A “green campus”: methodology and indicators

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Abstract In the last decades the concept of sustainability has been applied to evaluate the performance of different systems, with reference to the social, economic and environmental dimensions. The great interest towards sustainability has raised the need for its quantification, so that several indicators, indices and ratings have been proposed in scientific literature. Real systems, resulting from the aggregation of elementary units, are very complex, so that the use of conventional indicators could prove poorly efficient in assessing their overall sustainability. The present study aims at evaluate the environmental performance of a complex structure through an integrated methodology, in order to reduce pressures and environmental impacts of the various activities of its functional units, thus improving the overall sustainability of the system. The assessment of sustainability performance requires setting up a system of indicators, to be used in the developed methodology, pursuing the minimization of both energy and resource consumption, while providing a supporting tool for the decisional processes towards an overall eco-efficiency improvement. For experimental purposes the University campus of Salerno, in South Italy, was chosen as complex system and the operational aspects dealing with solid waste management, water consumption, energy efficiency and air quality were analyzed.

Keywords: sustainability, environmental indicators, methodology, assessment, green campus

1. Introduction

The awareness of the increasing use of limited resources and the following environmental issues has raised sustainability as a priority in all fields. A sustainable approach aims, indeed, at it breaks the linkages between economic growth and resource use and ensuring that the consumption of resources and their associated impacts do not exceed the carrying capacity of the environment . Especially since the 1992 Earth Summit, many environmental policy objectives have been formulated in terms of sustainability. The proliferation of these objectives has even spawned considerable discussion about how to measure sustainability.

All these instances are included in the concept of sustainability, even though there is no universally agreed definition on what sustainability means.

The original definition of sustainable development (SD) dates back to the Bruntland Report for the World Commission on Environment and Development (1987) as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Despite its acclaimed vagueness and ambiguity, this definition has been highly instrumental in developing a “global view” with respect to our planet’s future (Mebratu, 1998).

Since then, there have been many variations and extensions of this basic definition, highlighting the multidisciplinarity of sustainable development, based on three pillars: economic, environmental and social (the “*triple bottom line”*).

Since the first ecologists movements in the 1960s to summit and conferences of the main international organizations, the concept of sustainability has become an issue of global concern in planning and scheduling the objectives for development and growth: thousands of initiatives have been taken at local, national, and global level, especially to address different aspects of the environmental challenges.

As a multi-dimensional phenomenon, sustainable development has the goal to integrate economic, ecological, social and institutional subsystem into a whole, taking care of their mutual influence (Golusin *et al*., 2008). For this reason, different indicators have been developed in order to evaluate and measure sustainability, integrating not only environmental, but also economic and social components at all levels (OECD, 2004).

The history of SD and related indicators have been closely linked over time: Agenda 21, the Rio Declaration on Environment and Development, suggested that “governments and international organizations, together with the private sector, should develop criteria and methodologies for the assessment of environmental impacts and resource requirements throughout the full life cycle of products and processes. Results of those assessments should be transformed into clear indicators in order to inform consumers and decision makers*”*.

Many studies have proposed different methodologies to analyze the consumption of natural resources and to assess the sustainability of complex systems in different fields.

A complex system can be defined as an open system, exchanging energy and matter outwards, whose main characteristics are:

- many different components interacting with each other in a non-linear way, with a delay time;
- a high degree of heterogeneity on spatial and temporal scales.

Some of the main concepts and methods emerged in literature over the past years for the evaluation of environmental, economic, social processes or activities are Urban Metabolism (UM), Life Cycle Assessment (LCA), Environmental Sustainability Index (ESI), Ecological Footprint (EF).

In the 1960s the concept of Urban Metabolism, conceived by Wolman (1965), was proposed to point out the resource consumption in urban environments, aiming to understand complex systems through the study of energy and material flows in cities. UM is *the study of material and energy flows arising from urban socioeconomic activities and regional and global biogeochemical processes*. In practice, the study of an urban metabolism involves 'big picture' quantification of the inputs, outputs and storage of energy, water, nutrients, materials and wastes for an urban region. (Kennedy *et al*., 2007).

In this context, Life Cycle Assessment (LCA) is a technique to assess the ecological burdens and impacts throughout the consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources, through production and use to final disposal ("cradle-to-grave" approach).

In other words, LCA provides *a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle*. (ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines)

The Environmental Sustainability Index (ESI) was developed between 1999 to 2005 by Yale University's Center for Environmental Law and Policy, in collaboration with Columbia University's Center for International Earth Science Information Network (CIESIN) and the World Economic Forum, to evaluate environmental sustainability relative to the paths of other countries. The ESI is a measure of overall progress towards environmental sustainability. The index provides a composite profile of national environmental stewardship based on a compilation of indicators derived from underlying datasets.

Over recent years, new tools for the assessment of sustainability and its components have emerged, known as footprints. A "footprint" is a quantitative measurement describing the appropriation of natural resources by humans (Hoekstra, 2008). İn particular, a footprint describes how human activities can impose different types of burdens and impacts on global sustainability (UNEP/ SETAC, 2009). In this view, footprints can be grouped into different categories, such as the ecological, carbon and water, forming the so called "footprint family" (Galli *et al*., 2011), even thogh many other lesser known footprints exist.

Conceived by Mathis Wackernagel and William Rees at the University of British Columbia, the Ecological Footprint launched the broader Footprint movement and is now widely used by scientists, businesses, governments, individuals, and institutions working to monitor ecological resource use and advance sustainable development. The EF is the only metric that measures how much nature we have and how much nature we use.

These indicators have been largely applied to describe the sustainability of different kinds of institutions, including Higher education institutions (HEIs), which decided to incorporate principles and strategies of sustainable development into their policy actions, trying to assess their sustainabilty baseline.

''Greening initiatives'' have been widely accepted on university campuses in North America, Australia and Europe for the past two decades (Arroyo, 2017) and the objective of ''Greening the campus'' has been dominant in North America as some universities have signed the Talloires Declaration (Beringer *et al*., 2008) and/or have also followed the Campus Sustainability Assessment Framework (or similar frameworks) (Helferty and Clarke, 2009).

Moreover, experiments for evaluating the environmental performance of universities have already been around for a number of years, because universities appear to be an ideal place to implement sustainable strategies.

Similar to "small cities", due to their large size, population and the various activities taking place in campuses (Alshuwaikhat and Abubakar, 2008), universities can be regarded as examples of complex systems. Despite the fact that a growing number of universities have placed strategic emphasis on promoting sustainability in recent years (Horhota *et al*. 2014) and creating a "green campus", significant challenges remain (Beringer *et al*. 2008; Bero *et al*. 2012; Krizek *et al*. 2012; Kurland 2014). Nonetheless, the assessment of sustainability through different methods, indicators and ranking systems poses, currently, an open question, due to the multidisciplinary nature of the concept and the lack of wide accepted criteria.

The main objective of this study was to develop a methodology to evaluate resource consumption and analyze burdens and environmental impacts due to the many activities carried out in complex systems, in a circular process of improvement. In order to test its feasibility, the main campus of the University of Salerno was employed as a "living laboratory", for its specific features and representativeness.

2. Materials and methods

2.1. The University of Salerno

The University of Salerno, in southern Italy, has a very large catchment area, including, beside Campania, the Italian regions of Basilicata, Calabria and Apulia. Since

1988, the University – which currently counts around 38,000 students – has had its headquarters in the town of Fisciano, a few kilometers from Salerno in the Irno Valley, at the junction of motorway intersections that make it central and easy to reach. Organized in the form of a campus (the Fisciano and the Baronissi Campuses), the University, boasts modern facilities and efficient services for orientation, teaching, studying and leisure. It is a very large and still expanding complex, which covers an area of about one hundred thousand square meters. Furthermore, the Fisciano Campus, the principal one, offers many services such as university residences for students and teachers, sports facilities, an indoor semi olympic swimming pool, a university canteen, a theater, open green spaces and a thematic arboretum, thus providing a student-friendly environment.

For all these reasons, the Fisciano campus was chosen as an example of complex system: the operational aspects, dealing with solid waste management, water supply, energy efficiency and air quality were analyzed. The experimental setup was concerned with the implementation of the activities to be carried out with reference to the main environmental compartments, in order to develop an integrated model addressing all the dimensions in a sustainable way and mitigating adverse environmental impacts.

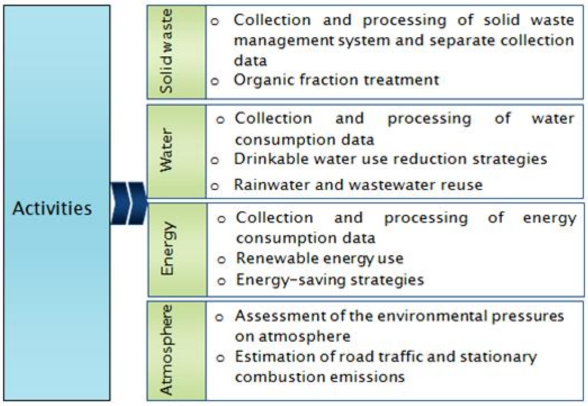

Figure 1. Experimental setup

With regard to the activities planned in the setup shown in figure, several points should be highlighted:

– the solid waste production is rather steady, so as the separate collection (24%), with paper as the main fraction (12%) and the organic fraction as the second collected one. The analysis of the organic waste production from the university canteen has been carried out through the characterisation of organic waste by composition and chemical physical analysis. The evaluation of possible treatment strategies has resulted in a proposal for a community composting plant for the organic waste treatment dedicated to the university campus;

– the analysis of water consumptions and sources of supply pointed out the main factors influencing water use:
  - ✓ water losses in the distribution network;
  - ✓ student population trend;
  - ✓ improper use of drinking water;
  - ✓ increase in University surface;
  - ✓ seasonal trends.

  Furthermore, water from wells is used for green watering and supplying of some facilities, scientific laboratories, toilets and technological plants.

– the annual energy supply of the main university campus is provided by:
  - ✓ energy from national grid (72%);
  - ✓ photovoltaic plan (7%);
  - ✓ cogenerator plan (21%).

the estimation of emissions from road traffic and stationary combustion sources has been assessed at a local scale. An atmospheric dispersion model has been used in order to assess the environmental pressures on atmosphere, providing simulation results within the regulatory limits.

2.2 The methodology

The methodology, focused on the environmental dimension of sustainability, consists of four steps, described as follows.

The first step is a wide theoretical framework of the general context, concerning analysis and organization of the environmental information required for the application of the subsequent stages. In particular, in the case study data collection and processing at the campus level was carried out, in order to evaluate both resource consumption and operational aspects dealing with solid waste and water management, energy efficiency and air quality.

The second step, the most important one, is focused on the selection of the indicators to be applied for the evaluation of the environmental performance of the complex system under examination. The main selection criteria of the indicators are (OECD, 2004):

- significance;
- accuracy;
- detection;
- technical and methodological characteristics.

According to the mentioned criteria, the selection of the most suitable indicators, among the most representative proposed in literature, was made distinguishing between detectable and effectively populating indicators as well as evaluating the main environmental pressures acting on the different sectors previously analyzed. It has been selected a core set of 41 indicators, grouped according to their specific sector, with a detailed description for each one in the Indicator data sheet. The Indicator data sheet model is composed of two parts, one related to "metadata", the information source data required to form the selected indicators, and another to "populating data".

The third step, the so called "Indicators specialisation", refers to the implementation of the chosen general indicators that will be adapted to the actual case, according to its specific characteristics. In particular, the process of adaptation was based on theoretical considerations as well as on the assessment of indicators effectiveness and consistency and data availability in the specific context under consideration.

In the fourth and last step, the methodology application required the use of the specific set of indicators previously developed, in order to :

- ✓ calculate the indicators and evaluate the trend;
- ✓ evaluate the *baseline* in terms of sustainability;
- ✓ cyclically assess the environmental performance of the system.

A cyclic application of the methodology allows an indicators review and the definition of sustainability trend, in order to ensure a constant improvement of the overall environmental performance.

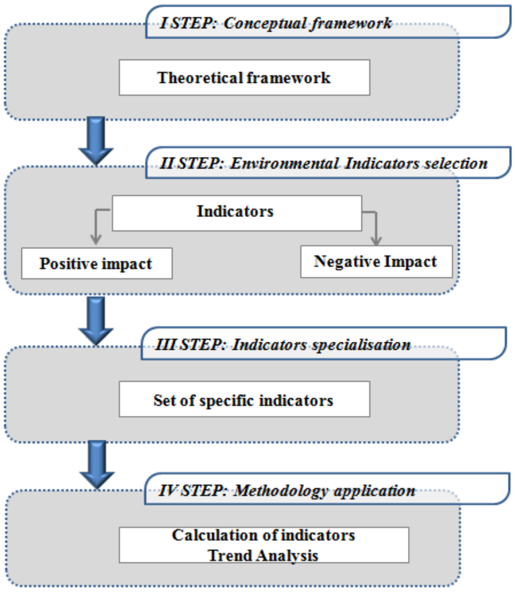

Figure 2. Methodological scheme

3. Discussion and conclusions

The aim of effectively achieve sustainability and manage the impacts of daily operations and activities in university campuses requires careful consideration and specification.

In the present case, the analysis of different sectors showed that there is a huge room for improvement of the overall environmental performance.

The chosen methodological framework is focused on the environmental profile of sustainability, rather than on the "*triple bottom line*", specifically in order to provide a flexible and effective assessment tool.

The difficulty in obtaining proper data, as experienced in this case, confirmed indeed that the application of more structured evaluation methodologies may be too complex. On this basis, the formulation of a methodological proposal without ranking objectives was preferred to the definition of a general methodology, aiming at the comparison of the environmental performance of different complex structures. This approach was found to be suitable for:

- ✓ evaluate the deviation from a "sustainability model", rather than absolute values;
- ✓ a sequential application to improve the environmental performance of the specific case;
- ✓ decisional processes, as a supporting tool.

The specific context of application influences the evaluation results, making not fully meaningful the comparison between complex structures, such as hospitals, resorts, university campuses. For this reason, the proposed methodology appears to be more appropriate for the assessment over time of the environmental performance of a specific structure, in a cyclical enhancing process. Validation and further refinement of the methodology through the application to specific cases should be also useful to reduce the subjectivity degree of the evaluation. In fact, the analysis and comparison of the results achieved through the methodology application over time could make them clearer and increasingly independent from the specific evaluator. However, the lack of data and significant difficulties in their breakdown represent an additional challenge for the future. The improvement and increase of resource efficiency and sustainability policies request both education and legally binding provisions in conjunction with supportive instruments, including appropriate monetary and fiscal policies and strict legislation. Finally, the results showed the need to make decisions based on an efficiency-benefit ratio, rather than a cost-benefit ratio, because the first one takes into account the impact generated in other areas, such as the environmental one, without deeming costs to be the most important factor. As a result, sustainability and environmental awareness should be no longer just slogans, but genuinely important strategies for the future.

References

Abdelalim A., O'Brien W., Shi Z. (2015). Visualization of energy and water consumption and GHG emissions: a case study of a Canadian University Campus, *Energy and Buildings* **109** 334-352.

Arroyo, P. (2017) A new taxonomy for examining the multi-role of campus sustainability assessments in organizational change, *Journal of Cleaner Production*. **140** 1763-1774.

Beringer A., Wright, T., & Malone, L. (2008). Sustainability in higher education in Atlantic Canada. International Journal of Sustainability in Higher Education, **9(1)**, 48–67.

Bero, B. N., Doerry, E., Middleton, R., Meinhardt, C. (2012). Challenges in the development of environmental management systems on the modern university campus. *International Journal of Sustainability in Higher Education*, **13(2)**, 133–149.

Bruntland G.H. (1987). Our common future. World Commission on Environment and Development (WCED), *Oxford paperbacks; Oxford University Press*.

Cucek L., Klemes J. J., Kravanja Z. (2012). A review of Footprint analysis tools for monitoring impacts on sustainability, *Journal of Cleaner Production* **34** 9-20.

Galli A., Wiedmann T., Ercin E., Knoblauch D., Ewing B., Giljum S. (2011). Integrating Ecological, Carbon and Water footprint into a "Footprint Family" of indicators: Definition and role in tracking human pressure on the planet. *Ecological Indicators*, **16,** 100–112.

Golusin M, Munitlak Ivanovic O. (2009). Definition, characteristic and state of the indicators of sustainable development in Southeastern Europe. *Agriculture Ecosystems & Environment*;130(1–2)

Helferty, A., & Clarke, A. (2009). Student-led campus climate change initiatives in Canada. International *Journal of Sustainability in Higher Education*, **10(3)**, 287–300.

Hoekstra A.Y. (2008). Water Neutral: Reducing and Offsetting the Impacts of Water Footprints. *Value of water Research Report Series No. 28*, UNESCO-IHE, Delft, the Netherlands.

Hoque1 A., Clarke A., Sultana T. (2016) Environmental sustainability practices in South Asian university campuses: an exploratory study on Bangladeshi universities, *Environment, Development and Sustainability* 1–18.

Horhota, M., Asman, J., Stratton, J., & Halfacre, A. (2014). Identifying behavioral barriers to campus sustainability - A multi-method approach. *International Journal of Construction Education and Research*, **15(3)**, 343–358

Kennedy C.,. Pincetl S, Bunje P. (2011). The study of urban metabolism and its applications to urban planning and design *Environmental Pollution* **159** (2011) 1965-1973.

Krizek, K. J., Newport D., White J., Townsend A. R. (2012). Higher education's sustainability imperative: How to practically respond?, *International Journal of Sustainability in Higher Education*, **13**, 19–33.

Kurland, N. (2014). Shared governance and the sustainable college. *International Journal of Sustainability in Higher Education*, **15(1)**, 63–83

Mebratu, D. (1998). Sustainability and sustainable development: historical and conceptual review, *Environmental Impact Assessment Review*, **18**, 493–520.

Munitlak Ivanovic O.., Golusin M. T., Dodic S. N., Dodic J. M. (2009). Perspectives of sustainable development in countries of Southeastern Europe, *Renewable and Sustainable Energy Reviews*, **13,** 2079–2087.

OECD Key Environmental Indicators 2004.

Rees W. (1992). Ecological footprint and appropriated carrying capacity: what urban economics leaves out, *Environment and Urbanization*. **4 (2)**, 121-130.

UNEP, SETAC (2009). Guıdelınes For Socıal Lıfe Cycle Assessment Of Products.

United Nations, UNCED – Division for Sustainable Development (1992). Agenda 21.

United Nations Department of Economic and Social Affairs; Division for Sustainable Development (1999). Work program on indicators of sustainable development of the commission on sustainable development.

United Nations, UNCED; Division for Sustainable Development. (2001) Indicators of sustainable development: guidelines and methodologies. Washington, USA

Wackernagel M, Rees W (1998). Our ecological footprint: reducing human impact on the earth, *The new catalyst bioregional series*, 9, *New Society Publishers*, Canada.

Wolman A., The metabolism of cities (1965) *Scientific American*, **213**, 179—190.

World Economic Forum's Global Leaders for Tomorrow (GLT) Environment Task Force, Yale Center for Environmental Law and Policy (YCELP), Columbia University Center for International Earth Science Information Network (CIESIN) (2001). 2001 Environmental Sustainability Index - Main Report.

http://www.footprintnetwork.org

http://www.urbanmetabolism.org/