IMPROVING ECO-EFFICIENCY OF THE BUILT ENVIRONMENT – TOOLS FOR LOCAL ACTION

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Even if a single town or a lone neighbourhood seems insignificant in terms of global phenomena, climate change, biodiversity losses and burdens on nature's regenerative capacity are always the results of local action. Numerous rating tools and accounting methods are already available for measuring neighbourhood eco-efficiency, regional carbon footprints and pollution loads, immediate levels of particulates in the air and regional material, energy and waste flows. However, the local developers of the built environment may find it difficult to select the tools that apply to the local conditions. In addition, due to a lack of standardisation and transparency, different tools assessing the same sectors of eco-efficiency may produce remarkably discordant results. Thus, the purpose of this study was to examine how regional eco-efficiency evaluation results can be uniformly compared and how the available eco-tools respond to the demands of urban development projects in Finland, which acted as a case country of the study being one of the Nordic countries. A collection of 37 available tools was reviewed and a functional toolbox was composed according to the expectations of the designers and constructors involved in improving the eco-efficiency of the built environment. The qualitative research was based on a comprehensive literature review, and some of the methods reported in grounded theory were utilised for analysing the data. As a result of the study it was stated that not only the individual tools evaluating different sectors of regional eco-efficiency could be improved but also that the already available sophisticated accounting methods of material flows, energy use and pollution loads could be added to the rating systems of neighbourhood eco-efficiency and built environment sustainability. In addition, ensuring the adoption of the principles of life cycle thinking into the whole framework of measuring local sustainability and regional eco-efficiency was found to be essential.

Keywords: eco-efficiency, environmental impact, evaluation tool, regional scale, sustainability, urban development project

INTRODUCTION

Worldwide economic growth and our high standards of living have been reached at the expense of the Earth's ecosystem preconditions and the planet's ability to sustain life (UNEP 2007; Rockström et al. 2009). The volumes of global material use and waste generation have grown to a point where we now consume at a faster pace than Earth's natural ecosystems can regenerate (WWF 2010). The increasing pressures on water supplies and reductions in arable land endanger the survival of the promptly multiplying world population (WWF 2010). Therefore, all around the world occurring ecological limits and natural resource constraints force us to improve the eco-efficiency of our living and actions. As well as local consumption causes global impacts; improvements in local environmental performance can make a difference. For example the worldwide depletion of fossil fuels supplies combined with detrimental loads of greenhouse gas emissions resulting in the imminent climate change is closely related to the local urban structures (EU 2009; Dodman 2009; Glaeser and Kahn 2010; Heinonen and Junnila 2011).

Individual people can improve the overall eco-efficiency by personal consumption and lifestyle choices. However, people may not be able to choose how long distances they have to travel to work and daily services or how energy-efficient and water-wise their homes and neighbourhoods are. On the other hand, even if local planning authorities and construction contractors built carbon-neutral buildings and smart public transport facilities the effect is negligible if they are not to gain the support of the inhabitants and to form a functional entirety (Flora and Millman 2011; Linstroth et al. 2011).

The concept of regional eco-efficiency and the tools for measuring eco-indicators of the built environment at the state, municipality, city, town and neighbourhood levels can enable government developers, city councils, local planning authorities, private construction contractors and consultant planners to co-operate with local inhabitants and neighbourhood community organisations for creating new green lifestyles in functional sustainable communities. Therefore, the regional greenhouse gas emission reduction targets and other local environmental goals can be achieved without undermining the inhabitants' quality of life (Flora and Millman 2011; Linstroth et al. 2011).

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The commercial organizations providing international certification systems of the built environment, such as British BREEAM, American LEED, Japanese CASBEE and Australian Green Star, have already addressed the challenge by developing neighbourhood scale versions of their rating tools (BRE Global 2011; USGBC 2009; IBEC 2007; GBCA 2011). However, different regions of the world vary greatly with regard to climate, legislative, cultural and ecological conditions. Thus, in the Nordic countries the international certification systems and rating tools typically tend not to take local conditions sufficiently into account (Retzlaff 2008). In Finland even the prerequisites of BREEAM for Communities or LEED for Neighborhood Development certification are sometimes infeasible (Säynäjoki et al. 2011).

As well, in the Nordic countries numerous rating tools and accounting methods are already available for measuring local air and water pollution loads, regional carbon footprints and ozone depleting substance emissions, immediate levels of particulates in the air and the regional use of energy and material resources, as well as for rating the eco-efficiency of a development project as a whole. However, due to a lack of national standardisation and overall transparency, different tools may produce remarkably discordant results. Therefore, guidance and consistency at a national level is needed for the local designers and developers to be able to select the relevant tools that apply to the development project in question and produce reliable results.

The purpose of this study was to examine how the available eco-efficiency evaluation tools respond to the demands of urban development projects in the Nordic conditions. In addition, the transparency and reliability of the eco-efficiency evaluation results and territorial emissions calculations were examined. As one of the Nordic countries, Finland acted as the case country of the study. The precise aims of the research were (1) to review the relevant eco-efficiency evaluation tools that are available in Finland, (2) to arrange the selection into a functional toolbox and (3) to estimate if the toolbox composed has potential to respond to the expectations of the developers involved in improving the eco-efficiency of the built environment in the Nordic countries.

STUDY DESIGN

Since the aims of this research were to review objects (tools), to analyse the reliability of the objects (tools) and to compose a selection of objects (a toolbox), which responds to the specific demands, qualitative methodology was relevant for conducting the study (Creswell 2009; Bryman and Bell 2011). The framework of this study was based on a comprehensive literature review. Additional data were collected by interviewing the developers of the tools examined. Of commercial tools plenty of data was available but it could not be considered as scientific knowledge or even as objective information. Therefore, critical approach was essential to discover the facts. As for the data, which was publicly available of the tools that are used for scientific research in Finland, was valid but scarce. Thus, access to the private documentation of developing and using the scientific tools was needed and obtained.

Especially the practitioners of grounded theory stress the importance of allowing theoretical ideas to emerge out of the data collected (Bryman and Bell 2011). In this study grounded theory was not used as a leading research strategy but some of the methods it has reported were utilised for analysing the data, which consisted of the documentation of developing, using, marketing and criticising the regional eco-efficiency evaluation tools available in Finland. Multiple matrixes were availed for organising and analysing the data, in other words for reviewing, conceptualising and comparing the features of the tools. Since the criteria of the regional eco-efficiency are not unambiguous, it is essential to mention that the eco-indicators used in this study are based on the results of a recent Finnish regional eco-efficiency specification study, the report of which is to be published shortly (Lahti et al. 2011). The authors of this paper have participated in the specification research mentioned above.

REVIEWING THE AVAILABLE TOOLS

From a global point of view a myriad of rating tools and accounting methods is available for assessing regional eco-efficiency of the built environment. However, in the Nordic countries the reliability of the assessments requires the tools in use to apply to the local conditions. In addition, to be credible, the methods should be transparent and thoroughly examinable. Based on the two conditions mentioned above, altogether 37 eco-efficiency evaluation tools were listed to possibly have potential to be useful in Finland. Nevertheless, in some cases the lack of transparency was compensated by international esteem or the inadequate applicability to the Nordic conditions was set off by the potential of creating a Nordic version of the international rating tool in question.

The accounting methods were examined thoroughly and the features of the tools were arranged into a table, which specifies (1) what kind of development projects the tools apply to, (2) how the tools evaluate the eco-efficiency of the built environment, and (3) which environmental impacts caused and which utilities produced the tools can recognise. The table itemises for example the cognitions of site location, traffic, infrastructure availability, building procedures, energy efficiency, water management, material use, recycling and waste management, pollution, biodiversity, green zones, social services and safety issues. Altogether 40 features of each tool were examined and recorded. The entire table of reviewing the available tools will be published in December 2011 as a part of a regional eco-efficiency assessment research project called KEKO – Regional eco-tools for Finnish cities and municipalities.

COMPOSING A FUNCTIONAL TOOLBOX

After the in depth examination of the tools they were arranged into a toolbox. A new table was divided into eight sections that represent the pigeonholes of a convenient toolbox. The column partition of the toolbox table refers to the specific eco-efficiency evaluation objects of the tools and is based on the recent Finnish specification study mentioned above (Lahti et al. 2011). The row partition, in turn, refers to the area broadness the tools apply to within the regional built environment scale and is based on the results of reviewing the available tools. The sections of the toolbox composed are shown in Table 1.

Table 1: The eight sections of the toolbox composed

The toolbox	(1) Total eco-efficiency	(2) Broader sustainability	(3) Material and energy flows	(4) Pollution loads and environmental impacts
Area level A	Section 1A	Section 2A	Section 3A	Section 4A
Area level B	Section 1B	Section 2B	Section 3B	Section 4B

Within this study (see Table 1), the difference between "(1) total eco-efficiency" and "(2) broader sustainability" is that the latter encompasses not only the environmental impacts caused in respect of the utilities produced but also some social and economic dimensions of sustainability. Since one function of the toolbox is to show all the alternatives that are relevant to a specific user's request, the tools are allowed to lie in multiple sections.

The expectations of the potential users

For making the toolbox more functional advised information of the tools included was produced for the developers involved in improving the eco-efficiency of the built environment in Finland. Thus, a discussion meeting on the expectations of the potential users of the toolbox was organised in June 2011. In all, the Ministry of the Environment, the cities of Helsinki, Espoo, Vantaa, Tampere, Lahti, Kuopio and Joensuu, the construction companies Skanska and YIT, the Finnish Funding Agency for Technology and Innovation, the Technical Research Centre of Finland, Finnish Environment Institute and Aalto University were represented in the discussion. According to the results of the discussion the pieces of information of the tool features that were found to be most relevant for the designers and constructors involved in improving the eco-efficiency of the built environment were produced and attached into the toolbox table.

CRITIQUE OF THE TOOLBOX COMPOSED

The shortages and the imperfections of the toolbox were reviewed and analysed for critically estimating if the toolbox composed has potential to be used for improving the eco-efficiency of the built environment in Finland and in other Nordic countries. In this stage the features of individual tools were not analysed any longer but instead the composition of the toolbox was assessed closer.

FINDINGS

The findings consist of the results of three separate investigation stages that are described in more detail above in the study design section. The three stages are reviewing the available tools, composing a functional toolbox and critique of the toolbox composed.

REVIEWING THE AVAILABLE TOOLS

The 37 eco-tools found to possibly have potential to be useful in estimating and improving the regional eco-efficiency of various Nordic urban development projects are: Aalto hybrid LCA model, Beyond Vuores, BREEAM for Communities, CASBEE-City, CASBEE for Urban Development, CitySim, EcoBalance, Ecocity, Ecocity Evaluator, EcoProp, ECOREG, EkoPassi, ENVIMAT, EU GPP, EU Ecolabel, FRES, Green Star Communities, HEKO, KASVENER, KUHILAS, KULE, KulMaKunta, KylaPassi, LEED for Neighborhood Development, LIPASTO, MenTouGou, Metka, Nordic Ecolabel, PIMWAG, PromisE, Rakentajan Ekolaskuri, Seutukeke, SYNERGIA, Urban Zone, WinEtana, YKEVAKA and YKR.

What kind of development projects the tools apply to

In the review table the regional scale, to which the tools were expected to apply, is divided into five levels. The applicability of the 37 tools to these levels of regional eco-efficiency evaluation is shown in Table 2.

Table 2: The number of tools applying to the five levels of the regional scale

(1) State level:	(2) City level:	(3) Municipality level:	(4) Town level:	(5) Neighbourhood level:
12 tools	17 tools	17 tools	22 tools	24 tools

Five tools were found not to apply to the regional scale at all, including SYNERGIA, EU GPP, EU Ecolabel, Nordic Ecolabel and Rakentajan Ekolaskuri. Therefore, they were rejected from further examination after the first investigation stage. Remarkably, virtually the same tools were found to apply either to all state, city and municipality levels or to both town and neighbourhood levels. Thus, for composing a toolbox, the first three levels were unified into (A) State, city and municipality level and the latter two levels into (B) Town and neighbourhood level.

How the tools evaluate the eco-efficiency of the built environment

Both residential and commercial buildings are included in the regional eco-efficiency evaluation by more than three quarters of the tools. The matrix of different tools covers inclusively maintenance and building retrofit as well as material use and recycling, waters and waste management, lightning, heating, cooling and additional use of electricity at all the five regional levels. Similarly, site location and traffic related issues are assessed by approximately three quarters of the tools, at least in some aspects, at all the regional levels. In addition to the environmental impact assessment, the tools evaluate the availability of public transport and the safety issues related to the local traffic conditions. However, only half of the tools observe the infrastructure available.

Which environmental impacts caused and utilities produced the tools can recognize

Of the environmental impact perpetrators energy efficiency, waste management and greenhouse gas emissions are covered by more than three quarters of the tools. In addition, other emissions than greenhouse gases, the share of renewable energy sources, material efficiency and biodiversity sensitiveness are covered by approximately half of the tools. In contrast, only one third of the tools were found to evaluate the utilities produced, that is to say the second half of regional eco-efficiency.

COMPOSING A FUNCTIONAL TOOLBOX

According to the results of the previous investigation stage, which was reviewing the available tools, 32 eco-tools were positioned into the eight sections of a new toolbox table, which is displayed as Table 3.

Table 3: The tools included in the toolbox

The toolbox	1: Total eco-efficiency	2: Broader sustainability	3: Material and energy flows	4: Pollution loads and environmental impacts
A – State, city and municipality level	KulMaKunta; Metka; YKEVAKA	CASBEE-City; ECOREG; Seutukeke	CitySim; ENVIMAT; FRES; KASVENER; KUHILAS; LIPASTO; YKR	Aalto Hybrid LCA, Ecocity Evaluator; ENVIMAT; FRES; KASVENER; KUHILAS; LIPASTO; Urban Zone
B – Town and neighbourhood level	EcoBalance; Ekopassi; HEKO; Kylapassi; PIMWAG	Beyond Vuores; BREEAM for Communities; CASBEE-UD; Ecocity; EcoProp; Green Star Communities; LEED-ND; MenTouGou; PromisE	KULE; WinEtana; YKR	Ecocity Evaluator; Urban Zone

Only a few tools apply to both A- and B-levels. However, many are found to have development potential to cover wider regional scale in the future. Table 3 shows that the total eco-efficiency rating tools and even broader targeted sustainable development assessment schemes cover sufficiently B-level and are swiftly spreading out to A-level. For example CASBEE published at first the UD-tool for B-level and at once the City-tool for A-level. In contrast, most of the accounting methods for measuring local energy, material and waste flows and regional carbon footprints and pollution loads have originally been developed for A-level and not yet been widely adopted to B-level, which requires more specific data and measurements.

According to the expectations discussion, which is described in more detail above in the study design section, the potential users of the toolbox appear to prioritize the effortless information of the function, the usability and the expenses of the alternative tools. In addition, the life-cycle perspective, the reliability and the uncertainties of the tools appear to be of the potential users' interest. Thus, of each tool a few sentences were written to answer to the questions that are shown in Table 4.

Table 4: The advised information the toolbox entails

The toolbox	1: Total eco-efficiency	2: Broader sustainability	3: Material and energy flows	4: Pollution loads and environmental impacts
Both A – State, city and municipality level and B – Town and neighbourhood level	What exactly can be evaluated by the application?		What exactly can be calculated by the application?	
	How does the application transform the different sectors of regional eco-efficiency to commensurate items?		How conscientiously does the method follow the principles of life cycle thinking?	
	What are the strengths and weaknesses of the tool? How can the reliability of the assessment be confirmed and what are the most significant uncertainties?			
	How simple and easy is the tool to use and what are the costs of the evaluation?			

According to the information the toolbox composed contains, each one of the tools could be improved. However, the most prominent finding was that the sophisticated methods for measuring material and energy flows, regional carbon footprints, other pollution loads and environmental impacts are not widely utilised in rating the total eco-efficiency or broader sustainability of the built environment. In addition, the life cycle thinking was found to be essential to adopt into the whole framework of rating regional eco-efficiency and sustainability.

CRITIQUE OF THE TOOLBOX COMPOSED

The toolbox composed is not a complete end product but a functional selection of what is already available for the designers and constructors involved in improving the eco-efficiency of the built environment. Most of the tools were found to have potential to be improved to better respond to the demands of Nordic urban development projects now and in the future. The advised information the toolbox entails of the function, the usability, the expenses, the life-cycle perspective, the reliability and the uncertainties of the tools as well as the contents of the first evaluation table, which was used for reviewing the available tools, can be utilised for improving the tools.

Majority of the eco-tools in the toolbox have been designed to apply to the Finnish conditions. Although, from a global point of view, the local conditions in all the other Nordic countries are rather similar to those in Finland. In general, the modifications that are needed for making the Finnish tools applicable to the other Nordic countries are minor to those that are essential for transforming the international rating systems to the forms that gracefully apply to the local conditions in the Northern Europe. Besides, the toolbox includes the most renowned international rating systems as well.

DISCUSSION

The purpose of this study was to investigate how the available eco-efficiency evaluation tools respond to the demands of urban development projects in the Nordic countries and to examine how transparent and reliable the eco-efficiency evaluation results are. There are several publications of the principles of measuring regional eco-efficiency in general (for example: Huppes and Ishikawa 2005; Kitzes et al. 2009; Li et al. 2010) as well as of continent specifications of the research field (for example: Wursthorn et al. 2011; Parshall et al. 2010) and of measuring eco-efficiency within case areas (for example: Schultz 2007; Penela and Villasante 2008). However, the Nordic point of view to the regional eco-efficiency assessment is not widely documented.

The results of this study both add to the scientific knowledge of measuring regional eco-efficiency and offer practical advice for the designers and constructors involved in improving the eco-efficiency of the built environment in the Nordic countries. Overall 37 eco-tools were found to possibly have potential to be useful for the Nordic urban development projects. 40 features of each tool were examined and documented to build a picture of the field. Based on the investigation a toolbox of 32 items was composed and described. Additional information of the tools' methodological and practical features was produced to make the toolbox more functional for the potential users. Eventually, the toolbox composed was judged not to be a complete end product but a functional selection of what is already available.

Since the life cycle thinking and a coherent allocation of the measurements of regional environmental loads to production and consumption based quantifications is not yet a standard in regional eco-efficiency evaluation methods, the toolbox composed in this study is not seamless. Nevertheless, the tools can be ranked and improved according to the analysis conducted. For example, as for the regional greenhouse gases, most of the assessing tools in the toolbox are already able to divide the emissions calculations to production and consumption based bodies. In addition, the recent improvements in eco-tool development seem to strengthen the life cycle point of view. However, the separated pieces of knowledge should be integrated into the overall rating systems of eco-efficiency and broader sustainability of the built environment. Therefore, the main objective for further research is to improve the quality and diminish the number of tools in the toolbox by combining the strengths of multiple methods.

According to Udo de Haes et al. (2004) creating one super tool with too many data and resource requirements is always a risk and thus composing a toolbox offers most flexibility regarding spatial and temporal information and the inclusion of multiple environmental impacts. Therefore, a safe option is to develop a seamless toolbox, which includes a few tools that can operate both solo and together.

A few issues are important to mention in revising the study. As for the different levels of the regional measurement scale, since the population density in the Nordic countries is extremely low the mentioned levels of state, municipality, city, town and neighbourhood representing the local setting are not of international standard. For example a Finnish town may have less than 1500 inhabitants (Regional Council of Ostrobothnia 2011). Besides, any toolbox composed is a product of temporary circumstances. However, the validity of the scientific knowledge produced aside is not to similarly get on. In addition, also incomplete and developable tools were selected into the toolbox to enhance the lifespan of the selection.

Recent improvements in regional greenhouse gas emissions measuring are remarkably widely documented (for example: Ramaswami et al. 2008; Brown et al. 2009; Salon et al. 2010; Heinonen et al. 2011). Since climate change has a privileged position in regional eco-efficiency evaluations there is a risk that the local actions for diminishing urban carbon footprints may cause environmental impacts we do not recognise. Therefore, stabilising the eco-efficiency evaluation toolboxes to cover more different sectors of eco-efficiency more comprehensively is essential for sincerely developing greener communities. Many of the greenhouse gas calculation tools have potential to be developed to measure multiple emissions and thus multiple environmental impacts.

CONCLUSIONS

The study suggests that since different regions of the world vary greatly with regard to climate, legislative, cultural and ecological conditions, it is worthwhile to survey and develop the scientific knowledge and practical tools that apply only to limited local conditions. As for improving regional eco-efficiency in the Nordic countries, the international rating systems can be benefited but local knowledge and precise tools are essential for a secure success.

Even the locality-focused research generally produces certain insights that add to the common knowledge of the eco-efficiency evaluation of the built environment. Besides, composing a local toolbox of the most relevant applications available is only the first step of learning to manage regional eco-efficiency. Additional scientific data of the details and the new aspects of improving regional eco-efficiency are produced perpetually (for example: Galli et al. 2001; Hauschild et al. 2011). The challenge for the small nations and communities is to adopt the voluminous beneficial international knowledge without losing the local focus.

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