for Sustainability Partnership* (GHESP) declaration pointed out ‘assessing and reporting’ of the progress of HEIs. Within Lazono’s comparison table *The Declaration of Barcelona* (2004) is another declaration addressing this issue; however, it also does not provide any framework for the evaluation and report of progress.

In addition to the declarations mentioned in the comprehensive study of Lazano, *the American College & University Presidents' Climate Commitment* (ACUPCC) also was initiated in 2006 with the support of the Advancement of Sustainability in Higher Education (AASHE) and the Second Nature. More than 700 institutions have committed ACUPP (Second Nature, n.d.). With the increasing concerns about climate change recent decades, CO2 reduction also introduced in ACUPCC as a theme. ACUPCC is seen as one of the most influential declarations concerned with minimizing the environmental impact of the campus and reducing CO2 emissions. The declaration also set the year 2050 as a target for universities to be ‘climate neutral’.

Yet, the declarations are criticized for being vauge in terms of presenting a sustainable campus framework development. According to Wright (2004) and Wals et al. (2010), they are inadequate to define targets and standards of sustainable campus operations and ‘the gap between practice and rhetoric’ remains. Wright (2004) points out that the low priority is given for sustainable campus operations in the majority of the SHE declarations with the following statement:

“Surprisingly, the notion of developing more sustainable physical operations on the university campus does not seem a priority for the majority of declarations” (Wright, 2004).

2.2.2. The Framework for Sustainable Campuses

Many universities adopt the above-mentioned declarations as a challenge to establish a sustainable campus and going into changes (Velazquez, 2006). According to Scott et al. changes towards sustainability in universities *''requires a focus not only on curriculum change but also on the gradual transformation of the overall way in which our universities are structured and operate''* (Scott et al., 2012: p. 9). At this point, several authors imply the significance of the 'whole-institution approach' in which the different aspects of HE institutions evaluated in a comprehensive manner for change towards sustainability.

According to Sterling (2004), there are three types of response by HE institutions towards sustainability which are 'accommodative', 'reformative' and 'transformative'. An *accommodative response* includes only 'bold-on' responses. For instance, a green building investment or adding new courses into the curriculum without any further consideration searched beyond remains in this level of response. The second response is a 'build in' response, which a further version of the accommodative one and in this level the practices held by HE institutions are questioned to produce new policies and practices. However, many resources support 'transformative response' which includes 'whole institutional change' and 'the redesign of organizational purpose towards sustainability' with reference to the enormity of sustainability-related challenges[10] (Sterling et al, 2013).

On the other hand, universities encounter several problems in different stages while giving responses to sustainability. Sonetti et al. (2016) classify the problems focused on the literature related to 'current sustainability framework development and adaptation', mainly as shown in Figure 2.10.

[10]For instance, Sterling (2004), Mader (2009), Second Nature (2012), Wals (2012).

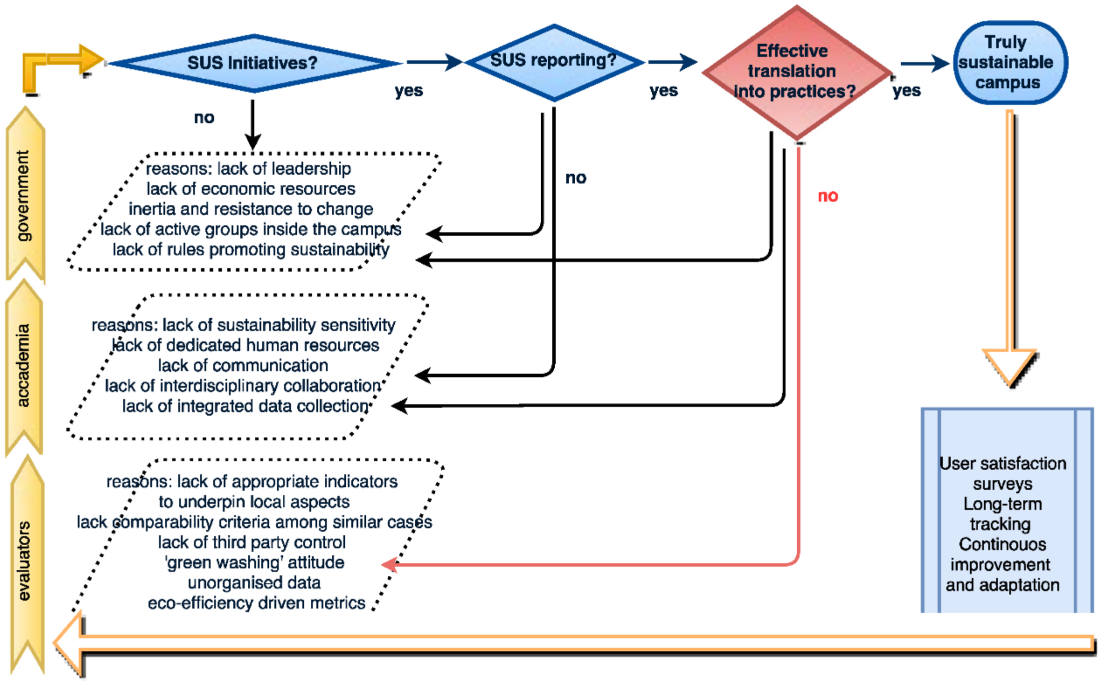

Figure 2.10. Different Classes of Problems Related to Current Sustainability Framework Development and Adoption (Source: Sonetti et al., 2014)

According to Sonetti et al. (2016), ‘lack of sustainability initiatives’, ‘lack of sustainability reporting’, ‘ineffective translation into practice’ are the main obstacles towards truly sustainable campuses. The government, academia, and evaluators are the agents that are responsible to build consensus on the sustainability framework; yet the indicated problems associated with the agents highlighted in the schema result in a gap between rhetoric and practices.

The red arrow in the schema implies the connection between ‘the effective translation into practices’ and ‘the current weaknesses of the evaluators’ (campus sustainability assessment tools). This connection also is the main focus of this study. The study supports the need for a transformative response in HE institutions towards sustainability to combat today's environmental problems. In this regard, the study attempts to enrich the approach of the evaluators.

Similar to the study of Sonetti et al., Shriberg (2002) offers insights related to ''the ideal assessment tool to measure progress'' of campuses (153). According to Shriberg, it is expected from an ideal sustainability assessment tool ''to identify important issues; to be calculable and comparable; to able to 'move beyond eco-efficiency, 'measure processes and motivations', and 'stress comprehensibility'' (Shriberg, 2002, 155-156).

Whereas the current CSA tools provide many criteria to assess universities' several issues and a ground enabling to track their progress, it can be concluded that they generally fail to reveal organizational and physical obstacles, strengths, opportunities and therefore, they remain limited to guide universities. Also, considering their scope, the physical aspects of the campuses need to be considered in a more systematic way to enrich the criteria and thus to able to have more comprehensive assessments upon the environmental sustainability of campuses. Following sections Section 4.2 and Section 4.3. introduce the green campus concept and evaluate the energy efficiency criteria of the CSA tools in the light of the above-mentioned discussion.

The concept of 'green campus' was introduced in the 1990s as a term highlighting the significance of the environmental sustainability of campuses. In the literature, while some sources use the term ''green campus'' changeable with the sustainable one, many sources highlight that the concept carries an environmental centric approach for sustainability. Throughout the literature review, several studies addressing the indicators of sustainable campus and green campus were examined. The following table illustrates the definitions and qualitative aspects gathered for sustainable and green campus concept.

Table 2.6. *Definitions and Qualitative Aspects of Green/ Sustainable University Campus*, *Proposed by the Author*

AUTHORS	*Descriptions for Green/ Sustainable Campus*	*The Approach to Campus Concept*
EPA et al., 2000	*-a system-wide culture of environmental sustainability, balancing function and design with existing and predicted resources.* *-a place where environmentally responsible practice and education go as one and where environmentally responsible tenets are borne out by example*	Within harmony with the resources
Creighton, 1999	*-the efforts to establish environmentally sustainable practices in educational institutions* *-the process of reducing the multitude of on- and off-site environmental impacts resulting from campus decisions and activities, as well as raising environmental awareness within the human communities of a higher educational institution*	Self-contained communities that are supported by vast systems of institutional and operational functions
Green Office Movement, 2019	*-meets its need for natural resources – such as energy, water, and materials – without compromising the ability of people in other countries as well as future generations to meet their own needs.*	Representing the development idea presented within Brunthland Report
Alshuwaikhat et al., 2008	*a sustainable university campus should be a healthy campus environment, with a prosperous economy through energy and resource conservation, waste reduction and an efficient environmental management, and promotes equity and social justice in its affairs and export these values at community, national and global levels*	Representing the triple bottom line theory

Whereas some definitions related green campus only signify the mission of decreasing environmental footprint in campuses; some others imply the significance of the green campus concept on the broader context and also, they give reference to the institutional and physical aspects of campus. Similarly, green campus initiatives, and sustainability assessment tools show differ on the consisting themes of green campus. Nevertheless, they basically cover waste, energy, water, and transportation criteria together with some institutional criteria of the universities (Green Campus Ireland, 2018).

With the aim of building a campus sustainability assessment framework, Cole (2003) introduced the campus sustainability assessment egg representing the ten themes of the sustainable campus by integrating two main aspects of university campuses 'ecosystem' and 'people' in a concentric way. In the framework, the sustainability of the ecosystem incorporates aspects of air, water, land, materials, and energy whereas the sustainability of people system consists of knowledge, health, and wellbeing, community, governance, economy and wealth. Her work is an early attempt to constitute a framework for CSA and adapted by many universities, especially in Canada.

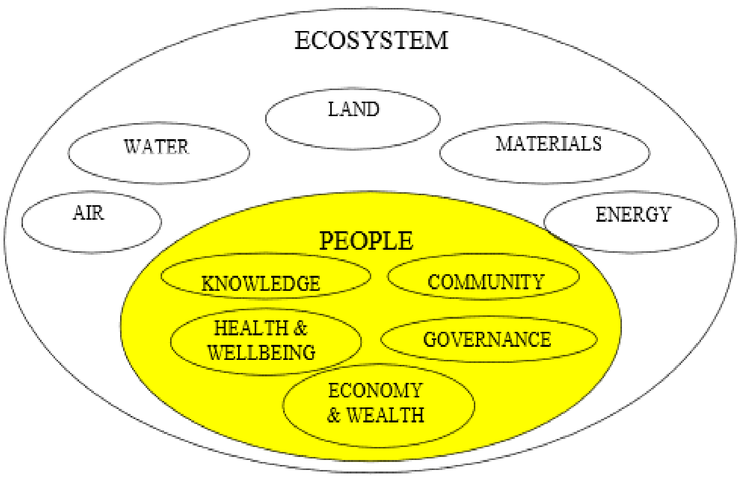

Figure 2.11. Egg of Sustainability (Source: Cole, 2003)

Another attempt related to building a campus sustainability assessment framework is the interrelated version of the domains in which universities integrate sustainability. The campus domains were identified by Cortese and Mcdonough (2001) as research, curriculum, operations, and engagement. In the study of Beth et al., these domains have been advanced in order to achieve a more comprehensive approach. The presented model by Beth et al. also consists of the integrating domains of campus sustainability. According to Beth et al., (2013) university campuses are the unique places that these four domains incorporate well towards sustainability. The following figure illustrates the integrating domains of campus sustainability presented by the study of Beth et al.

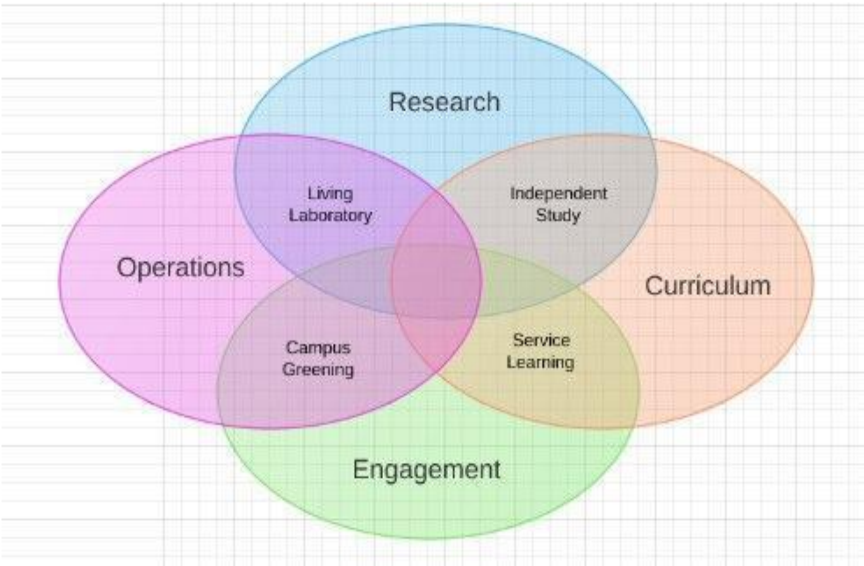

Figure 2.12. Integrating Domains of Campus Sustainability (Source: Beth et al., 2013)

Considering connection with this study, these studies have significance to understand different domains and aspects of the university campuses and also the relationship between the spatial and organizational considerations.

2.3. The Overview of the Campus Assessment and Rating Systems in terms of Energy Criteria

This section presents most widely applied CSA tools by the universities: the Sustainability Tracking and Assessment Rating System (STARS) and Green Metrics (GM) Ranking tools, and analyzes the energy criteria of these tools. The aim of the research conducted in this section to understand how these tools evaluate the energy efficiency issue within the green campus concept and also provide insights related to campus energy criteria at different scales for the multi-scale energy evaluation criteria.

2.3.1. The Sustainability Tracking and Assessment Rating System (STARS) Framework

The Sustainability Tracking, Assessment and Rating System (STARS) is "a self-reporting framework for colleges and universities to measure their sustainability performance" (STARS, 2019). It was established by AASHE in 2010 with the seek of a common base for sustainability assessment in HEI's. The STARS is a self-assessing, voluntary system to assess the progress in the institution over time.

The framework represents an attempt to implement the triple bottom line approach at the campus level with 'comprehensive' and 'measurable' objectives (Martin et al. 2012, 54). Accordingly; the rating criteria of the STARS firstly were organized into four defined categories: Academics, Engagement, Operations, and Planning and Administration. Later, Innovation and Leadership category also added (Martin et al., 2012).

The STARS has four rating levels: Bronze, Silver, Gold, and Platinum. Additionally, universities can apply the credit tool as a guideline without registering reporting tools. All reporting is conducted online via the STARS Reporting Tool. The credits developed by reviewing previous CSA tools, the sustainability reports of universities and also based on the recommendations of the experts and stakeholders. The STARS credits were aimed to be *objective*, *measurable* and *actionable* (Mertin et al, 2012).

In order to cover the vast majority of institutions, for some credits, it is not employed detailed specifications. Rather, the criteria are *open* and *flexible*. Whenever it is possible, the performance is evaluated with quantitative data or measurable outcomes in the tool. In this way, the assessment framework aims to catalyze tangible improvements and outcomes as possible (STARS,2019). Appendix A presents the STARS Credit Checklist including the subcategories, credit numbers and given criteria, available points and where the criteria applicable.

2.3.2. Green Metrics (GM) Ranking Framework

Green Metrics was developed in the year 2010 by the University of Indonesia. It aims to evaluate the universities with an environmental centric approach. It consists six main categories as ‘Energy & Climate Change’, ‘Setting& Infrastructure’, ‘Waste’, ‘Water’, ‘Transportation’, and ‘Education & Research’ (UI GreenMetric, 2019). Each heading has sub evaluation criteria and indicative performance measure to evaluate the campus greenness. Evaluation percentages associated with main categories are set to assess the overall success of green campus applications. With 21% Energy & Climate Change have the highest weighting in the tool.

The data provided for the tool is gathered and reported by the universities online. The evaluation method used in each category is a score based environmental performance evaluation. Currently, the available score in the tool 10.000 points. The tool has revised over the years in terms of its main categories and sub evolution criteria. A total of 55 evaluation criteria are used in the year 2018 whereas this number was 39 in 2005. The tool consists of both qualitative and qualitative performance measures and each evaluation criteria is asked for evidence. Each criteria is evaluated with scoring bands to be weighted and the rank made by a final calculation.

2.3.3. The Evaluation of the Energy Criteria of the Sustainability Tracking and Assessment Rating System (STARS) and Green Metric (GM) Ranking Frameworks

An increasing number of universities apply to the CSA tools in recent years. The STARS and GM Ranking tools are the most preferred ones among these tools. The tools both developed in the year 2010. The increase in the number of institutions registered these tools by the year of 2018 is significant. According to the data presented within their webpage of the GM, whereas only 85 universities applied for the GM ranking in the year 2010, the number have increased to 718 in 2018.

The Green Metric Ranking Network Strategic Framework (2018) also presents the data related to from which countries universities applied the GM Ranking tool each year and also how much students and faculty members totally include the ranked universities. According to the data, in the year 2010 from 35 countries universities ranked with the GM Ranking while 81 countries ranked in the year 2018. The total number of enrolled students in the ranked universities is 23.643.222 for 2018. These numbers are also significant as well as the assessment tools in terms of their contribution to the development of sustainability culture in broader context. Therefore, it can be started to evaluate these tools by stating that the tools also have significance in a broader social context.

Table 2.7. *The STARS & GM Ranking Tools, General Comparison, Proposed by the Author*

Tool	Number of Institutions Have Registered (2010 - 2018)	Assessment Framework	Ranking & Rating Categories Comprising the Campus Operations	Other Evaluation Categories	The Weight of The Energy Indicators
Tracking, Assessment & Rating System (STARS)	970	self-reporting framework	Buildings, Energy, Food & Dining, Grounds, Purchasing, Waste, Water, Transportation	Academics, Engagement, Planning & Administration,	0.45 (Within operations category)
GreenMetric Ranking Tool	1435 (METU is ranked as 303)	self-reporting framework	Energy & Climate Change, Setting & Infrastructure, Waste, Water, Transportation	Education & Research	(0.21)

In the literature, several studies evaluate or compare the weighting systems of these tools. For example, the study conducted by Ragazzi et al. (2017) determinates the main issues related the methodology of the GM Ranking are the lack of ‘scoring band’, ‘relativity of score’, and ‘high sensitivity of ranking’. However, this study is conducted over the picture that the tools presented with their energy criteria. Therefore, the evaluation and comparison of these tools are made over the criteria they have. The following tables (Table 4.4. and 4.5.) present the evaluation criteria of the STARS and GM Ranking tools over energy.

Table 2.8. *The STARS Evaluation Criteria over Energy (Source: STARS, 2019)*

The Criteria	Requirements
Emissions Inventory and Disclosure	Have completed an inventory to quantify the institution's greenhouse gas (GHG) and/or air pollutant emissions.
Greenhouse Gas Emissions	Have completed an inventory to quantify the institution's targeted greenhouse gas (GHG) emissions.
Building Design and Construction	Own new or renovated buildings that were designed and built in accordance with **green building code, policy/guideline, or rating system**.
Building Operations and Maintenance	Own buildings that are operated and maintained in accordance with a sustainable management policy/program or a **green building rating system** focused on the operations and maintenance of existing buildings.
Building Energy Efficiency	Have data on **grid-purchased electricity**, electricity from **on-site renewables**, utility-provided steam and hot water, and stationary fuels and other energy products.
Clean and Renewable Energy	Support the development and use of **clean and renewable energy** sources.

Table 2.9. *The GM Ranking Evaluation Criteria over Energy*

The Criteria	Requirements
Energy-efficient appliances usage are replacing conventional appliances	**Energy-efficient appliances usage** includes the use of energy-efficient appliances/lighting fixtures (e.g. A/C with inverter technology, LED light bulbs, computers, etc.). For example, the percentage of LED lamps used in the total building area.
Smart Building implementation	Percentage of the total floor area of **the smart building** to the total all floors building area
Number of renewable energy sources in campus	The ratio of **renewable energy production** divided by total energy usage per year
The total electricity usage divided by total campus	The total electricity usage divided by total campus population (kWh per person)

	population (kWh per person)	
	The ratio of renewable energy produced towards energy usage	The ratio of **renewable energy production** divided by total energy usage per year
	Elements of green building implementation as reflected in all construction and renovation policy	Please provide information on the elements of **green building** implementation as reflected in the construction and renovation policies in your university (e.g. natural ventilation, full natural daylighting, the existence of building energy manager, and the existence of Green Building, etc.).
	Greenhouse gas emission reductions program	The current condition of university in providing formal programs (from any scope) to reduce greenhouse gas emissions.
	The ratio of total carbon footprint divided campus population	Total carbon footprint of university.

By reviewing the content both the main assessment categories and the energy criteria of these tools, the criticism of **lack of interest on intersections of the domains** can be made. As Cole (2003) and Beth et al. (2013) illustrates that the domains of the campus have intersections. The efficiency considerations also can be sought in these intersections.

Additionally, two main criticism can be made with a spatial perspective;

- The approach presented in these tools is **technology-oriented** upon energy issue.
- A campus-wide decrease in energy usage is quantitively expected; however, the criteria used in the tools evaluate campus operations **only in building scale.**

In the light of the content analysis of these CSA tools, the study offers to evaluate the campus greenness over energy with the two main aspects of the university campuses: organizational, and spatial.

2.4. Concluding Remarks

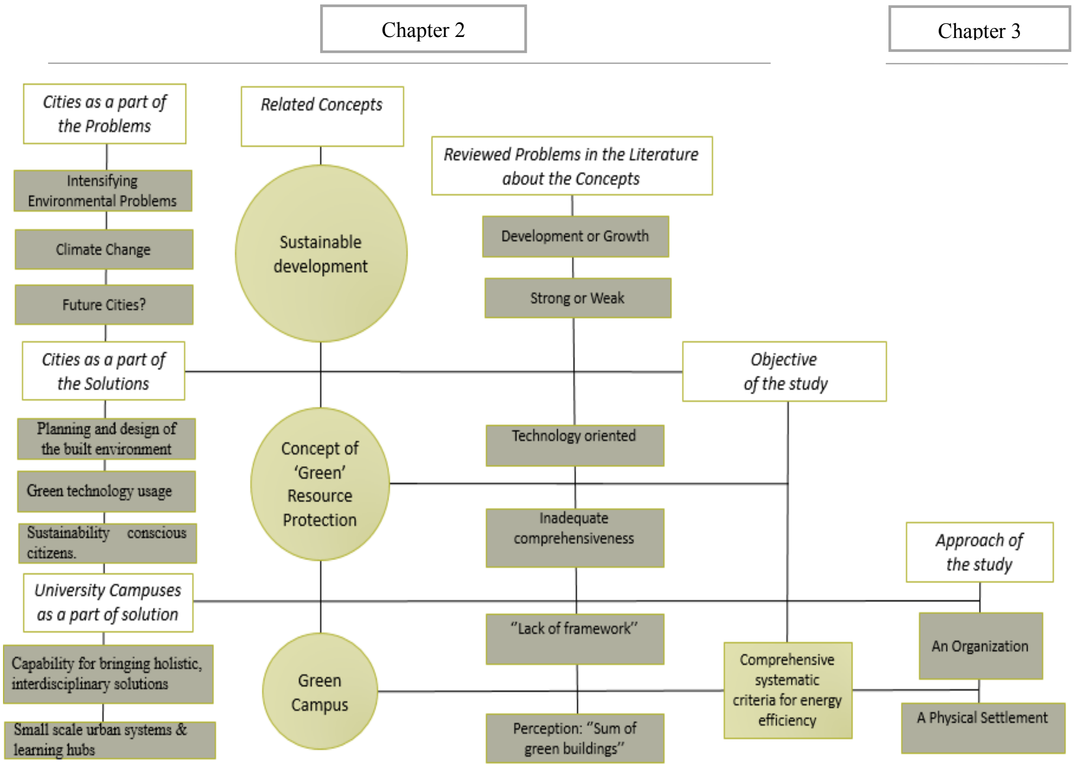

Figure 2.13. Author's Conceptualization

In this chapter, as illustrated in the Figure 2.13, connected issues and concepts related to the stated problem are covered. To combat intensifying environmental issues effectively in urban areas, some issues including 'source efficiency, clean energy production, access to information, and public participation' have come into prominence within sustainable development agenda (United Nations, 2014). Moreover, considering the complexity and intensity of current environmental problems, it becomes highly crucial for the sustainable development of urban areas providing the capacity to give quick, systematic, and effective responses.

For the actualization of this kind of development, new concepts have evolved within sustainable urban development scope such as “eco-cities," "green-cities," "low-carbon cities," "smart cities". Apart from the intention of these concepts -to bring a more holistic approach for sustainable urban development- the criteria of these models can be criticized to remain ‘technology-oriented’ mostly. However, to achieve a real shift from the ‘weak sustainability’ model into the ‘strong’ one in cities, these concepts need to be comprehensive, systematic and their influence needs to be greater than ‘technological fixes’ (Korhonen, 2018). In this respect, universities have many capabilities to provide insights so as to further the mentioned concepts.

In terms of the success of energy transition in cities, the primary energy-efficient solutions such as energy conservation in buildings and sustainable management of land require spatial integration of economic, institutional, social, and ecological processes. Passive strategies and active technologies for the built environment can make it possible to maximize the use of ambient energy within the built environment whereas the consideration of land uses at different scales in terms of the function and form can provide energy efficiency through convincing people to use sustainable modes of transportation. However, many design projects in the built environment still underestimate the local variables and green design elements and it results in higher energy demands for transportation as well as active heating, cooling, and lighting systems in buildings.

As ideal settings and microcosms, university campuses offer many opportunities both for research and the implementation of energy transition strategies. However, as discussed in a detailed way in this chapter, the same level problems exist for the ‘green campus’ concept. At this point, the objective of the study to create a comprehensive and systematic evaluation criteria on energy involving organizational and physical constituents of campuses.

To achieve this, the following chapter examines ‘the principles of transformative practices’ and the multi-scale spatial energy criteria in university campuses.

CHAPTER 3

RESEARCH CONTEXT: A-MULTI SCALE APPROACH TO THE ENERGY CRITERIA OF GREEN CAMPUS

The hypothesis of the study is that a multi-scale approach over the energy criteria of the CSA tools covering the spatial and organizational aspects of university campuses can provide more comprehensive, and systemic criteria for the transition towards sustainable university campuses.

As mentioned in the previous chapter, in terms of energy efficiency criteria, campuses are mainly evaluated 1) with a technology-oriented approach and 2) solely at building scale in the criteria of the CSA tools. On the other hand, the energy criteria on campus can be broadened with the spatial considerations at different scales. Moreover, campus domains are interrelated and therefore, energy issue can be evaluated not only in campus operations, but also in the intersections of the campus domains as Beth et al. (2013) suggests. At this point, the organizational aspects of the campuses is pivotal in terms of empowering these intersections and; thus, to able to achieve a transition towards sustainability in campuses.

In this regard, this chapter examines the organizational energy criteria at ‘transformative’ level and the spatial energy criteria of the campuses at multi-scale.

3.1. University Campuses towards Energy Transition as Organizations

Starik & Rands explains a sustainable organization as ‘‘one engages in activities that do not alter physical, chemical, biological, or social factors in ways that will dramatically reduce or eliminate the carrying capacity for otherwise sustainable entities’’ (Starik & Rands, 1995, p.909).

As organizations, the HE institutions encounter with some organizational challenges in terms of giving quick and systematic responses to environmental problems. On the other hand, by analyzing the social and systematic side of the issue, revealing the organizational processes, strengths, weaknesses, opportunities and perceptions; the processes and responses can gain capability in the HE institutions. This part of the study (Subsection 5.1.) aims to introduce the organizational challenges HE institutions have and present the associated energy criteria.

3.1.1. Principles of Transformative Practice

In a broad sense, the significant issues which lead to fail in the sustainability processes are 'lack of systematic and comprehensive understanding', the 'incorporation of different values' and 'inadequate insight for long term impacts of the actions' (Mader, 2009). These problems are mainly associated with the social and systematic side of sustainability issue. Universities with their organizational aspects hold weaknesses which make them to fail in sustainability due to above-mentioned reasons, on the other hand they also have many strengths to solve these problems with their unique aspects.

Doppelt (2003) identified "seven sustainability blunders" for organizations as patriarchal thinking, a silo approach to issues, unclear vision for sustainability, insufficient understanding over cause and effect, failure to institutionalize sustainability, lack of information, and lack of learning mechanisms. On the other hand, collaboration and co-creation culture, willingness to change, institutional learning play an essential role to tackle these problems (Brown & Key, 2005). These key aspects increase the knowledge building capability and potential for inclusion within organizations. However; the linear and fragmented structure of the organizations makes it harder to have sufficient knowledge building capabilities and connectivity. At this point; Meadows (2008) highlights that system behaviors are mainly efficient as the strength of connections and relationships between the elements of the system, rather than the strength of individual elements. Therefore, organizations should perceive their forces as a connected piece of a whole to adapt quickly and change for the better (Senge, 1990). In a university campus, 'forces' can correspond to different domains of university campuses.

The Graz Model illustrates the required principles and their interrelations that initiate 'transformative processes' in organizations. According to the Graz Model to achieve a 'transformative practice' five interrelated principles should be applied in organizations (Mader, 2013). The following chart represents these principles.

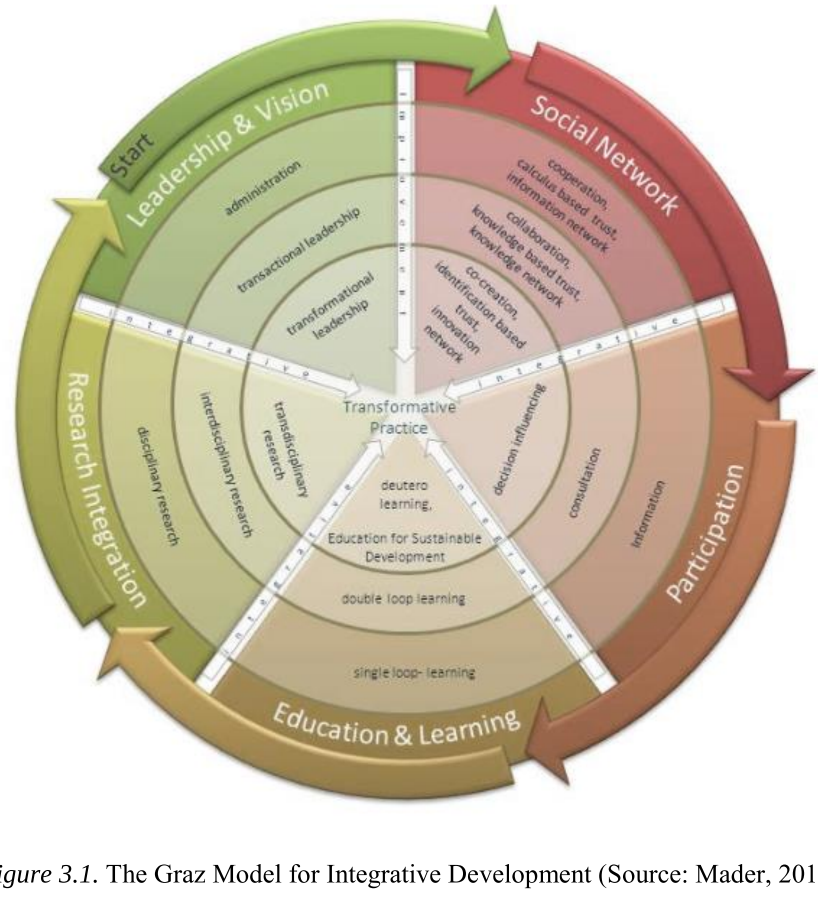

Figure 3.1. The Graz Model for Integrative Development (Source: Mader, 2013)

3.1.1.1. Leadership & Vision

Cebon implies that the efficiency issue is generally taken into consideration within the frame of the organization's structure and therefore within that distribution of power and acquisition of information; rather than based on cost-benefit analyses or environmental impact analyses (Cebon,1992). Therefore, to have adequate leadership and vision regarding the efficiency issue are the first step for the transition towards sustainable university campuses. Yet, the bureaucracy and rationalization within organizations result in putting efficiency considerations behind. DiMaggio & Powell called this as "organizational isomorphism" which implies a mimetic and normative mechanism leading to an increase in the number of similar organizations rather than competitive and efficient ones (DiMaggio et al., 1983). In this point; setting organizational visions and mission related to sustainability, to define what is sustainability for the organization, taking necessary organizational measures, and tracking and measuring are the significant considerations that can be applied.

From the reviewed literature and the CSA tools following criteria chart is developed to evaluate the leadership and vision:

Table 3.1. *Transformative Processes: Leadership & Vision*

Leadership& Vision	**Evaluation Criteria**
Definition of sustainability in the organization	• Usual/Unique definition • University Vision/not • Evaluation of outputs comparing the strategic goals
Level of Sustainability Leadership	• Sustainability Office/Committee • Duties of the Sustainability team • Administration /transactional leadership /transformational leadership • Sufficient funding for operations
Sustainability goals	• Determined/not determined • Measurable/ not
Tracking	• Data required to track progress • Applied Assessment tools
Reporting	• Feedback mechanism & tools

3.1.1.2. Social Network

Knowledge building capability and potential for inclusion are the other significant parameters of the sustainability issue in organizations. Brown & Key suggest that collaboration culture, willingness to change and understand the technical and managerial elements are essentials for a commitment to sustainability (Brown & Key, 2005). Similarly, the Graz Model presents three-level social network in organizations: cooperation -*information network*, collaboration -*knowledge networ*k and co-creation -*innovation network* (Mader, 2013). According to the model, the highest level representing knowledge building capability is co-creation-innovation network. In order to achieve this level social network, having partnerships both in inside and outside of the university, revealing the knowledge-building processes and the perceptions related these processes are essentials.

From the reviewed literature following criteria chart is developed:

Table 3.2. *Transformative Processes: Social Network*

Social Network	Evaluation Criteria
Partnerships	• Governmental/Corporate/ Community Partnerships /Student & staff
Networks	• Information network/ Knowledge network/ Innovation network
Internal perceptions	• Perceptions related efficiency within the organization successful/unsuccessful, central/fringe

3.1.1.3. Participation

Participation is directly linked with the collective–decision-making processes. With strong participation, universities can evaluate their investments and decisions healthily. In many organizations, easy and secure investments for efficiency can be evaluated as being expensive or time-consuming because of the 'insufficient decision-making capabilities', and the 'linear organizational arrangements' in the organizations (Biggart & Lutzenhiser 2007). Another significant point is that decisions can be evaluated with different perspectives if the relevant data achievable. Therefore, sharing the information related campus source consumption, sustainability related considerations, and future plans with all the members of the organization can strengthen the participation and feedback mechanisms.

From the reviewed literature following criteria chart is developed:

Table 3.3. *Transformative Processes: Participation*

Participation	**Evaluation Criteria**
Engagement	• Opportunities and capabilities for decision influencing & Knowledge Sharing
Communication Channels	• Use of communication tools for the engagement & knowledge building (Open Data related campus environmental impact, consumptions)
Feedback Mechanisms	• Existed /not, Strong/weak

3.1.1.4. Education, Learning & Research

Senge states that "We can build "learning organizations," organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set, and where people are continually learning how to learn together" (Senge, 1990: p.3).

Learning about efficiency & sustainability is not solely associated with curriculum content for universities. According to Bateson (1972) a key point related learning is that learning both can serve to the change or keeping the system stable. At this point, with a system perspective, Watzlawic et al. (1980) distinguish two types of change. First is occurs in 'a given system which itself remains unchanged' and the second is the 'one whose accurance change the system itself' (p.50).

Similarly, within a university campus, the curriculum changes alone is not enough to bring a transformative practice into the campus or society. The 'Single loop', 'double loop' and 'deutro learning' within the Graz Model implies the same idea. Deutro learning is conceptualized as 'higher order learning' in literature. In this level learning context and relationships cannot be reduced to individual level; therefore, this level of learning implies ‘institutionalization of learning processes that is, the establishment of appropriate structures, capabilities, processes, and strategies to facilitate learning at the organizational level (Visser, 2019 p.659). Thus, it is expected that learning occurs both in the individual and organization, students and employers in a university campus.

In terms of research activities, with a transformative perspective, it is needed to assess universities with criteria questioning more than the number of sustainability research. On the other hand, the CSA tools investigated in the framework of this study evaluates these criteria with a quantitive approach: upon the number of research and research fund. However, Graz model implies that the quality of the research is also significant for transformative practice. The model highlights the significance of making transdisciplinary research in organizations.

In this respect, the existence of a sustainability website, the existence and the amount of research funds, the events related to sustainability topics and student organizations, and the number & transdisciplinary of the research are the significant criteria of learning in universities. From the reviewed literature and the CSA tools following chart is developed:

Table 3.4. *Transformative Processes: Learning & Research*

Learning & Research	**Evaluation Criteria**
Education	• Single loop, double loop, deutro learning • Curriculum
Existence of a Sustainability website	• Existed/ not Existed
Events	• Numbers/ Support of the university
Student Organizations	• Numbers/ Support of the university
Research	• Disciplinary/Interdisciplinary /Transdisciplinary Research • Funds

3.2. University Campuses towards Energy Transition as Physical Settlements

The word *campus* derives from the Latin ‘‘field’’ was firstly used at Princeton University to explain college grounds (Eckert, 2012). Today, the word refers to the overall physical quality of higher education institutions (Bowman, 2011).

Temple (2014) & Edwards (2003) assert that physical space is a significant tool for the university to reflect and pursue its culture, missions, values, and historical background. Koester et al., (2006) also implies that the campus itself is the place for the demonstration of environmental sustainability and innovation. Therefore, the meaning of the campus also reflects more than its physical phenomena. The following concept (subsection 5.2.1) stresses the significance of this meaning shift with a socio-technical perspective (Koester et al., 2006).

3.2.1. Social Dimension of Campus Settlement: Learning Hubs

The literature suggests that one of the strongest advantages of the transition towards a sustainable university will be observed in a broader social context. According to Bursztyn (2008), this transition has a significant role in the transformation of ‘socio-technical dynamics’ towards a sustainable future. Cortese (1999) also supports the idea that this transition enables changes in human activities systematically with the following benefits:

· “*Future scientists, engineers, and business people will design technology and economic activities that sustain rather than degrade the natural environment, enhance human health and wellbeing, and mimic and live within the limits of natural systems.*

· *All professionals will understand their connection to the natural world and to other humans. They will know where products and services come from, where wastes go and what they do to humans and other living species. They will understand how to minimize this "ecological footprint."*

· *All current and future generations of humans will be able to meet their basic needs, pursue meaningful work, and have the opportunity to realize their full human potential personally and socially.*" (Cortese, 1999: p.1)

McIntosh (2008) extends the idea by stating that it is possible to increase resilience to the forces leading degradation of natural and cultural environments only through an experience of 'intimate reality of local place' for learners –'a walk at the interface between science and spirituality'.

Following two concepts emphasize two social functions of the campus settlement with this perspective.

"Learning campus" concept is acknowledged by Kenney as "one that maximizes the probability of chance encounters and encourages lingering once an encounter - whether by chance or by plan - takes place" (Kenney, 2005, p. 39). The concept highlights the importance of campus settlement upon its high potential to learn its users from it. Fisher (2007) and Jamieson (2009) also define a campus is a place as learning and knowledge generation is nurtured and encouraged within the whole campus.

''Living laboratory'' is another concept that highlights the significance of campus settlement to carry sustainability-related studies. (Orr and Cohen, 2013; Evans and Karvonen, 2014). The concept evaluates campus itself is a significant place for teaching and learning activities of students in natural resources management, ecology, environmental education and sustainable practices (Painter, et. al., 2013).

As an illustration, the study conducted by Choi et. al. (2016) in the Portland University shows that student's level of knowledge both on the energy efficiency strategies in campus and general sustainability awareness is considerably higher among the students involving green campus student activities. In this regard, considerations related to the educational and broader social functions of campuses can also be added as a criteria for the CSA tools.

Table 3.5. *Social Dimension of Campus*

Social Dimension of Campus	**Criteria**
Learning Campus	• Learning by observation /culture
Living Laboratory	• Carried out studies within campus to serve the practice & research

3.2.2. Physical Dimension of Campus: Green-Eco Design

The term -*green* is generally used for referring to 'resource protection'. However, it is also a catchall term used for ''policy topics or business sectors, including activities and technology associated with the movement of people and goods; waste management and recycling; pollution prevention, treatment, or abatement; energy that is clean or efficiently produced and consumed; the design, construction, maintenance, and dismantling of buildings; resource extraction; agriculture/gardening; natural resource management and other environmental services'' (Hammer, S. et al., 2011).

Considering the basic idea of the concept and the enormity of today's environmental problems together, for built areas, green concept can be evaluated as an attempt for providing a transformative approach towards ecologic sustainability. Today, conventional design practices, technologies, and systems -*brown practices* are criticized for being unsustainable in many ways by leading to contamination of water and soil, natural source dependency, and also pressure for vegetation and cultural space through using fossil resources (Ryn & Cowan, 2007). Lehmann (2010) states in his book "*The Principles of Green Urbanism: Transforming the City for Sustainability*" that, "we need to rethink the city itself, including the criterion for energy use, waste, food and water consumption."(p.68) However, as aforementioned, similar to weak(modern) sustainability continuum, there are some threats related green concept that can blur the difference between green and brown in built areas, such as remaining technology-oriented and being not sufficiently comprehensive.

Sustainability requires understanding the interactions as well as efficiency & conservation. Yeang (2012) asserts that design should be like prosthesis, which is integrated with nature. Guallart (2003) also implies that to perceive nature as wisdom and inspiration and make a qualitative intervention to it as possible have great value for efficiency.

In the built areas, insufficient consideration given native practices results in inefficient homeo places. On the other hand, green-eco design principles give priority to nature and native characteristics of place such as climatic, ecological, cultural, and economic rather than produce generic designs. The eco-design process starts with the observation of nature and understanding its elements, then it is possible to use geographical knowledge-native parameters in order to get passive energy and integrate tools with nature (Guallart, 2003). Moreover, eco-design principles imply the significance of the harmony in working principles of the system at different scales. In this sense, the concept also gives significance to the integration of multidisciplinary knowledge, and multi-scale perspectives.

Therefore, different spatial scales and relationships within the built environment are meaningful to consider for green design. At this point, universities have many strengths to further the green concept for the built areas by recognizing the significance of green design elements.

The goal of minimizing energy loss or known otherwise as energy efficiency can be included in all levels of design not only the building scale as mentioned earlier. Thus, several parameters pertaining to certain design scales are the criteria for the energy efficiency of campuses. Design levels considered in this study based on their presence in university campuses are the building scale, building modules, and campus scale.

Parameters to be observed in each scale will be explained explicitly in the following subsections.

3.2.3. Energy & Built Environment

The expectation related built environment is that it functions as a comfort provider for a variety of human needs through considering efficiency issues (Mclennan, 2004). This can be possible firstly by understanding the relationship between human needs and built environment, and natural elements.

''Energy'', comes from Greek ''ergon'' means ''work''. Other acceptances for the description of the word ''power actively and efficiently exerted'' and ''ability or capacity to produce and effect''. Energy is a must for the continuity of life, always maintains its significance for our lives. Energy had been used on purpose by our ancestors as 'ambient energy'-energy which already exists to use. Their energy technologies were clothing and shelter. Clothing reduces the loss of energy from the body and shelter enclosed space and reduces the energy flows. However, with the energy technologies evolves in time, namely controlling fire, burning fuel, the basic idea of using ambient energy has been forgotten.

People have sought energy efficiency for their shelter firstly through understanding the natural elements both they resist for and benefit from. Accordingly, the knowledge upon the relationship between natural elements and the built environment has evolved. Using the accrued knowledge and practical experience related to these relationships is the first step to be green. Therefore, campuses need to seek and assess these relationships within the campus environment starting from the early stages of interaction.

3.2.4. Spatial Energy Efficiency Variables at Multi-Scale

Search for a better understanding of energy efficiency strategies requires to consider the interaction between the spatial variables and energy. According to Ownes (1986), different aspects of spatial organization are significant at different scales considering energy efficiency. Therefore, the policies and strategies at different scales related to land use planning and built form determine the levels of energy consumption significantly. The following table is adapted into the study from her book '*Energy, Planning & Urban Form*'. The structural variables at different scales beginning from the individual settlement scale to the building scale in regard to the efficiency issue are determined in Owens' work as ''the size of settlement, shape of settlement, communications network within settlement (radial, grid, etc.), density, the interspersion of land uses, degree of centralization of facilities, layout orientation (of building or group of buildings), sitting and design'' (Owens, 1986: p.5).

Table 3.6. *Structural Variables at Different Scales from the Building Scale to Individual Settlemen*[11]*t* *(Source: Owens, 1986)*

Structural Variable	**Scale**	**Author's Conceptualization of Owens' Study for Campuses**
Size of Settlement	Individual settlement Scale	Campus Scale
Shape of settlement		
Communications network within settlement (radial, grid, etc.) Density		
The interspersion of land uses		
Degree of centralization of facilities		
Layout	Neighborhood Scale	Building Group Scale
Orientation (of building or group of buildings)		
Sitting	Building Scale	Building Scale
Design		

Similarly, universities also can adopt these structural variables at different scales for any construction or development plan to increase campus energy efficiency as interpreted in the table. The following subsections will present criteria related to these structural variables by focusing two spatial aspects of campuses: campus climate and transportation.

[11] Owen's work on 'Structural Variables at Different Scales from the Building Scale to Individual Settlement' was advanced and reproduced by the author.

3.2.4.1. Campus Climate Contribution to the Energy Transition

The climate elements namely radiation, temperature, wind, and pressure can change with different climatic factors as latitude, landform, and vegetation. Thus, Macro - Meso - Micro climates forms.

Macro climate typically occurs due to geographic location and characteristics of mountains.

Meso climate also called the *biotope* climate is a climate shaped with geomorphologic assets, latitude, and water and forest elements inside a macroclimate area.

Micro climate also called an *Eco Climate* represents the climate closest to the ground. This scale is affected by water elements, vegetation, relationship with direct sunlight and wind direction. Energy efficiency in built environment particularly concerned with the macro and micro climate.

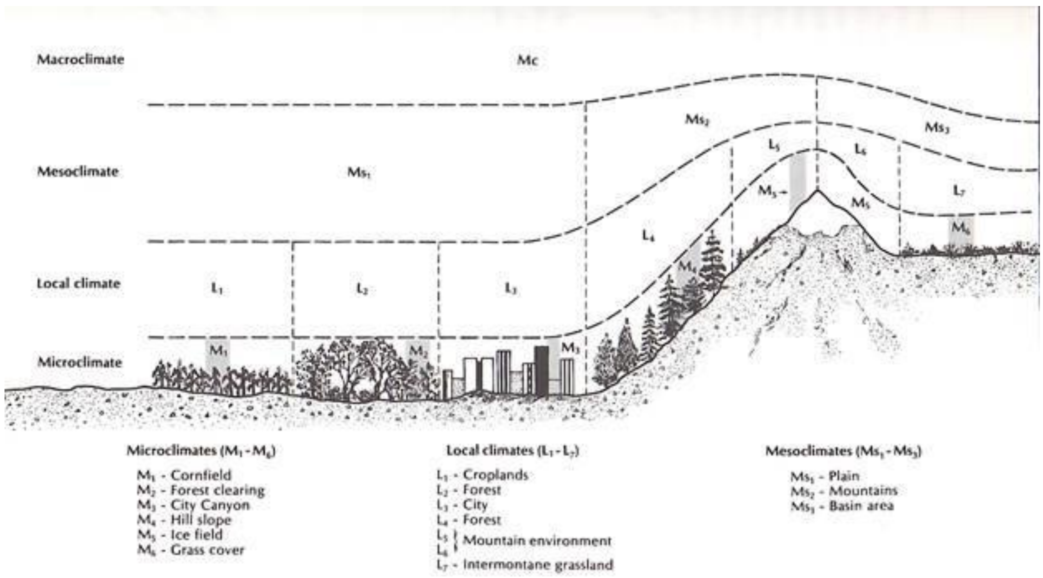

Figure 3.2. Area Scales of Climatic Investigation, (Source: Oliver and Hidore, p.163)

The related climate assets are radiation, temperature, humidity and wind (Olgyay, 1963). Built areas can benefit from these assets of micro and macro climate not only by using active technologies but also by using passive design technics: daylighting, ventilation; or passive technologies: shading devices for decreasing summer heat, solar chimney for increasing natural ventilation insulation materials and phase-change materials for slowing indoor air temperature exchange, and so on (Altan et. al., 2016: 210). Therefore, there is also a need for turning basic ideas systematically to be green through searching for the correct usage of these relationships, and also recognize these relationships at the early stage of construction.

The relationships between these assets and built environments can be sought in different scales for energy efficiency. The phase of the design of building, sitting and orientation can provide a profound effect upon energy efficiency. In building scale, building material selection and appropriate landscape material usage are other important components of this relationship in building scale. Additionally, in the campus, similar to the neighborhood scale, these relationships also affect energy efficiency in building group scale. Therefore, some parameters also can be recognized and sought in the building configuration scale and they can guide the constructions in campuses.

Through correct usage of these relationships, the following issues can be optimized to reduce energy demand in campuses;

- Reduced heat loss from the buildings' indoors during winter
- Minimization of heat taken indoors during summer
- Shading of outdoor public spaces in summer
- Provision of ventilation via climate-sensitive configurations of both outdoor public spaces and indoor spaces

A plethora of researches has been carried out to set forth these relationships from the building scale to the urban settlement scale within urban literature and some important parameters have been developed. Some of the most important contributions to assess energy efficiency in the urban settlement area in the table given below.

Table 3.7. *Energy Efficiency in Urban Scale, (Source: Kang Ko, 2012)*

Author	Year	Focus	Note/Contribution
Olgyay	1963	Principles of bioclimatic approach to building design and site planning.	Seminal academic study in architectural regionalism.
McClenon & Robinette (American Society of Landscape Architects Foundation)	1977	Comprehensive instructions for energy conserving site selection and planning focusing on landscape planting	Emphasis on natural factors (e. g. landform) in energy-conserving site planning with case studies, Good bibliography by topics.
Erley & Jaffe (American Planning Association)	1979	Site planning guidebook focusing on solar access.	One of a three-part series of consultant reports regarding solar access to US HUD and DOE.
Knowles	1981	Architectural and urban design applications using "solar envelop".	Seminal study that introduces the concept of solar envelops; extended work from Knowels and Berry (1980).
Owens	1986	The association between building energy performance and urban form within a larger framework of energy efficient spatial structure.	Seminal book on energy integrated urban and regional planning.
Littlefair et al. (BRE)	2000	Site layout design and planning utilizing solar access, microclimate and passive cooling.	The seminal book on climatic site layout planning; lots of examples from research.
Krishan et al.	2001	Design handbook for climatic building design.	Mostly building oriented but the great illustration on

Urban literature related to energy efficiency can also serve the energy efficiency issue in campuses. However, the CSA tools do not have any criteria questioning these relations. Whereas to set criteria for this relationship in different campuses right now, The considerations held by the universities related this criteria can be evaluated in CSA tools.

Following climatic factors can be expected to take into consideration at a different scale in the campus as follows:

Table 3.8. *Climate & Energy Efficiency Criteria*

Climate & Energy Efficiency	Criteria
Building Scale	• Adequate guidance on following issues -Initial Design -Orientation -Landscape Material Usage -Building Material Selection -Active Technologies -Passive Technologies
Building Group	• Adequate guidance on following issues -Configuration -Orientation

Additionally, it is important to make research for green energy usage at the campus scale. As presented in chapter 4, The CSA tools predominantly focus renewable energy and technology usage within the energy category. This criterion can be evaluated as a campus-scale criteria. However, institutions can have various obstacles or considerations related this issue. Therefore, it is also significant to evaluate the approach the university held related this criterion by questioning the efforts to understand the pros and cons. In this respect following criteria can also be added the energy criteria of CSA tools at campus scale.

Table 3.9. *Renewable Energy Criteria*

Campus Scale	• Renewable energy production • Research for the technology investment • Waste to energy option

3.2.4.2. Land Use Planning Contribution to the Energy Transition

Land use decisions that are more conducive to use non-motorized transportation or are required travel less may have a high contribution to reducing transport energy requirements within campuses. Although with policies and strategies universities try to decrease the travel demand, the demand is also highly related to functional and formal considerations in land use at different scales.

The CSA tools assess the transportation issue as a different category from energy. The criteria related to this part mainly concern with the existence of car decreasing strategies. However travel issue directly linked with the energy efficiency in campus and predominantly related with land use planning.

According to Owens (1986) relevant land-use variables with transportation energy demand are ‘‘size and shape of communication network’’, ‘‘density and development’’, and ‘‘interspersion of different activities’’. A campus also can make land-use arrangements considering these variables and set development strategies accordingly to reduce on-campus travel energy demand.

The lower physical separation means the lower travel needs within campus like cities; however, as well as compact development, optimizing the functional organization of activities is significant. In this respect, the travel distance between the facilities, and organizations of connected functions within campus also mainly determine the transportation demand. Therefore, both in the initial settlement phase of campus and in the development phase, these factors can be evaluated as significant energy efficiency criteria.

Although mainly with the policies and strategies universities try to decrease their travel demand, it is also highly related above mentioned green design considerations. Fogg brings another perception to the issue by introducing persuasive design. As Fogg states 'persuasive design' '–an actual interaction with the product changes the behavior'. Therefore, functional and formal considerations in land use can make an energy-efficient choice more convenient for the users of campus comparing to the policies.

Therefore, limiting the expansion of the campus by compact development, giving priority to the proximity of connected functions, providing 'effective integration at a smaller geographic scale' by the interspersion of campus activities, providing a campus core, and providing the continuation in public places are significant considerations to decrease travel related energy demand in campuses.

Land-use factors and supporting activities can be taken into consideration at campus-scale in the CSA tools as follows:

Table 3.10. *Land Use & Energy Efficiency*

Land Use & Energy Efficiency	Criteria
Campus Scale	• Land use decision mechanism • Limiting expansion • Infill development • The proximity of connected functions • Continuation of public places, pedestrian-friendly core • Interspersion of different activities
Supporting Strategies	• Well connected travel modes • Bicycle route, parking, integration with the city (integrated with city or not) • Rings and their operation planning • Carless zone , other strategies for the seek of decrease in number of car

3.3. Concluding Remarks

This chapter firstly examines the organizational aspects of university campuses at ‘transformative level’, and secondly studies the multi-scale spatial energy criteria on the campuses to constitute a comprehensive and systematic energy criteria tool. As studied in chapter 2, one of the main referred problems in the literature on the CSA tools are ‘lack of appropriate indicators to underpin local aspects’, and ‘greenwashing attitude’. In this chapter, the criteria are aimed to be collected and systemized to response these problems and to fill the gap in the energy criteria of the CSA tools. Another objective of the chapter, to present criteria with a new systematic perspective to have more comprehensive approach on energy criteria of ‘green campus’. The main problems that the chapter aimed to response, and the approach employed in this chapter can be summarized as in the Following image.

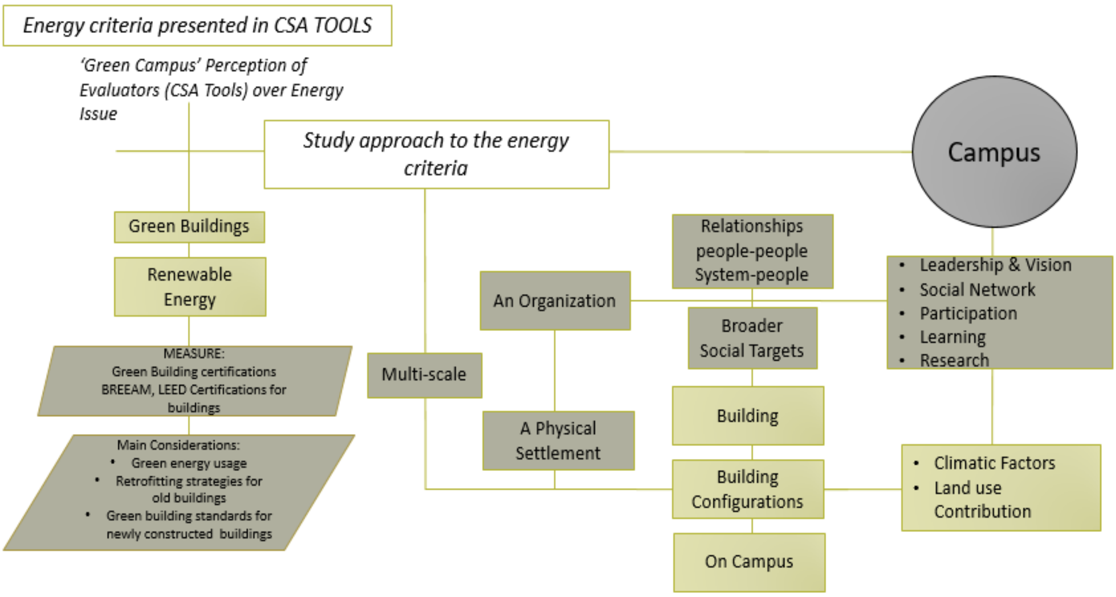

Figure 3.3. Author's Conceptualization

The following chapter tests the approach and the designated criteria tool presented in this chapter by employing case study method. In this regard, the METU Campus is evaluated with each criteria determined and systemized in the Chapter 4.

CHAPTER 4

A MULTI-SCALE ENERGY EFFICIENCY EVALUATION: METU CAMPUS

This chapter aims to evaluate the Middle East Technical University (METU) Campus with the designated multi-scale energy efficiency evaluation tool. The chapter also presents gathered insights on the organizational and spatial energy criteria.

4.1. The METU Campus

The motto of METU is ‘‘*we can change the world*’’. This stated mission can be achieved with a change in ourselves, and therefore, it should be observed within the campus environment at first. Therefore, the METU Campus itself is expected to be avant-garde with its green campus operations, as well as engaging in research and practices which are at the forefront of addressing green technology and solutions.

As an urban university, the METU Campus also is a part of the city Ankara and has strong economic, social, and spatial relationships with the surrounding urban environment. In this sense, it is also significant to commit to be greener campus to serve the sustainability of city Ankara.

The METU campus is settled on 20thkm Ankara-Eskişehir highway with its 1,545,000m2 campus area as one of the first university campuses of Turkey (MSGK, 2016). Recently, the campus serves approximately 30.000 people including working people within Technopolis and provides accommodation about 7000 people within the campus. With its large number of users, mixed land uses, and urban campus character, the METU Campus is an example of a small-scale urban system.

The METU Campus Plan was made by Altuğ and Behruz Çinici in 1961. Altuğ and Behruz Çinici states the main considerations regarding the plan of the METU Campus as "*to create a university city which has contributions on both the planning field in Turkey and the communal life"*(Çinici, 1964).

Figure 4.1. The METU Campus, Initial settlement (Source: Arkiv, nd)

The campus was established on steppe land in the urban area. At the initial phase of establishment, 75% of the land was made afforestation in order to prevent erosion (ACDM, 2012). With the afforestation project, the campus also served the greenness of the city of Ankara through creating a large green area and rich ecosystem within the city.

In the year 1959, the sample parcel was selected by the joint work of Forestry Society and METU in order to conduct trials and then, forestation campaign was initiated. As a result of these efforts, the METU Campus has become the largest green part of Ankara.

In 1995, the Ministry of Culture of Turkey started to preserve the METU forestry as a Natural and Archaeological site. The METU Campus Afforestation Project also won the International Aga Khan Architecture award in the ''innovative concepts category'' because of the added values it has created. Also, the project awarded by the Tema Foundation in the year of 2003. The Tema Foundation states that ‘‘the project proves that it is possible to cure today’s important environmental problems by sensitive urban planning’’ to stress the significance of the project (Tema, 2003).

The project succeeds in being a culture for the university. Until today, approximately 33 million trees resistant to dry conditions have been gained to the campus and the city (ACDM, 2012). UNEP also presents the project as a global exemplar in several thematic areas: ‘climate change’, ‘ecosystem management’, ‘environmental governance’, ‘resource efficiency’ (UNEP, 2013).

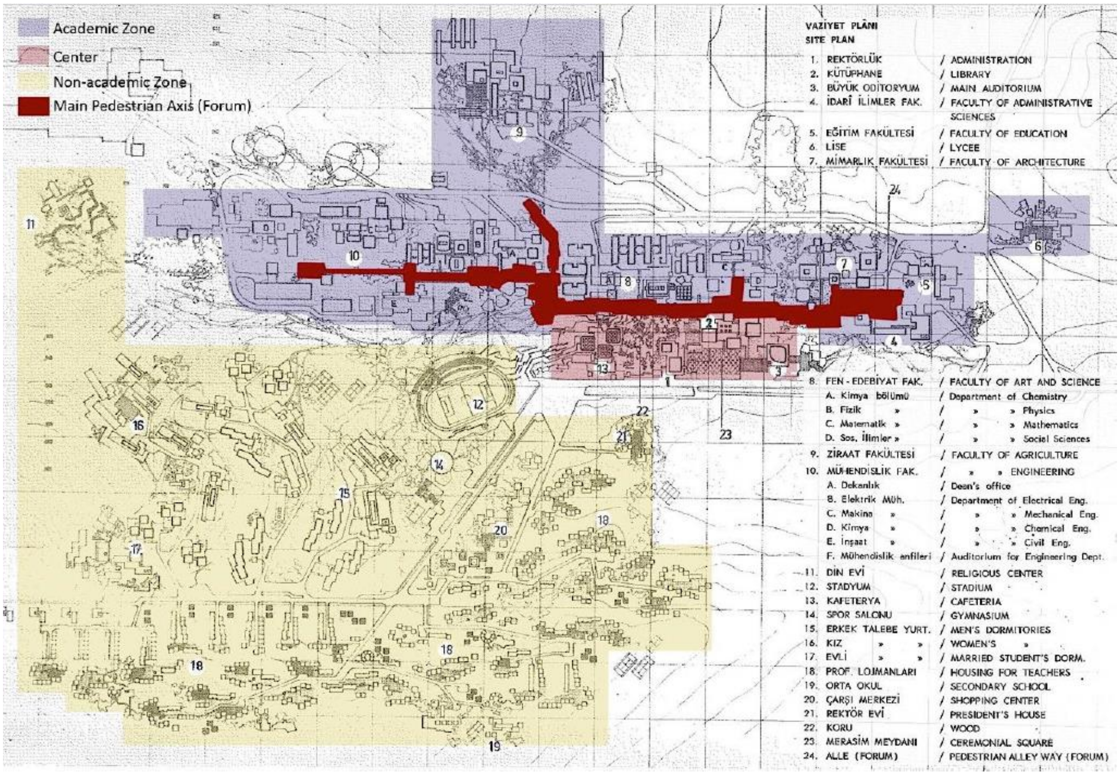

Figure 4.2. Altuğ-Behruz Çinici Plan (1961) (Source: Çinici, 1964)

In 1961, the Altuğ-Behruz Çinici Plan was selected to implement by competition. From that time, all the buildings constructed within the campus have also been selected with competitions. The METU Campus has a core campus area. The Altuğ-

Behruz Çinici Plan divided the core campus area into three parts according to their functions as follows: center, academic zone and nonacademic zone.

Campus-scale green campus approaches considered in the Çinici Plan can be summarized as in the following table.

Table 4.1. *Campus Scale Green Campus Approaches Considered in the Çinici Plan (Source: Çinici, 1964; ACDM, 2012; MSGK, 2016)*

Campus Scale Green Campus Approaches Considered in the Çinici Plan
The METU Campus was designed by giving significance to the pedestrian access on campus. The time for the longest pedestrian circulation was proposed as 20 minutes in Çinici Plan
The academic zone is proposed as a car-free areas
Strict separation of vehicular and pedestrian traffic was proposed
The academic zone is designed on a spine which aims to create a micro-climate with the supported micro-climatic elements
Plantation Campaign was realized & adopted by the organization (Non irrigational plantation 3100 hectares/ Irrigational Plantation 30 Hectares 8,700,000 Conifers, 24,550,000 Deciduous trees)

Currently, METU has not any specific material guiding sustainable campus operations. Two documents 'Spatial Strategy and Design Booklet' and 'METU 2018-2022 Strategic Plan Booklet' can be applied to gather data related to current green operations, strategies, and targets. The information mentioned within these booklets can be summarized as follows:

- Considering the construction process with natural elements
- Development of recommendations to minimize CO2 emissions
- Considering the ecosystem as a whole within and outside the campus and repair the missing connections

- Developing alternative energy usage technics
- Afforestation of hard ground which has low usage level

These targets can be evaluated as generic targets. They need to be filled up with strategies and implementations. At this point, as an initial step, it is significant to set these strategies and also reveal organizational perceptions, strengths, weaknesses, opportunities and threats for the METU towards to be source efficient campus.

In this sense, the following section firstly evaluates the METU Campus with the generated energy efficiency evaluation tool and secondly, it presents insights related the university performance for each criteria.

4.2. Data Collection

1.1.1. Research Tools

Shriberg (2002) examined eleven different CSA's and offered some suggestions for an 'ideal CSA'. According to his study, an ideal CSA able to ''identify important issues, measure processes and motivations, and stress comprehensibility'' (Shriberg, 2002: p.262). To reveal significant issues on the METU Campus, processes, organizational perception differences, the research applies semi-structured interviews as well as the review of the data in the related documents the university has.

The internal and external documents: *The METU Strategy Plan*s, *the METU Campus Spatial Strategy and Design Booklet*, *The Directore of Building and Technical Works Strategy Plan*, *The Directore of Building and Technical Works Budget Plan,* the energy usage data of the campus, the building specifications, the university webpage, and the published studies related to the sustainability of the METU Campus are reviewed throughout the research. To complement the data obtained from the above-mentioned documents, and gain more insight individual interviews with different stakeholders of the university are conducted.

A number of semi-structured interviews are made to obtain focused, qualitative data from the different stakeholders of the METU Campus. The interviews consist both open-ended and closed questions to enable to generate in-depth data. These questions are grouped thematically in order to uncover the descriptive data and obtain more specific insights. More specifically, it is aimed to reveal different organizational perspectives holding by the stakeholders, the governance of the decision making processes and the amount of organizational awareness related to the issue with the semi-structured interviews. To this end, the following stakeholders of the university are involved in the research.

Table 4.2. *University Stakeholders involving the Research*

<table>
<tr><th colspan="2">STAKEHOLDERS</th><th>NUMBER OF INTERVIEWEES</th></tr>
<tr><td colspan="2">University Administration</td><td>2 (an ex-vice president, an advisor to the president)</td></tr>
<tr><td rowspan="5">The Directore of Construction and Technical Works</td><td>Campus Spatial Planning Office</td><td>2 employees</td></tr>
<tr><td>METU Construction and Technical Works</td><td>3 employees</td></tr>
<tr><td>University Spatial Planning Commission</td><td>3 member</td></tr>
<tr><td>METU Electricity Works</td><td>2 employees</td></tr>
<tr><td>METU Gas and Water Works</td><td>2 employees</td></tr>
<tr><td colspan="2">Student Societies, University Platforms Engaging with Energy Efficiency, Green Energy and Sustainability Issues</td><td>3 members (ADIM ODTÜ, Green Campus Student Society)</td></tr>
</table>

Potential stakeholders are firstly determined according to their organizational positions and their level of involvement with energy efficiency and green campus initiatives. The list of interviewees extended based on the referrals provided by the first interviewees.

Seven main themes prepared based on the literature review before the interviews. These themes were covered during the semi-constructed interviews considering the knowledge and the area of expertise of interviewees. These themes are determined as energy consumption of the campus, organizational process related to any new development and refurbishment, organizational planning and sustainability leadership, communication, measuring and reporting, study and research, and spatial energy efficiency strategies at different scales.

The obtained data and the gathering method in this part of the research is thematically summarized within the following table:

Table 4.3. *Research Themes & Data Resource*

RESEARCH THEME	INTERVIEWEES	DOCUMENTS
Energy Consumption of the Campus (consumption data, spotted problems)	Directorate of Construction & Technical Works	The Excel documents of monthly and yearly heat and electricity consumption of the campus
Organizational Process related any New Development and Refurbishment (the governance of decision-making processes, decision control systems)	Directorate of Construction & Technical Works University Administration	
Organizational Planning, Sustainability Leadership (Current situation, future plans, insights)	Green Campus Student Society, The Directorate of Construction & Technical Works, University Administration	METU Strategic Plan 2018-2022 Booklet
Communication, Outreach& Collaboration (University communication channels on related issues, collaborations, related future plans and insights)	University Administration Green Campus Student Society	Social media, METU webpage, University Communication Boards
Measuring & Reporting	Green Campus Student Society, The Directorate of Construction & Technical Works	UI Green Metrics Data provided by the university
Study & Research (conducted research, curricula, campus as a learning hub, campus as an open lab)	University Administration	Syllabuses, University Library
Spatial Energy Efficiency & Green Energy Considerations (Current energy efficiency considerations at multi-scale, future plans, provided budget to increase campus greenness over energy issue, obstacles, and insights)	The Directorate of Construction & Technical Works	Campus maps, individual site assessments, The METU Spatial Strategy and Design Booklet, The Directore of Building and Technical Works Strategy Plan, The Directore of Building and Technical Works Budget Plan

Lastly, content analysis of the themed data was used to provide distill meaning. According to Berg content analysis is "a careful, detailed, systematic examination and interpretation of a particular body of material in an effort to identify patterns, themes, biases, and meanings (2007, p.303-304). In this study, the themed data was analyzed to identify major organizational and spatial energy efficiency considerations, factors, processes, future plans, and organizational perspective differences and thus, the organizational and multi-scale spatial weaknesses, strengths and opportunities of the campus upon energy issue.

4.3. Multi-Scale Energy Efficiency Evaluation of the METU Campus

This section evaluates the METU Campus with the designed criteria tool. The tool consists the evaluation categories and sub-categories, evaluation criteria, current performance of the university, future considerations, and the existence/ nonexistence of opportunities and threats for each criteria.

Table 4.4. *The Multi-scale CSA Assesment Criteria over Energy & the Evaluation of the Metu Campus Greenness over Energy*

Caregories/ Sub-Categories	**Evaluation Criteria**	**Current Performance**	**Future Considerations to Progress**	**Opport.**	**Threats**
Leadership& Vision					
Definition of Sustainability for the University	Defined / not Defined	Not Defined	Not Existed	x	
	Usual/Unique Definition	No	-		
	Defined as a mision/not	Not	-		
Level of Sustainability Leadership	Sustainability Office/ Committee	No	Not Existed		
	Duties of the Sustainability team	Not Existed	-		
	Administration / Transactional/ Transformational Leadership	Administ.	Not Existed		

	Sufficient Funding for Efficiency Strategies or Operations	No	Not Existed	x	
Sustainability Goals	Determined/not Determined	Existed but not specific	-	x	
	Measurable/ not	Not	Not Existed		
	The Evaluation of Outputs comparing the Strategic Goals	Yes	Existed		
Tracking	Data gathering to Track Progress	Partly	-		
	Applied CSA Tools	Green Metric	Existed	x	x
Sustainability Reporting	Feedback Mechanism & Tools	Not Existed	Not Existed		
Social Network					
Partnerships	Governmental/Corporate/ Community Partnerships /Student & staff	Existed in each level but not strong as expected	Existed	x	x
Networks	Information Network/ Knowledge Network/ Innovation Network	Mostly at information network level	-	x	
Evaluation of the Perceptions related Efficiency Strategies within the Organization	Surveys Existed/not Existed	Not Existed	Not Existed		
	Internal Perceptions Successful/ Unsuccessful, Central/ Fringe	-	-		

Participation					
Engagement	Opportunities and Capabilities for Decision Influencing & Knowledge Sharing	Existed	Not Existed		
Communication Channels	Use of Communication Tools for Enhancing Engagement & Knowledge Building Capability	No	Not Existed	x	
	Open Data belonging Campus Environmental Impact & Consumptions	No	Not Existed		x
Feedback Mechanism	Existed / not	Existed	-		
	Strong / Weak	Weak	Not Existed	x	x
Learning					
Education	Curriculum: Sustainability related Courses	Existed	Existed		
	Publications	Existed	Not Existed		
	Single loop/ Double loop/ Deutro learning	Limited	-		
Events on 'Green Campus'	Existed / not	Existed	-	x	x
	Support of the University	Limited	Not Existed		
Student Societies interested with campus greenness /efficiency issues	Existed / not	Existed	-	x	
	Support of the University	Not Existed	Not Existed		

Sustainability Research	Disciplinary/ Interdisciplinary/ Transdisciplinary	Existed but generally disciplinary		x	
	Research Fund	Not Existed	Not Existed		
Building Scale					
Existed Efficiency Considerations & Guidelines for Each Criteria	Design	Limited Not Specified	Not Existed	x	
	Orientation	Not Existed	Not Existed		
	Landscape Material Usage	Partly Existed	Not Existed		
	Building Material Selection	Partly Existed	Not Existed		
	Active Technology Usage	Not Existed	Existed		x
	Passive Technology Usage	Partly Existed	Existed		x
Building Configuration Scale					
Existed Efficiency Considerations & Guidelines for Each Criteria	Configuration	Not Existed	Not Existed		x
	Orientation	Not Existed	Not Existed		x
	Landscape Material Usage	Partly Existed	Not Existed		
Campus Scale					
Learning Campus	Learning by Experience / Campus Culture	Existed but Limited	Not Existed	x	
Living Laboratory	Carried out Studies within the Campus to Serve Sustainability Practice & Research	Not Existed	Not Existed	x	
Land Use	Land Use Decision Mechanism	Existed but			x

	Limiting Expansion	Existed	Not Existed		x
	Infill development	Existed	Existed		x
	The proximity of connected functions	Mainly Adopted as a Strategy but Has Limitations	Not Existed		x
	Interspersion of different activities	Existed	Not Existed		x
	Continuation of Public Places, Pedestrian-Friendly Core	Existed	Existed		
Supporting Strategies to Decrease Transportation Energy Demand on Campus	Well Connected Travel Modes with City	Existed	Existed		
	Bicycle Route & Parking, Integration of the bycle Road with City	Partly Existed	Existed	x	
	Rings and their Operation planning	Existed	Existed	x	
	Other Strategies for the seek of Decrease in the Amount of Car Usage	Existed	Existed		x
Alternative Energy	Renewable energy	Not Existed	Existed		x
	Research for Renewable Energy Investment	Evaluated	Existed		
	Waste to energy option	Not Evaluated	Not Existed		

4.4. Insights related to the Energy Transition on the METU Campus

In this research, during the interview and data analysis process, it is aimed to identify significant issues; reveal organizational viewpoints, processes, and future plans as well as the criteria performance. In this respect, the following sub-sections present collected insights for each criteria during the research.

4.4.1. The METU Campus towards Energy Transition as an Organization

4.4.1.1. Leadership & Vision

Following insights on the criteria of 'Leadership & Vision' category was gained throughout the research.

The definition of sustainability for the university is not clearly mentioned in any published documents or the website of the university. The mission and vision of the METU highlight the transformative role of the university. However, they do not specifically refer source-efficiency or sustainability.

Currently, the university has not a campus sustainability office or a sustainability committee within the organization. Also, the university has not generated any sustainability plan for the campus. The conducted interviews with the university administration and the METU Green Campus Society members reveal that to have a campus sustainability office or prepare a sustainability plan for the university currently are not in the agenda. On the other hand, the conducted interviews with the societies draws that there is a high level of interest by the students of these societies to contribute any process related to a preparation of sustainability plan or a sustainability commissions initiative. These mentioned issues are the initial steps to have a transformative level change on the campus.

During the conducted interviews with the university administration and the employees of the Directore of Construction & Technical Work, it is observed that not enough motivation and intellectual stimulation are hold by the university employee toward efficiency and sustainability issues. At this point, the level of sustainability stewardship of the university administration has pivotal role. The administration of the METU needs to show transactional and more significantly transformational leadership to initiate the perceptional change within the organization.

Sustainability goals of the university are determined within the Spatial Strategy and Design Booklet and METU 2018-2022 Strategic Plan Booklet. However, they are not specific targets or goals. Therefore, the diffusion of the targets into the unit strategic plan cannot be optimized.

The funding allocated for the sustainability research and sustainable campus operations can be evaluated as very insufficient. The strategic plan of the university consists directly referring objectives within. The plan stresses that the practices on campus do not represent sufficiently sustainability concept. The plan also presents needed collaborations and allocated budget to ‘‘provide campus needs and functions in a sustainable, smart and durable manner’’ (The METU SP 2018-2022, 2017: p.131). The objectives determinated within the plan are monitored and revised with 6 months cycles. However, the interview conducted with the administration provides some insights related the issue. Since there is not specific determination of needs for sustainable operations in the budget plan, maintenance issues are generally given significance in the unit strategic plans.

Another problem related to the determined sustainability goals, the university does not set any measurable goal on the campus sustainability. This criteria is also an initial consideration to have a transformative change. The environmental footprint of the university, released emissions by the university, energy consumption amount, number of car entrance; all can be monitored and a specific amount of decrease can be determined as target. Also, needed feedback mechanisms and tools are required to set for sustainability reporting.

Currently, the data to track progress sustainability issues on the campus partly exist. The data related to the car entrance amount, the total amount of electricity and gas consumption of the buildings are monitored by the related units. However, they are not enough to track the progress. According to the data provided by the university administration, calculations for some buildings on their emissions release have been made recently. Also, several student studies attempted to calculate campus environmental footprint and car emission release on the campus exist. Still, these attempts are needed to be evaluated in a comprehensive manner by the university administration.

The university applied Green Metric Ranking tool to be evaluated and ranked in the year 2018. It was initiated by the METU Green Campus Society. The necessary data for the tool collected by the student's efforts. According to the METU Green Campus Society members, the idea was adopted by the administration, and the needed data were made available to the society members when needed. However, in the interviews, the society members also signify the problems that they faced during the process. According to the society members, since a sustainability office does not exist in the university, to collect direct and clear information for the criteria of the CSA tool was not easy. Lack of availability and accessibility of the data within the organization made the data gathering process harder for them.

4.4.1.2. Social Network

Following insights on the criteria of 'Social Network' category was gained throughout the research.

The partnerships of the university on the sustainability issues existed for each level. Governmental, corporate, community, student and staff partnerships are observed during the research. For instance, there is a planned partnership with municipality to build bicycle connection between the city and the METU Campus. Also, the university has a Technopark within the campus area and sustainability related researches are conducted with the partnership of the university in the Technopark. However, the partnerships with Technopark upon the METU Campus sustainability or the energy transition are not strong as expected. The interviews conducted with administration and the spatial planning office employee prove this situation in many ways. Based on these interviews, the technology or ideas produced within the companies on the Technopark area are not generally transferred into the campus environment. Also, the university has several community & student collaborations for the sustainability activities. However, it is again observed that these activities are not initiated with administrative efforts; rather, they are the part of funded projects or student clubs activities.

In terms of the knowledge network within the university, it can be say that the network remains at an 'information network' level. During the interviews, it is observed that the ideas to increase efficiency cannot be discussed effectively within the organization or not be delivered properly to the managerial part. On the other hand, with a 'transformative' perspective, it is expected that the network both enable to create knowledge and innovation beyond an information flow in universities.

4.4.1.3. Participation

Following insights on the criteria of Participation' category was gained throughout the research.

Considering the level of organizational engagement, in the METU, several mechanisms exist. Even if there is not a sustainability commission in the METU, the Commissions within the units have the potential to discuss the campus operations and energy transition strategies. On the other hand, the knowledge building capability in these commissions can be evaluated as limited in some ways. The commissions are constituted with the employee of the same unit and administrative stuff at high level. Therefore, the involvement of different stakeholders such as students into the decision process is also necessary to encourage engagement and knowledge building capability within the organization.

Another criteria to increase the participation to the energy transition of METU Campus or any process related to the sustainability of campus are to use the communication tools effectively and having open Data on the campus environmental impact. Many universities which are committed to be ‘green campus’ have sustainability webpage and social media accounts as well as promotional activities within the campus to increase engagement. On the other hand, in the case of the METU, the university does not have a sustainability website or any social media account that fostering the engagement of employees and the students with the campus sustainability, and knowledge building.

These mentioned issues also make weaker the feedback mechanisms within the university. Having open and easily accessible data for the all members of the university as possible can contribute significantly to the transformative processes on the campus.

4.4.1.4. Learning

Following insights on the criteria of learning category was gained throughout the research.

The METU has curriculum consisting courses involving directly and indirectly sustainability issue. These courses or sustainability related studies published by the university are available via the METU website. However, the data is only achievable with search. Currently, related studies published by the METU members and the sustainability related courses in the curriculum are tried to gather by the Green Campus Study Society on their website[12].

[12] The website lists 15 courses directly and indirectly related with the sustainability education and the published theses on the sustainability of the METU Campus by the METU students until now.

When ‘the learning capacity of the organization’ evaluated in the METU, it can be concluded from the gathered data that the curriculum and existing sustainability cultures within the organization affect the organizational learning positively. However; the university does not have any organizational change for the seek of supporting sustainability learning within the campus as aforementioned. Thus, ‘the change within changelessness’ decreases the learning capacity on the campus.

According to the data gathered from the interviews with the administration, in terms of sustainability research, mainly externally funded projects exist and the university administration follows closely these researches. However, mentioned projects during the interviews which consists of ‘smart campus’ and ‘green campus’ approaches are conducted at a disciplinary level. In this respect, the university is required to support interdisciplinary and transdisciplinary researches on these issues.

4.4.2. The METU Campus towards Energy Transition as a Physical Settlement

4.4.2.1. Building Scale

Following insights on the building scale energy criteria was gained throughout the research.

On the METU Campus, all building projects are selected with competitions. However, the specifications do not give priority efficiency issue in a detailed way. The design and orientation of the buildings, building material selection, the relationship between the planned building and material selection are specified very limitedly in the competition specifications. Therefore, the other pressures such as morphological conditions or limited area remained within the campus for construction lead the construction process rather than the efficiency considerations from the initial stage of the projects. Also, with the aim of protecting the identity of the campus, or decreasing initial construction expense material selection process generally leads without energy efficiency considerations.

University also does not provide a guideline for energy efficiency in the construction processes. Many design tools can be advised to and requested to use by the construction firms for the optimization of energy efficiency on construction projects.

The university works for decreasing energy consumption of existing buildings on the campus. Some retrofitting considerations partly implemented on the existing buildings such as thermal insulation and changing old lamps with led technology. These strategies are regarded as significant attempts for the evaluation criteria of analyzed CSA tools in the study. However, in the case of the METU Campus, these issues need to be taken more comprehensive way at building scale.

Following charts represents electricity and gas consumption amount in the METU Campus for the years 2013-2018.

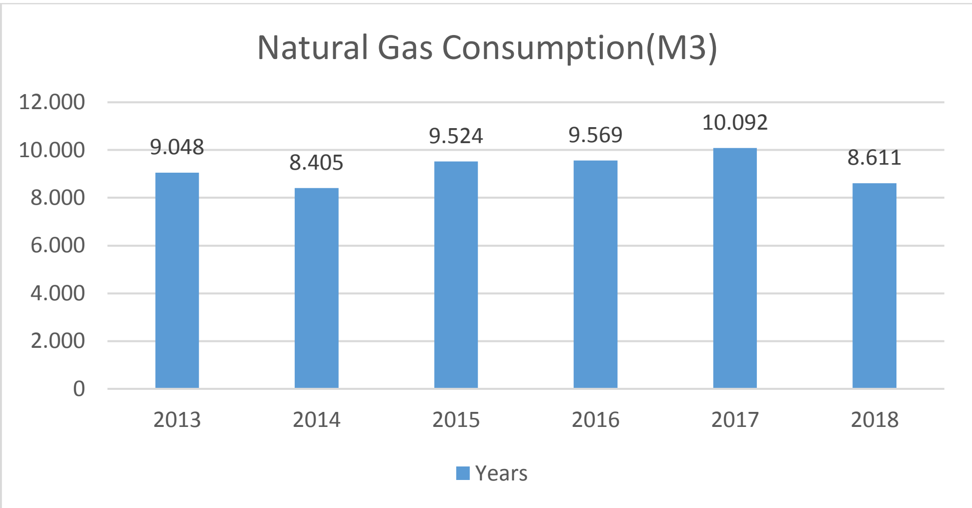

Figure 4.3. The Natural Gas Consumption of the Buildings on the METU Campus

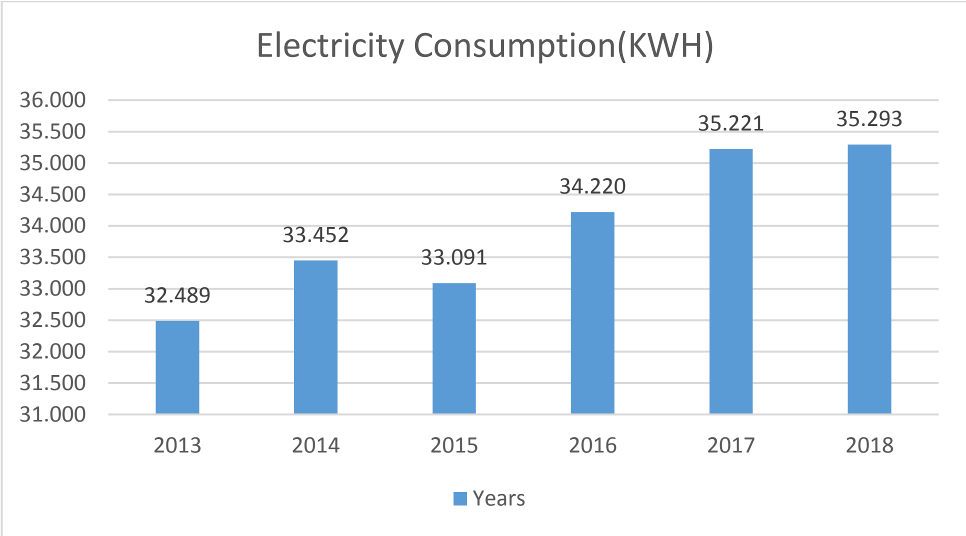

Figure 4.4. The Electricity Consumption of the Buildings on the METU Campus

As can be seen in the above charts, the total amount of electricity and gas consumption of the buildings on campus do not consistently decrease within the past five years. According to the interview conducted with the stuff of the METU Electricity Works and the METU Gas & Water Works, some steps for monitoring the contribution of the active or passive technology implemented in the campus buildings are needed. Since there is no 'share-mater' in the buildings, the contribution of the applied active or passive technology cannot be observed as well as consumption data of the individual buildings.

4.4.2.2. Building Configuration Scale

Following insights on the building configuration scale energy criteria was gained throughout the research.

In the generated tool, as Owen's suggests configuration, orientation and landscape material are also considered as efficiency criteria at building configuration scale. For the case of the METU Campus, the interviews and the university settlement plan show that for the main priorities are given to morphological issues in the configuration and orientation of the building groups on the METU Campus due to the initial construction expenses and also to the limited construction area remained within the campus.

On the other hand, the university does not have any guiding material to provide energy efficiency with natural assets of the campus, namely: with the campus climate and landscape material usage. In the initial settlement plan, in terms of landscape material usage on building configuration scale, some considerations exist to create outside microclimate such as usage of the water elements. However, as can be drawn from the interviews with the METU Spatial Planning Office, on the METU Campus, there are not direct considerations to increase the energy efficiency of building configuration with the appropriate usage of landscape material or the relationships between the climate and building configuration.

4.4.2.3. Campus Scale

On the campus scale, many criteria can be sought for the energy transitions of the campuses. The evaluated main criteria for the METU Campus in the generated criteria list are 'the educational role of the campus', 'land use', 'transport energy demand & alternative energy'. Following insights on these criteria was gained throughout the research.

In the case of METU, since the campus is an urban campus, the educational role of the campus is highly significant in broad sense. While this strong relationship makes easier to transfer successful green campus operations into the city, the campus also serves to the city as learning campus and living laboratory with its educational function.

In the METU, it is expected that sustainability learning also occurs outside of the classroom with experience and campus culture. Also, the studies are expected to be carried out on campus to make the campus a living laboratory for its users. However, in the METU, these approaches are not currently adopted as institutional strategies. Some sustainability activities are hold in the campus by the societies or funded projects, yet; they are not enough to use the potential of campus for education. Easily experienced green campus operations and curriculum integrated activities on campus pivotal to increase the sustainability learning of the campus users.

Another energy criteria on campus scale is 'land use', to evaluate this spatial criteria 'land use decision mechanism' in the organization, 'compact development' strategies and the efforts related to 'public space connection and continuation' are assessed as the sub-criteria on the METU Campus.

In the METU Campus, the METU Spatial Planning Office takes land use decisions and then, in the METU Spatial Commission, these decisions are discussed as needed. Therefore, it can be said that a land use decision mechanism is existed in the university. Moreover, it can be drawn from the conducted interviews with the METU Spatial Commission members and the METU Spatial Planning Office employees, limiting expansion, infill development, having short distance between connected functions, interspersion of different activities and continuation of public places are the existing strategies of the university in the land use decisions.

Nevertheless, in the interviews some limitations and future considerations on land use criteria were also revealed. The initial idea in the Çinici Plan was to build compact and walkable built area in the METU Campus. These approach has been consistently pursued within the following years. However, currently, some threats on this criteria exist. This consideration is not the priority for future development due to the limited area remained within the academic zone and the protected forest area. Similarly, the proximity of connected functions and the interspersion of different activities are existing considerations in the initial plan and the campus development. However, for future development, this consideration will not be the priority of administration and the spatial planning office due to the limited area remained within the academic zone for planned construction.

Another criteria can be applied in campus scale having ‘Supporting Strategies to Decrease Transportation Energy Demand on Campus’. The METU Campus has well connected travel modes with the city. Subway line and bus stops exist at the entrance of the Campus. Some employee of the spatial planning office are also the members of transportation planning commission of the university. This aspect of the commission is significant to have holistic approach on transportation strategies. For instance, a new entrance was opened in 2019 and rings are started to schedule from this entrance to strengthen the connection with the city.

The METU has its bicycle route plan partly implemented. Bicycle parking in different points on the campus and at the entrances of the university are existing. According to the interviews conducted with the administration, integration of the bicycle route with the city also planned with the collaboration of municipality. The METU has carless academic zone, the alle designed initially with the consideration of creating a carless student zone. Also, the university has satellite parking, and limited access policy to support public transport, walking and biking on campus. However, according to the administrative employee, the amount of car usage doesn’t show decrease on the campus. Therefore, for the university, it is significant to produce holistic strategies upon this issue.

Last criteria to consider on campus scale is alternative energy usage. This criteria is evaluated in the analyzed assessment tools with the renewable energy usage percentage on campus. However, to bring this issue into the university agenda and to evaluate the feasibility of technological investment are also significant criteria of the process. In the generated tool, this criteria were also evaluated with this approach. In the case of the METU, the university does not have any implementation for alternative energy usage on the campus. However, the feasibility research and cost analysis of the investment were made by spatial planning office. Currently, on this issue university does not have any progress due to the budget problem.

CHAPTER 5

CONCLUSION

Many aspects of university campuses are a scaled-down form of urban systems. University campuses consist of the components of cities and also show similar consumption and dispose patterns with cities. These aspects of the campuses make them ideal testbeds for the attempts related 'green' concept besides their education and research functions towards a sustainable future. However, as literature implies, there is a lack of consensus in green campus framework, and also a gap between theory and campus practices; therefore, there is a need for further study to increase effective practices in a systematic way.

The main obstacles highlighted in the literature towards 'truly sustainable campuses' are 'lack of sustainability initiatives', 'lack of sustainability reporting', and 'ineffective translation into practice' (Sonetti et al., 2016). The thesis focused on the 'ineffective translation into practice' class of the problem and attempted to present a new systematic perspective in regard to two stressed issues within this class in a broad sense: 1) 'lack of appropriate indicators to underpin local aspects', 2) 'greenwashing attitude'.

More specifically, the analyzed CSA tools within the study evaluate the energy transition on campus with the energy criteria working solely at building scale and with a technology-oriented approach. In this sense, the study aimed to have comprehensive and systematic energy evaluation criteria for campuses. With the aim of creating the capacity to reveal the organizational obstacles, potentials and physical phenomenon of university campuses, the study reviewed the literature by emphasizing two main aspects of university campuses: their organizational and spatial dimensions.

As methodology, the thesis aimed to systemize obtained criteria. Therefore, the study suggested a multi-scale approach for the systemization of the spatial criteria. On the other hand, as presented in the Chapter 2, campuses also have interrelated domains and the energy criteria can be also sought in different domains of the campus. To integrate the organizational criteria at a transformative level in the generated tool, the energy criteria were aimed to cover integrating domains of the campus.

To test the designated tool, case study method was applied in the research. The METU Campus greenness on energy was evaluated with the designed tool. The data collection for the METU Campus was made 2 main research tools: data analysis and depth interview. The interviews were conducted with the different stakeholders in the university. Each criteria thematized in the first stage. Then, the open-ended and closed questions were asked to the different stakeholders of the university. With semi-constructed interviews, it was aimed to have more insight related to each energy criteria. Thus, as well as the existing considerations; future plans, strengths, weaknesses, opportunities and threats, and organizational perceptions were revealed during the conducted interviews.

5.1. Discussion on the METU Campus

In this section, the presented data in the Chapter 4 are discussed in the frame of SWOT analysis and some recommendations for the METU Campus to achieve transformative level change are made.

- Strengths

The strong interest of the student societies to the efficiency and green campus issues is one of the most powerful strengths of the university. The interviewed societies are highly interested in contributing the campus greenness and take active role on the issues related to the campus greenness. They have initiated several green campus activities in the METU Campus, including the evaluation of the METU Campus on the GM Ranking tool.

Although there is not a sustainability commission in the METU, the existence of a commission engaged with spatial decisions is a strength for the university to discuss and progress on spatial efficiency criteria. This commission can be enriched with the involvement of different stakeholders to increase participation and thus, to strengthen the knowledge building capability.

Also, the university has effective spatial strategies supporting car use decrease such as creating traffic loops, carless student zone, and compact development zones. The considerations taken initial settlement plan to create carless zone and the knowledge production capability between the construction works and transportation planning commission are the main strengths university hold on this issue.

The university has renewable technology and investment assessments. Even if there is no renewable technology implementation on the campus. This approach can be made convenient to adopt these technologies later.

- Weaknesses

The university does not have an office or commission focusing the campus sustainability. Therefore, the energy efficiency considerations on campus remain behind due to the insufficient importance given efficiency in strategy plans and budget plans. Also, the university does not use the communication tools effectively to increase knowledge building capability or promote the campus greenness.

Strategies to decrease travel energy demand exist in the METU; yet they are not effective as expected. The interest to the car usage is not lowered with time in the METU. Therefore, the strategies implemented for the decrease in car usage are needed to be evaluated more systematically. Such as together with bicycle road construction, bike-sharing program, hiring program, promotional activities are required to be considered.

The educational aspect of the campus is not used effectively in the METU Campus. The campus currently is not used for curriculum activities. Also, the examples that enable the users to experience paradigm shift in terms of 'green' concept or energy transition are not existed.

There is not any guide, or construction standards determined by the university to be applied in the competition specifications. This situation affects the spatial energy efficiency both at building scale and building configuration scale on campus. In terms of passive building implementation or energy efficient building design, the priority given to formal aspects to the buildings rather than the efficiency considerations due to the lack of standards determined.

On building scale, the effectiveness of retrofitting strategies cannot be measured due to the lack of data related to individual building energy consumption. Also, the strategies on the campus buildings are not applied systematically. These issues are problematic in terms of the determination of needed operations and investments in campus buildings and monitoring the contribution of taken efficiency measures.

Also, any data belonging to the campus environmental impact is not existed in the university. The measurement of the carbon emissions is one of the significant criteria to evaluate the progress on the energy transition of the campuses. However, in the case of the METU Campus, the measurement was made only the inside of several buildings Therefore, currently for the university it is not possible to determine a carbon emission decrease target or track the campus wide progress.

- Opportunities

Due to the high interest shown to the efficiency related issues and the leadership potential, the involvement of the student groups and platforms into the decision mechanism is an opportunity for the METU. Also, they can be evaluated as the most experienced stakeholder on ‘green campus’ among the interviewed stakeholders. Therefore, to support and fund their activities or researches can contribute to the campus greenness significantly on future.

In terms of external collaborations, some cooperation with the municipality and the citizens of Ankara on sustainability issues have existed. Yet, to be an urban campus is a strong advantage to strengthen these collaborations and thereby, to reinforce the transition on the METU Campus. On the other hand, this relationship also provides significant opportunities to transfer learned practices for efficiency such as passive design strategies or the applicable technologies to the city Ankara.

- Threats

The limited construction area remained within the core area of the campus is a threat for future development of the METU in terms of the land use contribution to the energy efficiency criteria both at building configuration and campus scale. Conducted interviews with the employee of the spatial planning office and administration reveals that there is a consensus on sprawl for future development of the METU Campus. This process need to be governed holistically by considering energy efficiency at each scale.

Even if the existence of a spatial commission is the strength of the university, the impact of the commission on decision making can be limited due to the organizational hierarchy. This is a threat that can influence the knowledge building capability of the organization.

In the light of these analyses a number of short term, midterm and long term strategy can be suggested for the METU Campus as follows:

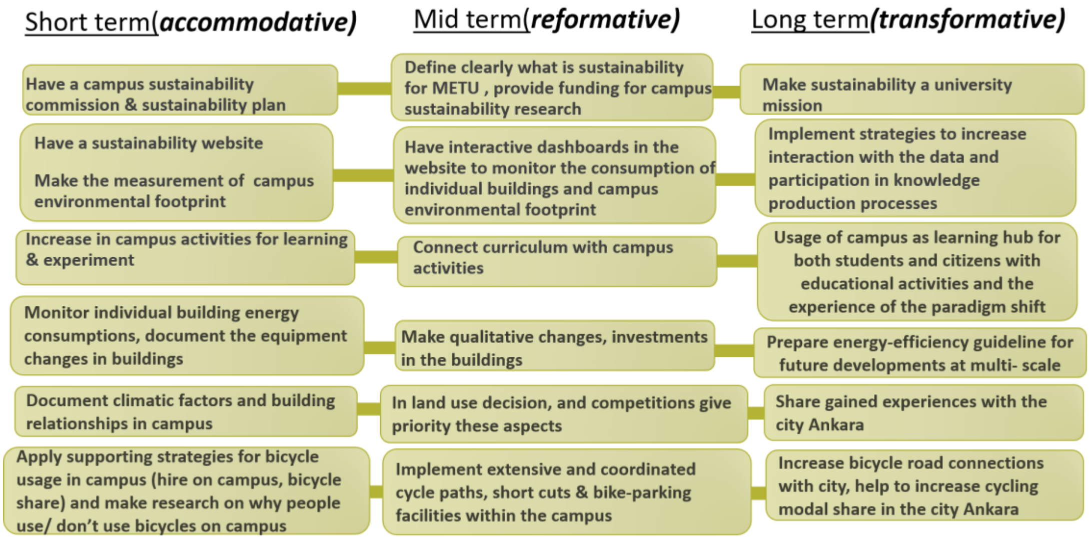

Figure 5.1. A Number of Short Term, Mid Term & Long Term Strategies for the Energy Transition of the METU Campus

For the initial stage of energy transition, it is significant to discuss and determine the strategies with their impacts, implementation time span, and budget plans. Currently, the METU also does not hold this kind of approach for its green campus operations. In this respect, implemented or proposed green operations also carry the risk to be 'accommodative' changes. In other words, they can remain as 'change within changelessness'. Therefore, with the light of the research results, the university is advised to move towards energy transition with a comprehensive approach and urgently set initial strategies together with an implementation plan.

5.2. Limitations

This study presents an approach and set of criteria for the evaluation of campus greenness on the energy transition without providing a weighting system or rigid criteria. On the other hand, the analyzed CSA tools in this study have weighting systems to rank the greenness of the university campuses. In this respect, currently, the designated criteria ‘tool’ function as an evaluator for the energy transition of campuses without enabling a *Cross-institutional* assessment.

To collect the basic data on the assessment criteria were hard due to the organizational restrictions and lack of data availability in the METU. That’s why, data gathering process took more time than expected and could not been fed from the data provided for the GM Ranking tool.

The analyzed CSA tools evaluate the campuses with the data provided by the universities and the proof documents. Nevertheless, in this study, the research employed semi-constructed interview method to collect the evaluation data. As aforementioned, the reason to apply semi-constructed interviews was to gain insight related to the issues on campus; thus, to have a more comprehensive assessment for each criteria. To do this, at the initial stage of the research, it was planned to conduct a higher number of interviews with the stakeholders. However, to make in-depth interviews took more time than expected during the research and a number of interviews were conducted more than one times to gain more insights about the issues.

In this research, the spatial energy efficiency criteria of the campus aimed to enrich with a multi-scale approach. However, the generated tool evaluates the campus at multi-scale by questioning the related criteria. More specifically, the current processes, decisions, approaches and future considerations are assessed with the tool. On the other hand, with using the spatial analysis tools and architectural programmes as research tools, the efficiency strategies for individual buildings and the optimal configurations of campus buildings could be also analyzed to guide the campuses for future development at each scale. In this sense, this study can be evaluated as the first step of a broader study on energy efficiency in university campuses.

5.3. On Future

To open a floor for the development of the generated tool and further research on the energy transition several propositions can be made.

The approach of the designed 'tool' in this study allows to evaluate future considerations as well as the current performances on the each criteria. Furthermore, it assesses the existence of threats and opportunities for each criteria to able universities to question the existence of these issues in their campuses. Future studies focusing the other evaluation categories of the CSA tools can also be adopted this approach to evaluate the 'greennes' of the campus. Similarly, in the future studies, the multi-scale spatial criteria approach presented in this study can be applied effectively into the different categories of the CSA tools such as 'water' and 'waste' or the generated criteria on energy can be expanded by adding new criteria to the each scale.

Beginning from the first chapter, the study advocates the need of comprehensive and systematic approaches and transformative changes with reference to the enormity of today's sustainability problems. In the case of 'green' campus concept, the study presented an approach and studied the literature to enable to have 'transformative' changes on campuses. However, the study were built within a phenomena. In other words, we speak within the context that we depend and we still make 'changes within changelessness'. A 'transformative' approach can be questioned within a different architectural context that enables to think freely from existed infrastructure.

REFERENCES

AASHE (The Association for the Advancement of Sustainability in Higher Education). (2019). Stars Technical Manual. Version 2.1. Available online: https://stars.aashe.org/pages/about/technical-manual.html (accessed on 2 August 2019).

Alshuwaikhat HM, Abubakar I. (2008). *An integrated approach to achieving campus sustainability: assessment of the current campus environmental management practices*. J Clean Prod, 16: 1777-1785.

Beynaghi, A., Moztarzadeh, F., Maknoon, R., Waas, T., Mozafari, M., Huge, J., Leal Filho, W. (2014). *Towards an orientation of higher education in the post Rioþ20 process: how is the game changing?* Futures 63, 49e67.

Biggart, N., & Lutzenhiser, L. (2007). "Economic sociology and the social problem of energy inefficiency." *American Behavioral Scientist, 50(8),* 1070-1087.

Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Brown, M., & Key, G. (2005). "Examining factors that influence the commitment to energy master planning in industrial organizations." *Proceedings of the American Council for an Energy Efficient Economy, Summer Study on Energy Efficiency in Industry,* pp3-17-24.

Brundtland, G. (1987). *Our Common Future.* Report of the World Commission on Environment and Development. Oxford: Oxford University Press. Retrieved from http://www.un-documents.net/our-common-future.pdf

Bursztyn M. (2008). *Sustainability science and the University: towards interdisciplinary*. In: Working Paper for Center for International Development at Harvard University, No. 24; 2008. Accesed 23.11.2010 from: http://www.hks.harvard.edu/centers/cid/publications/research-fellow-graduate-student-working-papers/cid-graduatestudent-and-postdoctoral-fellow-working-paper-no.-24

Cebon, P. (1992). High performance industrial energy conservation: A case study. *Proceedings of the American Council for an Energy Efficient Economy*. pp. 10.19-29. Washington, DC: ACEEE Press

CGUN. (2018) http://www.cgun.org.cn/en/content.aspx?info_lb=107&flag=1 accessed: 19.06.2019

Climateactiontracker.org. (2019). *Turkey | Climate Action Tracker*. [online] Available at: https://climateactiontracker.org/countries/turkey/ [Accessed 1 Aug. 2019].

Cole, L. (2003). *Assessing sustainability on Canadian university campuses: development of a campus sustainability assessment framework*. Royal Roads University.

Cornet, Y.; Gudmundsson, H. (2015). *Building a meta-framework for sustainable transport indicators: a review of selected contributions*, Transportation Research Record: Journal of the Transportation Research Board (in press).

Cortese, A.D. (1999). "*Education for Sustainability: The University as a Model of Sustainability*" available at :http://www.secondnature.org/pdf/snwritings/articles/univmodel.pdf retrieved o 22.09.2011

Costanza, R. (2010). *Creating a sustainable and desirable future*. Macalester International. 26: 3-22

Çinici, B. (1970) *Altuğ-Behruz Çinici, 1961-1970: Mimarlık Çalışmaları*", Ajans Türk Matbaacılık Sanayi, Ankara.

Çinici,B. (n.d.)“*Ortadoğu Teknik Üniversitesi Kampus Planlaması Raporu”,* Ankara.

De Coninck, H., A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, S. Fuss, J.-C. Hourcade, D. Ley, R. Mechler, P. Newman, A. Revokatova, S. Schultz, L. Steg, and T. Sugiyama. (2018). Strengthening and Implementing the Global Response. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

Denhez F. (2007). *Atlas du Rechauffement Climatique, Un Risque majeur pour la planete book*, press.

DiMaggio, P., & Powell, W. (1983). “The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields.” *American Sociological Review, 48,*147-160.

Doppelt, B. (2003). “Overcoming the seven sustainability blunders.” *The Systems Thinker, 14(5),* 1-7.

Eckert, E. (2012). ‘‘Assessment and the outdoor campus environment: using a survey to measure student satisfaction with the outdoor physical campus.’’ *Planning for Higher Education*, 41.1: 141+. *Academic OneFile*. Web. 10 July 2019.

Eia.gov. (2019). *U.S. Energy Information Administration (EIA) - Total Energy*. [online] Available at: https://www.eia.gov/totalenergy [Accessed 31 Jul. 2019].

Ekins, P., Simon, S., Deutsch, L., Folke, C., De Groot, R., (2003). *A framework for the practical application of the concepts of critical natural capital and strong Ecological Economics*, 44, 165–185.

Elizabete M., Seiffert., Loch Carlos. (2005). *Systemic thinking in environmental management: Support for sustainable development*. Journal of Cleaner Production 13(12):1197-1202, DOI: 10.1016/j.jclepro.2004.07.004

EPA., (2000). Greening the Campus: Where Pratice and Education Go Hand in Hand,http: //www.epa.gov/region01/steward/univ/index.html

Evans, J., Karvonen, A. (2014). 'Give me a laboratory and I will lower your carbon footprint!' urban laboratories and the governance of low-carbon futures. Int. J. Urban Reg. Res. 38, 413e430.

Fisher, K. (2007). The New Learning Environment: The Campus as Thirdspace. *In*: *Educause Australia Conference April 29th- May 2nd 2007 Advancing Knowledge: Pushing Boundaries*. Melbourne, 1–8.

Findler, F., Schönherr, N., Lozano, R., Stacherl, B. (2019). Assessing the Impacts of Higher Education Institutions on Sustainable Development—An Analysis of Tools and Indicators. *Sustainability*, *11*, 59.

Greenmetric UI. (2019). Ui Greenmetric. Criteria & Indicators. Available online: http://greenmetric.ui.ac.id/criterian-indicator/ (accessed on 22 August 2019).

Green Office Movement. (2019). What is a green university? (Definition, arguments and project examples). Retrieved 24 June 2019, from https://www.greenofficemovement.org/green-university/

Guallart, V. (2003). The Metapolis Dictionary of Advanced Architecture, Actar, Barcelona, 187

Hammer, S. (2011). "Cities and Green Growth: A Conceptual Framework", OECD Regional Development Working Papers 2011/08, OECD Publishing. http://dx.doi.org/10.1787/5kg0tflmzx34-en

Hordijk,I. (2014). *Position paper on sustainable universities*. Journal of 'Cleaner' Production, *14*(9),810–819.

H W. Tan. (2016). "Thoughts over the development of green campus in China", World Environment, vol. 5, pp. 30–34.

IPCC. (2007a). *Summary for Policymakers. In: Climate Change 2007: Mitigation.* Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R.

IPCC. (2007b). *Climate Change 2007: Impacts, Adaptation and Vulnerability.* IPCCWorking Group II Contribution of Working Group II to the Fourth AssessmentReport of the Intergovernmental Panel on Climate Change. Ed. Martin Parry, M.,Canziani, O., Palutikof, J., van der Linden, P. Hanson, C. Cambridge.

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151

IPCC, (2018). Summary for Policymakers., *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. *World Meteorological Organization, Geneva, Switzerland, 32 pp*

IRENA. (2018). *Renewable capacity statistics 2018*, International Renewable Energy Agency (IRENA), Abu Dhabi.

J. Cook (2016) "Consensus on consensus: a synthesis of consensus estimates on human-caused global warming," *Environmental Research Letters* Vol. 11 No. 4; DOI:10.1088/1748-9326/11/4/048002

Jamieson, P. (2009). The Serious Matter of Informal Learning. *Planning for Higher Education*, 37 (2).

Kenney, D.R., Dummont, R., and Kenney, G. (2005). *Mission and place. Strengthening learning and community trough campus design*. Westport, CT: Praeger Publishers.

Koester, R.J., Eflin, J., Vann, J. (2006). *Greening of the campus: a whole-systems approach*. J. Clean. Prod. 14, 769e779.

Korhonen J., Honkasalo A., Seppälä J. (2018). *Circular economy: The concept and its limitations.* Ecological Economics, 143:37-46

Krewitt, W., S.Simon, W Graus, S.Teske, A. Zervos and O. Schafer. (2007). The 2 degrees scenario – a sustainable world energy perspective, Energy Policy, 35(10):4969-80.

Lehmann, S. (2010). *The principles of green urbanism: Transforming the city for sustainability*. London: Earthscan.

Lozano, R., Lukman, R., Lozano F. J., Huisingh, D & Lambrechts, W. (2011). *Declarations for sustainability in higher education: becoming better leaders, through addressing the university system*. Journal of Cleaner Production. 48(2013). p.10-19

Martin, J., Samels, J. E., & Associates. (2012). *The Sustainable University: Green Goals and New Challenges for Higher Education Leaders.* Baltimore: John Hopkins University Press.

Meadows, D. (2008). *Thinking in Systems*. White River Junction, VT: Chelsea Greenc Publishing.

McIntosh, Alastair. (2008). *Hell and high water: Climate change, hope and the human condition*. Edinburgh.

NASA Science. (2010). “The Earth's Radiation Budget" National Aeronautics and Space Administration. http://science.nasa.gov/ems/13_radiationbudget

Newman, P., Kenworthy, J. (1999). *Sustainability and Cities: Overcoming Automobile Dependence*. Island Press, Washington, DC.

Orr, D.W., Cohen, A. (2013). Promoting partnerships for integrated, Post-Carbon development: strategies at work in the Oberlin Project at Oberlin College. Plan. High. Educ. 41, 22.

Pacala, S. and R. Socolow (2004). Stabilization wedges: solving the climate problem for the next 50 years with current technologies, Science305: 968-72.

Painter, S., Fournier, J., Grape, C., Grummon, P., Morelli, J., Whitmer, S., & Cevetello, J. (2013). *Research on Learning Space Design: Present State, Future Directions*. Society for College and University Planning. Retrieved online: http://www.acmartin.com/sites/default/files/LearningSpaceDesign-L_0.pdf

REGIONS 2020. (2009) *The Climate Change Challenge for European Regions* EU Commision Policy development, Directore-General Regional Policy, Brussels, March 2009 pdf., available at https://espas.secure.europarl.europa.eu/orbis/node/174

Riffat, S., Powell, R. and Aydin, D. (2016*). Future cities and environmental sustainability*. Future Cities and Environment, 2, p.1. DOI: http://doi.org/10.1186/s40984-016-0014-2

Ryn, S., Cowan, S. (1996). Ecological Design, Island Press, London

Second Nature. (n.d.) Commitment Action Innovation. Retrieved June, 2018, from http://secondnature.org/

SEEP. (2013). Strategic Energy Efficiency Plan of Turkey of 25.02.2012, Official Journal, Retrived in 01.04.2019 from http://www.resmigazete.gov.tr /eskiler/2012/02/20120225-7.html

Selby, David, Kagawa, Fumiyo, Budrich Verlag. (2015). *Sustainability Frontiers: Critical and Transformative Voices from the Borderlands of Sustainability Education* Barbara Budrich Publishers. Opladen.

Senge, P. (1990). *The Fifth Discipline: The Art and Practice of the Learning Organization.* Doubleday.

Shriberg, M. Institutional Assessment Tools for Sustainability in Higher Education. Int. J. Sustain. High. Educ. **2002**, 3, 254–270.

Starik, M., & Rands, G. (1995). Weaving an integrated web: Multilevel and multisystem perspectives of ecologically sustainable organizations. *The Academy of Management Review,* 20(4), 908-935.

Stern, P. (2005). “Understanding individual’s environmentally significant behavior.” *Environmental Law Reporter, 55,* 10785-10790.

Talloires Declaration. (1990). [online] Report and Declaration of the Presidents Conference (1990). Available at: http://ulsf.org/talloires-declaration/ [Accessed 1 Jun. 2019].

Temple, P. (2014). *The Physical University: Countours of Space and Place in Higher Education*. Paul Templ. Abingdon, New York: Routledge.

UN CSD (United Nations Commission on Sustainable Development). (2012). *Indicators of Sustainable Development Framework and Methodologies*. UN CSD, New York.

UNDESA. (2014). Revision of the World Urbanization Prospects, *Sustainable Development in the 21st century, summary for policy-makers*, Department of Economic and Social Affairs, New York, June, available at http://sustainabledevelopment.un.org/content/documents/UN-DESA_Back_Common_Future_En.pdf.

UNEP. (2014). *Greening Universities Toolkit: Transforming Universities into Green and Sustainable Campuses – A Toolkit for Implementers,* United Nations Environment Programme.

UNESCO. (1997). *Educating for a Sustainable Future: A Transdisciplinary Vision for Concerted Action*. United Nations Educational, Scientific and Cultural Organization. EPD 97/CONF.401/CLD.l Retreived April, 2019, from http://unesdoc.unesco.org/images/0011/001106/110686eo.pdf

United Nations. (1994). *Report of the International Conference on Population and Development, Cairo, 5-13 September 1994*, Sales No. E.95.XIII.18, chap. I, resolution 1, annex..

United Nations. (2014). *Prototype Global Sustainable Development Report*, Division for Sustainable Development, New York, June, http://sustainabledevelopment.un.org/content/documents/1454Prototype%20Global%20SD%20Report.pdf.

Velazquez, L., Munguia, N., Platt, A., & Taddei,J. (2006). *Sustainable university: what can be the matter* Journal'of'Cleaner'Production, *14*, 810–819. doi:10.1016/j.jclepro.2005.12.008

Verisk Maplecroft. (2019). Urbanisation and Climate Change Risks. [online] Available at: https://www.maplecroft.com/insights/analysis/84-of-worlds-fastest-growing-cities-face-extreme-climate-change-risks/ [Accessed 25 Jul. 2019].

Viebahn, P. (2002) An environmental management model for universities: From environmental guidelines to staff involvement," *Journal of Cleaner Production*, vol. 10, no. 1, pp. 3-12.

Wake Bronwyn. (2016). Feeling the heat. Nature Climate Change, volume 6, page 742, https://doi.org/10.1038/nclimate3099, Published 27 July 2016

Web of Science. (2019). Retrieved July 2019, from http://www.webofknowledge.com

Wright, T. (2004). The evolution of sustainability declarations in higher education", In Higher Education and the Challenge of Sustainability (Ed) Corcoran, P., Wals A: Kluwer Academic, Dordrecht, Netherlands, pp. 7-14.

Yang Tian-ren. (2015) ''Green Campus as a Plot site towards low-carbon city: Enlightenment from Cornell Action Plan'' *Low-Carbon City and New-type Urbanization: Proceedings of Chinese Low-carbon City Development International Conference,* Springer, 211-224.

Yeang, K. (2012). Ekolojik Tasarım Rehberi, YEM Yayın-193, İstanbul

APPENDICES

A. The Sustainability Tracking, Assessment & Rating System (Stars) Evaluation Criteria

Category	Subcategory	Credit Number and Title		Points available	Applicable to:	Minimum requirement
Academics (AC)	Curriculum	AC 1	Academic Courses	14	Institutions that have students enrolled for credit.	Conduct an inventory to identify sustainability course offerings.
		AC 2	Learning Outcomes	8	Institutions that have degree programs.	Have adopted one or more institution-level sustainability learning outcomes and/or have students graduate from degree programs that
		AC 3	Undergraduate Program	3	Institutions that have undergraduate majors, academic programs, or the equivalent.	Offer at least one sustainability-focused, undergraduate-level major, degree program, minor or concentration.
		AC 4	Graduate Program	3	Institutions that offer at least 25 distinct graduate programs.	Offer at least one sustainability-focused, graduate-level major, degree program, minor, concentration or certificate.
		AC 5	Immersive Experience	2	Institutions that offer immersive educational programs.	Offer at least one immersive, sustainability-focused educational study program.
		AC 6	Sustainability Literacy Assessment	4	All institutions.	Conduct an assessment of the sustainability literacy of the institution's students.
		AC 7	Incentives for Developing Courses	2	All institutions.	Have an ongoing program that offers incentives for academic staff to develop new sustainability courses and/or incorporate sustainability into
		AC 8	Campus as a Living Laboratory	4	Institutions where students attend the physical campus.	Utilize the institution's infrastructure and operations as a living laboratory for applied student learning for sustainability.
	Research	AC 9	Research and Scholarship	12	Institutions where research is considered in employee promotion or tenure decisions.	Conduct an inventory to identify the institution's sustainability research.
		AC 10	Support for Sustainability Research	4	Institutions where research is considered in employee promotion or tenure decisions.	Have programs to encourage and/or support sustainability research.
		AC 11	Open Access to Research	2	Institutions where research is considered in employee promotion or tenure decisions.	Facilitate open access publishing.
Engagement (EN)	Campus Engagement	EN 1	Student Educators Program	4	institutions with students who are enrolled for credit and attend the physical campus.	Coordinate an ongoing peer-to-peer sustainability outreach and education program for students.
		EN 2	Student Orientation	2	Institutions that hold student orientation.	Include sustainability prominently in student orientation activities and programming.
		EN 3	Student Life	2	All institutions.	Have co-curricular sustainability programs and initiatives.
		EN 4	Outreach Materials and Publications	2	All institutions.	Produce outreach materials and/or publications that foster sustainability learning and knowledge.
		EN 5	Outreach Campaign	4	All institutions.	Hold at least one sustainability-related outreach campaign directed at students and/or employees.
		EN 6	Assessing Sustainability Culture	1	All institutions.	Conduct an assessment of campus sustainability culture that focuses on sustainability values, behaviors and beliefs.
		EN 7	Employee Educators Program	3	All institutions.	Administer or oversee an ongoing peer-to-peer sustainability outreach and education program for employees.
		EN 8	Employee Orientation	1	All institutions.	Cover sustainability topics in employee orientation and/or in outreach and guidance materials distributed to new employees.
		EN 9	Staff Professional Development and Training	2	All institutions.	Make available professional development and training opportunities in sustainability to non-academic staff.
	Public Engagement	EN 10	Community Partnerships	3	All institutions.	Have at least one formal community partnership to work together to advance sustainability.
		EN 11	Inter-Campus Collaboration	3	All institutions.	Collaborate with other colleges and universities to support and help build the campus sustainability community.
		EN 12	Continuing Education	5	Institutions that have formal continuing education or community education programs.	Offer continuing education courses that address sustainability and/or have at least one sustainability-themed certificate program through a
		EN 13	Community Service	5	All institutions.	Have data on student engagement in community service and/or a formal program to support employee volunteering.
		EN 14	Participation in Public Policy	2	All institutions.	Advocate for public policies that support campus sustainability or that otherwise advance sustainability.
		EN 14	Trademark Licensing	2	Institutions whose logo is trademarked and appears on apparel, and have gross annual licensing revenue of $50,000 or more.	Have adopted a labor rights code of conduct in its licensing agreements with the licensees who produce its logo apparel.

Operations (OP)	Air & Climate	OP 1	Emissions Inventory and Disclosure	3	All institutions.	Have completed an inventory to quantify the institution's greenhouse gas (GHG) and/or air pollutant emissions.
		OP 2	Greenhouse Gas Emissions	8	All institutions.	Have completed an inventory to quantify the institution's Scope 1 and Scope 2 greenhouse gas (GHG) emissions.
	Buildings	OP 3	Building Design and Construction	3	Institutions that have new construction and/or major renovation projects completed within the	Own new or renovated buildings that were designed and built in accordance with a published green building code, policy/guideline, or
		OP 4	Building Operations and Maintenance	5	All institutions.	Own buildings that are operated and maintained in accordance with a sustainable management policy/program or a green building rating
	Energy	OP 5	Building Energy Efficiency	6	All institutions.	Have data on grid-purchased electricity, electricity from on-site renewables, utility-provided steam and hot water, and stationary fuels
		OP 6	Clean and Renewable Energy	4	All institutions.	Support the development and use of clean and renewable energy sources.
	Food & Dining	OP 7	Food and Beverage Purchasing	6	Institutions that have that have dining services operated by the institution, a contractor, or a	Purchase food and beverage products that are sustainably or ethically produced and/or plant-based.
		OP 8	Sustainable Dining	2	Institutions that have that have dining services operated by the institution, a contractor, or a	Have programs and initiatives to support sustainable food systems and minimize food waste.
	Grounds	OP 9	Landscape Management	2	Institutions with managed grounds comprising one or more percent of the total area of the	Manage grounds organically or in accordance with an Integrated Pest Management (IPM) program.
		OP 10	Biodiversity	1-2	Institutions with managed grounds comprising one or more percent of the total area of the	Have conducted an assessment to identify endangered and vulnerable species and/or areas of biodiversity importance on land owned or
	Purchasing	OP 11	Sustainable Procurement	3	All institutions.	Apply sustainability criteria when making procurement decisions.
		OP 12	Electronics Purchasing	1	All institutions.	Purchase environmentally and socially preferable electronic products.
		OP 13	Cleaning and Janitorial Purchasing	1	All institutions.	Purchase cleaning and janitorial paper products that meet multi-criteria sustainability standards.
		OP 14	Office Paper Purchasing	1	All institutions.	Purchase office paper with post-consumer recycled, agricultural residue, and/or Forest Stewardship Council (FSC) certified content.
	Transportation	OP 15	Campus Fleet	1	Institutions that own or lease motorized vehicles.	Include vehicles that are hybrid, electric and/or alternatively fueled in the institution's motorized fleet.
		OP 16	Commute Modal Split	5	All institutions.	Conduct a survey to gather data about student and/or employee commuting behavior.
		OP 17	Support for Sustainable Transportation	1	All institutions.	Have implemented strategies to encourage more sustainable modes of transportation and reduce the impact of student and employee
	Waste	OP 18	Waste Minimization and Diversion	8	All institutions.	Have data on the weight of materials recycled, composted, donated/re-sold, and disposed in a landfill or incinerator.
		OP 19	Construction and Demolition Waste Diversion	1	Institutions that have conducted a major construction, renovation and/or demolition project	Divert non-hazardous construction and demolition waste from the landfill and/or incinerator.
		OP 20	Hazardous Waste Management	1	All institutions.	Have strategies in place to 1) safely dispose of all hazardous, special, universal, and non-regulated chemical waste and minimize the
	Water	OP 21	Water Use	4-6	All institutions.	Have data on potable and non-potable water use.
		OP 22	Rainwater Management	2	All institutions.	Use green infrastructure and low impact development (LID) practices to help mitigate stormwater run-off impacts and treat rainwater as a
Planning & Administration (PA)	Coordination & Planning	PA 1	Sustainability Coordination	1	All institutions.	Have at least one sustainability committee, office, and/or officer tasked by the administration or governing body to advise on and implement
		PA 2	Sustainability Planning	4	All institutions.	Have a published plan that includes measurable sustainability objectives and/or include the integrated concept of sustainability in the
		PA 3	Inclusive and Participatory Governance	3	All institutions.	Have formal participatory or shared governance bodies, include diverse stakeholders on the institution's highest governing body, and/or host or
		PA 4	Reporting Assurance	1	Institutions that are submitting a scored report for the first time under a new version of STARS or for	Complete an assurance process that provides independent affirmation that the information in its current STARS report is reported in accordance
	Diversity & Affordability	PA 5	Diversity and Equity Coordination	2	All institutions.	Have a diversity and equity committee, office and/or officer and/or make diversity trainings and activities available.
		PA 6	Assessing Diversity and Equity	1	All institutions.	Have engaged in a structured assessment process to improve diversity, equity, and inclusion on campus.
		PA 7	Support for Underrepresented Groups	3	All institutions.	Have policies, programs or initiatives to support underrepresented groups and foster a more diverse and inclusive campus community.
		PA 8	Affordability and Access	4	All institutions.	Have data related to the institution's accessibility and affordability to low-income students.
	Investment & Finance	PA 8	Committee on Investor Responsibility	2	Institutions with endowments of $1 million or larger.	Have a formally established and active committee on investor responsibility (CIR) or similar body.
		PA 9	Sustainable Investment	3-5	Institutions with endowments of $1 million or larger.	Make positive sustainability investments and/or have investor engagement policies and practices.
		PA 10	Investment Disclosure	1	Institutions that have an investment pool.	Make a snapshot of investment holdings available to the public on at least an annual basis.
	Wellbeing & Work	PA 11	Employee Compensation	3	All institutions.	Have data on the hourly wages and total compensation provided to employees.
		PA 12	Assessing Employee Satisfaction	1	All institutions.	Conduct a survey or other evaluation that allows for anonymous feedback to measure employee satisfaction and engagement.
		PA 13	Wellness Programs	1	All institutions.	Have a wellness and/or employee assistance program and/or prohibit smoking within all occupied buildings.
		PA 14	Workplace Health and Safety	2	All institutions.	Have an occupational health and safety management system (OHSMS) and/or data on work-related injury or ill health.
Innovation & Leadership (IN)	Innovation & Leadership	IN --	Catalog of optional credits available	0.5 each (up to 4	All institutions (varies by credit).	Have an occupational health and safety management system (OHSMS) and/or data on work-related injury or ill health.

(Source: AASHE, 2019)

B. **The Green Metric (GM) Ranking Tool Criteria**

Setting and Infrastructure (SI) (15%)

The campus setting and infrastructure information will give the basic information of the university policy towards green environment. This indicator also shows whether the campus deserves to be called Green Campus. The aim is to trigger the participating university to provide more space for greenery and in safeguarding environment, as well as developing sustainable energy.

The indicators are:

1. The ratio of open space area towards total area
2. Area on campus covered in forest
3. Area on campus covered in planted vegetation
4. Area on campus for water absorbance
5. The total open space area divided by total campus population
6. University budget for sustainable effort

Energy and Climate Change (EC) (21%)

The university's attention to the use of energy and climate change issues takes the highest weighting in this ranking. In our questionnaire we define several indicators for this particular area of concern, i.e. energy efficient appliances usage, renewable energy usage policy, total electricity use, energy conservation program, green building, climate change adaptation and mitigation program, greenhouse gas emission reductions policy. With this indicator, universities are expected to increase the effort in energy efficiency on their buildings and to take more about nature and energy resources.

The indicators are:

1. Energy efficient appliances usage are replacing conventional appliances
2. Smart Building implementation
3. Number of renewable energy sources in campus
4. The total electricity usage divided by total campus population (kWh per person)
5. The ratio of renewable energy produced towards energy usage
6. Elements of green building implementation as reflected in all construction and renovation policy
7. Greenhouse gas emission reductions program
8. The ratio of total carbon footprint divided campus population

Waste (WS) (18%)

Waste treatment and recycling activities are major factors in creating a sustainable environment.The activities of university staff and students in campus will produce a lot of waste, therefore some programs and waste treatments should be among the concern of the university, i.e. recycling program, toxic waste recycling, organic waste treatment, inorganic waste treatment, sewerage disposal, policy to reduce the use of paper and plastic in campus.

The indicators are:

1. Recycling program for university waste
2. Program to reduce the use of paper and plastic in campus
3. Organic waste treatment
4. Inorganic waste treatment
5. Toxic waste handled
6. Sewerage disposal

Water (WR) (10%)

Water use in campus is another important indicator in Greenmetric. The aim is that universities can decrease water usage, increase conservation program, and protect the habitat. Water conservation program, piped water use are among the criteria.

The indicators are:

1. Water conservation program implementation
2. Water recycling program implementation
3. The use of water efficient appliances (water tap, toilet flush, etc)
4. Treated water consumed

Transportation (TR) (18%)

Transportation system plays an important role on the carbon emission and pollutant level in university. Transportation policy to limit the number of motor vehicles in campus, the use of campus bus and bicycle will encourage a healthier environment. The pedestrian policy will encourage students and staff to walk around campus, and avoid using private vehicle. The use of environmentally friendly public transportation will decrease carbon footprint around campus.

The indicators are:

1. The Ratio of total vehicles (cars and motorcycles) divided by total campus population
2. Shuttle service

(Source: UI Green Metric, 2019)

C. Previous Studies of Sustainability Assessment Tools in HE

Author(s)	Tools Analyzed	Methodology	Main Findings
Shriberg (2002)	$n = 11$ AISHE, Campus Ecology, Environmental EMS Self-Assessment, Environmental Workbook and Report, Greening Campuses, Grey Pinstripes with Green Ties, Higher Education 21's Sustainability Indicators, Indicators Snapshot Guide, Performance Survey, SAQ, State of the Campus Environment	A content analysis with a focus on strengths and weaknesses of tools was conducted.	The tools vary greatly in their purpose, function, scope, and state of development.
Yarime & Tanaka (2012)	$n = 16$ AISHE, Campus Ecology, Campus Sustainability Selected Indicators Snapshot, College Sustainability Report Card, CSAF, CSAF core, CSARP, EMS Self-Assessment, Environmental Workbook and Report, GASU, Good Company's Sustainable Pathways Toolkit, HEPS, Penn State Indicator Report, SAQ, STARS, State of the Campus Environment	A mixed-method approach with a quantitative and a qualitative part was applied: (1) comparative analysis of criteria and (2) content analysis of individual indicators.	The main focus of the tools is on campus operations and governance issues. Education, research, and outreach are not well addressed.
Sayed et al. (2013)	$n = 4$ SAQ, CSAF, CSRC, STARS	Each tool was rated based on 27 questions related to five areas of campus life of a specific university.	STARS was identified to be the most effective SAT. SAQ and CSAF have limitations in assessing SD in campus operations.
Fischer et al. (2015)	$n = 12$ AISHE, Alternative Universal Appraisal, Conference of Rectors of Spanish Universities, CSAF, German Commission for UNESCO, Graz Model of Integrative Development, Green Plan, Innovación y Educación Ambiental en Iberoamérica, People & Planet, Red de Ciencia, Tecnologia, SAQ, STARS, UI GreenMetric	A mixed-method approach with a quantitative and a qualitative part was applied: (1) comparative analysis of criteria and (2) introductory passages in supporting documents.	Indicators and criteria are biased towards the field of operations.
Bullock & Wilder (2016)	$n = 9$ ACUPCC, College Sustainability Report Card, Grey Pinstripes with Green Ties, Pacific Sustainability Index (PSI), Princeton Review's Green Ratings, Sierra Club's Cool Schools, STARS, The Guardian's Green League, UI GreenMetric	Sustainability assessment frameworks and SATs based on the GRI-HE framework were evaluated.	The evaluated sustainability assessments and SATs are not comprehensive and lack coverage of the economic and social dimension of sustainability.
Alghamdi et al. (2017)	$n = 12$ Adaptable Model for Assessing Sustainability in Higher Education, AISHE, Alternative University Appraisal, GASU, Green Plan, SAQ, STARS, Sustainable Campus Assessment System, Sustainable University Model, UI GreenMetric, Unit-based Sustainability Assessment Tool, University Environmental Management System	A desk study approach with quantitative and qualitative elements was applied including a review of research articles, academic books, network platforms, graduate theses, and websites.	The tools share similar characteristics in terms of their criteria and indicators, which can be grouped into: management, academia, environment, engagement, and innovation. Environmental indicators have the highest share among the tools.
Berzosa et al. (2017)	$n = 4$ AISHE, SAQ, Sustain Tool, USAT	A descriptive analysis of SATs based on single case studies was performed.	The SATs positively influence creating specific plans in education, research, outreach, and campus operations. They have a strong focus on the environmental dimension and delivered similar outcomes.

(Source: Findler et al., 2019)