ECO-EFFICIENCY INDICATORS FOR URBAN AREAS UNDER THE LIDERA SYSTEM

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Abstract

The goal of the presented study was to identify what eco-efficiency indicators (EI) (IE (*Indicadores de Eco-eficiência*)), characterize a specific area, and specially what their performance levels are, based on a rating Portuguese system, LiderA.

This study intended to prove that it is possible to develop eco-efficiency indicators for urban areas according to the LiderA system, and that the indicators can show the development in the search for sustainability, by helping to provide a benchmark for it.

After choosing ten areas of the LiderA system, a set of EI for urban areas were proposed, namely indicator of soil permeability, green spaces, energy consumption, water consumption, urban gardens, CO_2, waste produced, public transports, rail transports, footpaths and cycle paths, jobs and commercial areas.

These were first applied to three sustainable international communities, Viikkii, BedZED and SEFC, to evaluate their performance and register it as a reference. Afterwards, this set of indicators was applied to the case study of the “Póvoa Central Eco-bairro”, evaluating it with LiderA.

The initial hypotheses were confirmed, having the difficulty of establishing EI for some areas been recognized, given to its characteristics of a quantitative nature, and its necessity of normalization in order to originate effective comparisons.

Even though there may exist some discrepancy between the areas under focus, given to the specific characteristics of the area itself, or caused by factors inseparable of its region or country, it is accepted that there are always common factors which allow an effective comparison of the EI. These can also be considered easy to use by the ones responsible for, and by the planners of, urban areas.

Keywords: Eco-efficiency, indicators, sustainability, urban areas, rating systems

1. Introduction

The urban space has become in the preferencial place for social life. Currently, about 50% of world population lives in towns, whereas in Europe the proportion is close to 80 % (Boyd, cit. in Nunes, 2009).

Is expected that about 65% of world population will be living in urban areas by the year of 2025 In Portugal, this percentage stands at 45%, however, this proportion tends to increase. Cities occupy only 2% of the Earth's land surface, but they consume however, 75% of its resources (Dias, cit. in Nunes, 2009).

Since Local Agenda 21, to the Thematic Strategy on the Urban Environment included on the sixth Environment Action Programme, and to the "Estratégia Nacional de Desenvolvimento Sustentável" (National Strategy for Sustainable Development), stand out several international and national guidelines in order to counteract the impact of urban areas and promote sustainability in its scope.

The search for sustainability in urban areas goes through reordering of urban space, urban democratic administration, and by maintenance of existing stocks of natural resources (Bremer, cit. in Nunes, 2009), passing for example by sustainable construction.

The existing solutions in the built environment and how communities act are so, crucial to the pursuit of a good environmental performance, enabling it to achieve high environmental efficiency, namely eco-efficiency.

Promoting eco-efficiency in urban areas power these objectives, allowing the integration of sustainable development at the urban planning, assisting in the reduction of environmental impacts associated with buildings and urban areas.

2. The concept of eco-efficiency

The concept of eco-efficiency goes back to the 70's, when it was called "environmental efficiency", but evolves in the 90's to a corporation connection with sustainable development. It was introduced by the World Business Council for Sustainable Development (WBCSD), in 1992.

According to this, "eco-efficiency is achieved by making goods and services available at competitive prices, which satisfy human needs and contribute to quality of life, and on the other hand, progressively reduce ecological impact and the intensity of the use of resources through a cycle of life, until reaching a point that its at least compatible with the capacity of renovation estimated for planet Earth".

Eco-efficiency allows helping both corporations, as organs of sovereignty and other organizations to become more sustainable. It consists on an instrumental for sustainable development, which means, in a new management model, where less inputs are used, therefore causing less pollution, a reduction of waste and an account of the minimum costs possible (Cimino, 2002).

According to WBCSD or the Working Group of Experts on Internation Standards of Accounting and Reporting – United Nations Conference on Trade and Development (ISAR/UNCTAD), eco-efficiency can be expressed in two ways:

Table 1: Potential expressions for eco-efficiency

Eco-efficiency	
WBCSD	**ISAR/UNCTAD**
$\frac{Value\ of\ the\ product\ or\ service}{Impact/environmental\ influence}$	$\frac{Impact/environmental\ influence}{Value\ of\ the\ product\ or\ service}$

2.1. Eco-efficiency indicators

As stated by Nunes, autors like Boyd, Deelestra, Bell and Morse, and organizations such as the Organization for Economic Co-operation and Development (OECD), have defended the creation of criteria and indicators, as a necessary condition to the promotion of an integrated process of decision making that leads to sustainable development (Souza *et al*, cit. in Nunes, 2009).

In accordance with the definition of the OECD, an indicator consists in a figure that indicates, gives information, describes a phenomenon, the environmental quality or an area, meaning, however, more than what is directly associated with the said figure. An indicator quantifies and simplifies events or a phenomenon, helping to understand complex situations. In this sense, this type of tool has proved to be very useful in various levels of decision making.

It is necessary to highlight the difference between indicators and data or observed variables. Data or an observed variable becomes an indicator as long as its role in the evaluation of a certain phenomenon has been established (Tanguay *et al*, 2009).

Among environmental indicators, the indicators of environmental performance defined by the Global Reporting Initiative (GRI), the European Common Indicators (ECI), the indicators of generic application of environmental influence, and the indicators of environmental impact presented by the WBCSD, stand out.

The need to measure and quantify eco-efficiency thus resulted, in including the term “eco-efficiency indicators (EI)”. The WBSCD gathered practical and specific guidelines for corporation on how to implement eco-efficiency, presenting the EI as an instrument of measurement and communication of the environmental performance of the product or process (Salgado, 2004). According to the formula proposed by the WCSBD or by ISAR/UNCTAD, EI can be produced.

The use of EI allows both communication between the companies’ sectors and with other companies, a process known as benchmark[1]. The main goal is to improve the performance of the activity or process in question and monitor it with transparent measurements, verifiable, and therefore relevant, to managers and interested parties alike (WBSCD, cit. in Salgado, 2004).

[1] Search for best practices at a company or organization leading to a higher performance, disseminating it, creating a comparative process with other organizations.

The EIs and their levels can also be import in the process of benchmarking concerning urban areas.

Overall, the preference for the use of this type of indicators as come mainly from companies, but an ever growing preference for the use of this kind of tools for eco-efficiency evaluation on a regional scale has been shown, having appeared some initiatives on an European and worldwide level. Examples of this are the project “Life-Environment” ECOREG conducted in the region of Kymenlaakso in Finland, and the initiative “Eco-eficiência 2003”, which took place in the Autonomous Community of País Basco in Spain.

However, the regions studied proved to be heterogeneous, including segments of urban, rural or mainly industrial areas.

2.2. Eco-efficiency indicators in rating systems

A way of implementing environmental indicators and of eco-efficiency is to integrate them in systems of evaluation and deliberation, used to evaluate the sustainability of buildings, enterprises and urban areas.

Generally speaking, a system of performance evaluation for buildings constitutes a way to evaluate their environmental performance when confronted with a series of explicit criteria (Cole, cit. in Pinheiro, 2006). Meanwhile, new approaches have surged, which aimed the evaluation of sustainability reaching all the urban space, as, for example, the systems BREEAM Communities, LEED-ND and LiderA.

Concerning the analyzed systems, no distinct class named “indicators” is specified. In some cases, it is not possible to infer indicators for the criteria, being instead only referred measures and courses of action for their implementation than properly utilized methods for their evaluation.

Basically, in the BREEAM Communities and LEED-ND system, the indicators present themselves in their majority, in a qualitative nature, and only in some exceptions are presented units of measurement for usage. Percentage is the most recurring unit. It is also observed a reduced relativity of indicators.

It is verified that the LiderA system presents a greater number of indicators with a quantitative nature, as in more situations, the units of measurement to use.

We come to the conclusion that the majority of environmental indicators used by performance evaluation systems for urban areas cannot be generally considered EI, but still, important indicators susceptible to being used or modified under definition of urban area had been reviewed.

With the intent of measuring and monitor the sustainability along with reporting the development of urban zones, it is important to select them and show how relative they can be.

3. Set of eco-efficiency indicators proposed

In accordance with the reviewed environmental indicators, a set of indicators was established according to some thematic areas defined by the LiderA system. Both the eco-efficiency formula according to ISAR/UNCTAD and the one of WBCSD are equally valid mathematically and the choice of nominator and denominator can be based solely on what is common to use in the process in question (Muller & Sturm, 2001).

Was chosen the formula according to ISAR / UNCTAD due to the need for standardization, because only doing it allows creating a set of indicators that could provide an effective comparison between different urban areas. The added values used as the denominator held mainly to the economic and social. The numerator is related to the impact or influence on the environment caused by the services and activities in the urban area, and is associated with the value being added.

Table 2: Set of eco-efficiency indicators proposed

Area	Designation		Eco-efficiency indicators	Unit
Soil	**IE1**	Soil permeability	$\frac{Deployment\ area}{Urban\ area}$	m^2/m^2
Natural Ecosystem	**IE2**	Green spaces	$\frac{Green\ space\ area}{Urban\ area}$	m^2/m^2
Energy	**IE3**	Energy consumption	$\frac{Primary\ energy\ comsuption}{Builted\ area}$	Kgep/m^2GBA
Water	**IE4**	Water consumption	$\frac{Water\ consumption}{Inhabitant}$	l/inhab (/day)
Food	**IE5**	Urban gardens	$\frac{Community\ garden\ areas}{Inhabitant}$	m^2/inhab
Atmospheric emissions	**IE6**	CO_2	$\frac{CO_2\ e\ emissions}{Urban\ area}$	ton CO_2e/m^2 (/year)
Waste	**IE7**	Waste produced	$\frac{Amount\ of\ waste\ produced}{Inhabitant}$	Kg/inhab (/year)
Access for all	**IE8a**	Public transports	$\frac{Distance\ of\ public\ transport}{Inhabitant}$	m/inhab
	IE8b	Rail transports	$\frac{Distance\ to\ railway\ stations}{Inhabitant}$	m/inhab
	IE8c	Footpaths and cycle paths	$\frac{Distance\ of\ footpaths\ and\ cycle\ paths}{Inhabitant}$	m/inhab
Economic diversity	**IE9**	Jobs	$\frac{Number\ of\ local\ jobs}{Urban\ area}$	$jobs/km^2$
Amenities and social interaction	**IE10**	Commercial areas	$\frac{Business\ units\ area}{Urban\ area}$	m^2/m^2

The description, objective and urban aspect, such as the relevance of each indicator are set out below in Table 3.

Table 3: Short description of the indicators

Indicators	Objective and urban aspect
IE1	Verify the proportion of impervious areas on the total urban area. Encouraging the creation of an urban density and mesh, with regard for the existence of permeable important areas.
IE2	Verify the proportion of green space compared to the total urban area. Incentive to safeguard areas for green spaces within the urban mesh, reflecting a concern for biodiversity management.
IE3	Determine the primary energy consumed by urban area. Encourage greater energy efficiency on the demand side, allowing for reduced dependence on fossil fuels, maximizing the investment in renewable energy and increasing the contribution of these to the local energy balance.
IE4	Determine the amount of water consumed per capita in the urban area, translating a quantification of water requirements at the level of direct consumption. Promotion of measures to reduce water consumption level of the buildings, and invest in treatment systems in urban areas, such as collecting and storing rainwater.
IE5	Analyze the proportion of area granted for establishment of cultures of food production. Incentive to safeguard areas for food production within the urban mesh (use of space in buildings), and the organization of networks and community groups.
IE6	Measuring the amount of CO_2, N_2O and CH_4 emitted locally by urban area, taking into account the various local emission sources (energy, transport) in the form of CO_2 equivalent (local contribution to global climate change). Invest on the application of renewable energy technologies in-situ, passive performance systems, such as a good public transport network.
IE7	Check the amount of waste generated per capita. Encouraging the application of measures to raise awareness and reduce waste separation and bet on recycling systems in-situ.
IE8a	Analyze the availability of public transportation within the boundaries of the urban area per capita. Encouraging the establishment of good transport infrastructure and in their most frequency.
IE8b	Check the availability of public transport by rail near the urban area. Analyze the minimum required distance traveled per capita to reach a train station (from the edge of urban area). Encouraging the establishment of good transport infrastructure and investment in its high frequency.
IE8c	Check availability on footpaths and cycle paths in the urban area. Encouraging its inclusion as an integral part of urban structure.
IE9	Check the availability in local jobs for urban area. Encouragement of local employment.
IE10	Verify the proportion of commercial space per urban area. Incentive to safeguard spaces for trade within the built area.

Performance levels were established (Table 4), which resulted from application of these indicators based on information from three models of sustainable communities international reference: Viikki in Helsinki in Finland, Beddington Zero Energy Development (BedZED) in Beddington in the UK and Southeast False Creek (SEFC) in Vancouver, Canada. The reason for this choice was due to Viikki, being the pioneer community in the application of principles of construction and sustainable living, for BedZED, as a reference level of energy efficiency, and SEFC, being still in final completion of his project and thus at the forefront of the latest principles of sustainability.

The best performance levels achieved were chosen and they were corresponded to LiderA classes explained in Table 4. Only for CO_2 indicator was not able to be obtained a value for the three communities and it was decided to use a reference value for the County of Vila Franca de Xira (VFX).

Table 4: Reference levels of performance

Indicators	Performance levels	Achieved in:	Match to LiderA's classes
IE1	0,26 m^2/m^2	Viikki	(A++)
IE2	0,74 m^2/m^2	Viikki	(A++)
IE3	7,1 Kgep/m^2GBA (/year)	BedZED	(A++)
IE4	72 l/inhab (/day)	BedZED	(A)
IE5	83,5 m^2/inhab	Viikki	(A++)
IE6	9383,78 ton CO_2e/km^2	County of VFX	(E)
IE7	104 Kg/inhab (/year)	BedZED	(A++)
IE8a	2,96 m/inhab	SEFC	(A++)
IE8b	0 m/inhab	SEFC	(A++)
IE8c	7,59 m/inhab	SEFC	(A++)
IE9	18514,53 jobs/km^2	SEFC	(A++)
IE10	0,22 m^2/m^2	SEFC	(A++)

4. Application to the case study

This paper's approach was applied in the project entitled “Póvoa Central - uma eco-comunidade” (Póvoa Central - an eco-community) created by the instrument “Política de Cidades Polis XXI - Parcerias para a Regeneração Urbana” (Policy of Polis Cities XXI - Partnerships for Urban Regeneration), and the “Programas integrados de criação de eco-bairros”.

The indicators were applied in the situation of the ultimate achievement of the project and in accordance with the best performance of the proposed goals for the project.

For some indicators the determination for the case study could not be identical to the determination to the communities of Viikki, BedZED and SEFC due to lack of information.

For CO_2 indicator, with no *a priori* data on emissions of CO_2 or CO_2e for the study area, proceeded to the identification of major local emission sources in the area of intervention and determination of associated emissions. Was taken into account: the electricity household and services consumption, public electricity consumption and sources of emissions related to transport.

As for energy consumption indicator, wish regard to domestic energy consumption for the site, this information was not available, but there was for the County of VFX. As such, the consumption had to be obtained from there for the project area. For jobs and commercial areas indicators, the data collection had to be done based on inquiries in the area.

On Table 5 is presented the levels achieved in each indicator, and the resulting classes of the evaluation by LiderA.

Table 5: Results for each indicator and evaluation under LiderA system

Indicators	Result	LiderA evaluation
IE1	0,74 m^2/m^2	A
IE2	0,27 m^2/m^2	A
IE3	10,43 kgep/m^2ABC	A+
IE4	140 l/hab (/dia)	D
IE5	3,48 m^2/hab	G
IE6	9686,30 ton CO_2e/km^2	A+
IE7	342,23 Kg/hab (/ano)	D
IE8a	1,78 m/hab	A+
IE8b	0 m/hab	A++
IE8c	0,08 m/hab	G
IE9	1010,72 postos/ km^2	G
IE10	0,03 m^2/m^2	B

5. Discussion

Overall, there have been found greater constraints on the following indicators: energy consumption (IE3), CO_2 (IE6), public transports (IE8), jobs (IE9) and commercial areas (IE10).

It is assumed that for the energy consumption indicator, greater reliability of data from household electricity consumption in the study area could have been satisfied through the use of official data for the area, or from a sample made from local inquiries. Due to lack of time to make a reasonable number of inquiries, and logistics that would entail, this was not possible.

For transport accounted for CO_2 indicator would be much more reliable conduct a detailed study on the number of vehicles that cross the area daily, and to estimate this effect, rather than to perform based on the amount of fuel deriving from the fuel stations in the intervention zone.

We also emphasize the domestic consumption of natural gas, important share, that although the total emissions determined for the area are already high, much would contribute for those becoming higher. For lack of data this could not be counted for this indicator.

Also highlighted the temporal gap present in the calculations of different contributions to final CO_2 emissions accounted for CO_2 indicator. The energy consumption collected referred to the year 2008, consumption of public transport route in the area were for the year 2009, and the quantity of fuel provided by fuel stations reported to the current year.

At the level of IE8, and more specifically the public transports and Footpaths and cycle paths indicators (IE8a and IE8b), involving the study of transport availability in the area, were noted several limitations upon the establishment of these indicators. Key factors had to be kept outside, much due to the nature of quantitative indicators, namely:

- For IE8a: the frequency of transport was not considered. A result of this indicator may reflect a good performance at the distance that encompasses transport within the urban area, but they have a frequency insufficient to local inhabitants.

- For IE8b: there have been no accounts for the fact that can exist more than one train station, being only important the distance measure to this nearer. A community with more than one station near naturally has better transport availability. This happened in SEFC, but was not taken into consideration.

Under the concept of compact and multifunctional city and within the radius from 800 to 900 m (chosen in this study) it has been found that, in terms of transport they have a distribution on its route that requires movement always less than that distance. Concerning access to other basic goods (public services, schools, restaurants and others), the area presents with a broad distribution, and any defects could be offset by the introduction of "bus-ecológico" (gree-bus).

For jobs and commercial areas indicators (IE9 and IE10), the biggest shortcomings are related to the availability of time, which meant that the inquiries were subject to a short timescale and therefore was not made an integral survey of all commercial establishments. In the case of establishments closed temporarily there was no possibility, in some cases, to account for its contribution to the number of jobs or commercial area.

It is recognized the natural gap between the SEFC project, implemented over the root assumptions of urban sustainability, taking into account low impact mobility, a concern for economic diversity and the local amenities with a huge supply at these levels, and the project taken as a case study.

In general, certain methods used in this approach could have been done differently (and more specifically those related to energy consumption, CO_2, jobs and commercial areas), and certainly many of the results would be more reliable if the available time and resources had been greater.

For the other indicators, since the method for determination was the same as for Viikki, BedZED and SEFC or strictly based on data for the intervention area, the comparison between them and the case study, was certainly more reliable.

6. Conclusions

Regarding the initial hypotheses of this dissertation, even after taking into account the presented limitations, it is proved that it is possible to develop EI for urban areas, according to a performance evaluation system, LiderA. We also verify that the EI may show the performance in the search for sustainability, by helping to report it.

With this tool, the promotion of eco-efficiency in urban areas can improve the potential for the integration of sustainable development in urban planning, assisting in reducing environmental impact associated with built-up areas.

Even though there may exist some discrepancy between the areas under focus, given to the specific characteristics of the area itself, or caused by factors inseparable of its region or country, it is accepted that there are always common factors which allow an effective comparison of the EI. These can also be considered easy to use by the ones responsible for, and by the planners of, urban areas.

Nevertheless, these indicators do not cover all twenty-two areas covered by LiderA, which would be ideal for the structure of this type of approach. This is because the ten areas studied alone, may not be enough to evaluate all aspects of an urban area's sustainability.

The difficulty of establishing EI for some areas was recognized, given to its characteristics of a quantitative nature, and its necessity of normalization in order to originate an effective comparison.

It is agreed that the success of this type of approach is strictly dependent on an effective monitoring, specially of water and energy, for without them, a correct environmental management is impossible. In addition, it is also required that changes in different courses of action are taken when necessary, in order to achieve the outlined goals.

Overall, we verify that the project “Póvoa Central – uma eco-comunidade” presents good measures on an environmental, social and economical level. However, it is preferable to define objectives and goals which are more quantitative, adapting according to them, the type of action that should be taken.

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