Abstract

A comprehensive assessment tool of the built environment of cities, referred to as "CASBEE-City™ (Low Carbon Type)", is now under development in Japan to support local governments and other stakeholders in identifying environmental, social and economic characteristics of their cities and to quantify the effectiveness of environmental policies. CASBEE-City implements the concept of environmental efficiency and allows evaluation of a city from two aspects: the aspect of decreasing negative environmental load emitted outside the city, and the aspect of improving environmental quality and activities inside the city.

The target of this thesis is to make an original and unique approach to the possibility to import the CASBBE-City manual to other countries outside Japan. This possibility is studied through the implementation of the CASBEE-city methodology to the cities of Madrid and Barcelona. Until now, several indicators regarding sustainability have been measured and analyzed in both cities during the last years. Spanish local governments have been implementing various environmental policies towards sustainable improvements in the cities. However, many countries such as Spain have not established methodology to evaluate the efforts and achievements obtained.

Therefore, this thesis develops an evaluation of the effectiveness of Spanish environmental policies according to CASBEE-City with the idea to provide the platform for cities and ministries to cooperate in studying on topics of importance in redevelopment of existing urban areas.

題目は「CASBEEによるスペインの都市の環境効率評価」です。従来、スペインの自治体は持続可能性を向上させるために様々な環境政策を実施してきました。しかし、スペインをはじめ多くの国々はこうした政策努力やその効果を評価する方法論を確立できていません。そこで、私は日本の環境性能評価ツールCASBEE都市の方法論に基づき、スペインの都市の環境政策を評価することを試みました。

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4. Introduction

Sustainability is highly linked to human well-being and economic development. Although scientists can predict some of the future impacts of global climate change, other effects will take place completely unexpectedly. Hence, the need arises to develop an assessment tool to visualize the environmental performance of cities as a whole, in order to be able to expose the weaknesses of local environmental policies towards sustainability. Nowadays, the development of suitable indicators for evaluation and the sharing of this information are allowing to plan and promote regional and national initiatives unto developing low-carbon cities.

4.1. Scope and objectives of the report

The aim of this final thesis, »Environmental Efficiency Assessment on Spanish Urban Settings Applying CASBEE methodology« is to apply an original and certified assessment tool which involves scoring performance and derivation of weightings in order to evaluate urban settings. The assessment tool used in this thesis is CASBBE-City, developed in Japan under the initiative of the Japan Sustainable Building Consortium. CASBEE stands for Comprehensive Assessment system for Built Environment Efficiency and it is a cooperative project between industry, government and academia. The city evaluation consists of giving a score for environmental efficiency based on CO2 emissions and environmental quality. CASBEE, which is based on the concept of Eco-efficiency, is nowadays widely used in the societies of government, industry and academia of Japan. As this assessment tool was designed for Japanese cities, the goal of this thesis is also to analyze how successful is the assessment of non-Japanese cities like Madrid and Barcelona applying the CASBBE-City methodology. The target is to make an original and unique approach to the possibility to import the CASBBE-City manual to other countries outside Japan.

The development of the thesis took place in Ikaga's professor laboratory located in the faculty of Science and Technology of Keio University and was extremely attached to the development of the CASBBE-City manual itself. Under this circumstances, the evaluation and score level calculation for the Spanish cities of Madrid and Barcelona is referred to the national Japanese benchmarks.

5. CASBEE

5.1. Background

Since the settlement of the leading UK Building Research Establishment Environmental Assessment Method (BREEAM) in 1990, numerous other methodologies to assess buildings have been developed worldwide such as LEEDTM (Leadership in Energy and Environment Design) in the USA, and GB Tool (Green Building Tool) as an international project. In Spain, an initiative named VERDE was developed by the Arquitectos, Urbanistas e Ingenieros Asociados. This tool is directed at new residential, offices, commercial, hotels, hospitals and educational buildings.

In Japan, a cooperative project between industry, government and academia with the assistance of Japanese Housing Bureau, Ministry of Land, Infrastructure, Transport and Tourism led to the establishment of a new organization, the Japan Sustainable Building Consortium (JSBC), with its secretariat administered by the Institute for Building Environment and Energy Conservation (IBEC). This organization developed the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE). Today, the enhancement and diffusion of CASBEE are being promoted under the MLIT Environmental Action Plan (June 2004) and the Kyoto Protocol Target Achievement Plan (approved by the Cabinet on April 28, 2005) 10. In recent years, CASBEE has been quickly adopted by major local governments nation-wide. Consequently, environmental performance assessment of buildings in now carried out in many buildings in Japan. CASBEE assessment methodology has attracted a great deal of attention worldwide because of its clear concept. After the publication of »Housing and Building scale CASBEE manuals« and therefore, once being experienced with assessing individual buildings, CASBEE for Urban Development (CASBEE-UD) which covers groups of buildings, was released in 2006. The Japan Sustainable Building Consortium does not have a declared position regarding the promotion or use of CASBEE outside Japan. To date, the CASBEE manuals have been translated into Chinese, Korean and English [2].

CASBEE is composed of four assessment tools corresponding to the building lifecycle. "CASBEE Family" is the collective name for these four tools and the expanded tools for specific purposes. The CASBEE assessment tools are CASBEE for Pre-design, CASBEE for New Construction, CASBEE for Existing Building and CASBEE for Renovation, to serve at each stage of the design process. Each tool is intended for a separate purpose and target user, and is designed to accommodate a wide range of uses (offices, schools, apartments, etc.) in the evaluated buildings.[7]

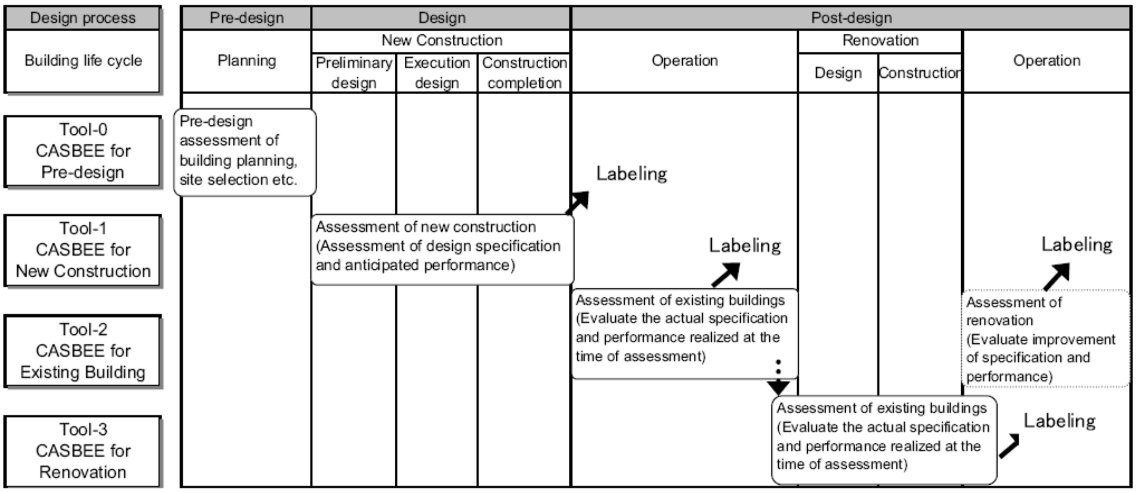

Fig. 1 Building Lifecycle

- **CASBEE for Pre-design** *(underdevelopment)*

This tool aims to assist the owner, planner and others involved at the planning (pre-design) stage of the project. It has two main roles:

1) To assist in grasping issues such as the basic environmental impact of the project and selecting a suitable site.

2) To evaluate the environmental performance of the project at the Pre-design stage.

- **CASBEE for New Construction**

This is a self-assessment check system that allows architects and engineers to raise the BEE value of the building under consideration during its design process. It makes assessments based on the design specification and the anticipated performance. It can also serve as a labeling tool when the building is subjected to expert third-party assessment. Remodeling and replacement construction are evaluated under "CASBEE for New Construction."

- **CASBEE for Existing Building**

This assessment tool targets existing building stock, based on operation records for at least one year after completion. It was developed to be applicable to asset assessment as well.

- **CASBEE for Renovation**

There is growing demand for building stock renovation, especially in Japanese market. In the same way as "CASBEE for Existing Building," this tool targets existing buildings. It can be used to generate proposals for building operation monitoring, commissioning and upgrade design with a view to ESCO (Energy Service Company) projects, which will be increasingly important in future, and for building stock renovation. This tool is designed for ascertaining the degree of improvement (increased BEE), relative to the level that preceded renovation. Labeling is also possible by third-party agencies.

5.2. CASBEE for cities

The first European Conference on Sustainable Cities and Towns Towards Sustainability took place in Aalborg on 27 May 1994. The conference adopted the Aalborg Charter, which provides a framework for the delivery of local sustainable development, and calls on local authorities to engage in Local Agenda 21 processes. The following conferences on the same topic took place in Lisbon (1996), Hannover (2000), Aalborg (2004), Sevilla (2007) and Dunkerque (2010). The European Community signed the Kyoto Protocol on 29 April 1998. Spain approved Kyoto's Protocol measures on 2002 after depositing the instruments of ratification.

In Japan, the Japanese Regional Revitalization Bureau set up the Eco Model Cities (EMC) program [3], selecting 13 cities (6 cities were originally selected in 2008 and 7 more cities were selected in 2009) that have developed pioneering initiatives which focus on the application of policies and measures in the process of a low-carbon society development. In order to verify the effectiveness of policies established along the EMC program it is important to keep monitoring the environmental status of cities. Taking into account that there are not established methodologies to perform this status updating, the JSBC decided to apply the methodology of CASBEE in order to develop a new assessment tool specifically designed for cities [4].

In 2008 began the development of the idea about a new manual of the CASBEE family regarding city scale under the initiative of the Japan Sustainable Building Consortium (JSBC). CASBEE-City, now under development in Japan is a stand-alone system, independent of whether a building-scale or a CASBEE for Urban Development assessment has been made before. CASBEE-City uses the scalability of CASBEE beyond individual buildings to assess the environmental performance of whole cities by using a triple bottom line approach. Evaluating the effectiveness of city policies focusing into the environmental, social and economic aspects it will help the administration, the citizens and the industry sector to understand the current situation and to cooperate towards a common achievement.

5.2.1. Assessment methodology

CASBEE-City implements the concept of environmental efficiency and allows evaluation of a city from two aspects: the aspect of decreasing negative environmental load (L) emitted outside the city, and the aspect of improving environmental quality (Q) and activities inside the city.

In order to define the terms Q and L used in the Built Environment Efficiency (BEE) definition (Equation 1), the new concept of hypothetical boundary at the site boundary is introduced, as shown in Fig. 2.

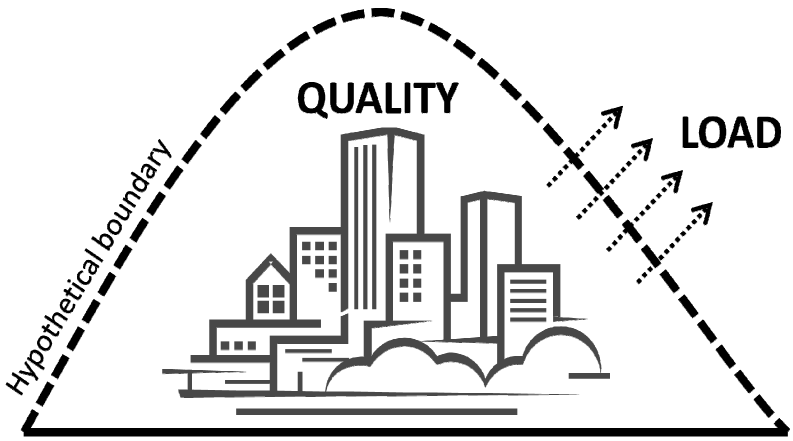

Fig. 2 The hypothetical boundary implemented in CASBEE-City

Category “Q” is assessed as the improvement of environmental quality within the virtual enclosed space and it is composed of Q1: Environmental aspects, Q2: Social aspects and Q3: Economic aspects. Category “L” is assessed as the negative impact on the environment outside the virtual enclosed space and it is composed of L1: Greenhouse gas emissions (per year, per capita), L2: Environmental load reduction and CO_2 absorption and L3: Support to other regions for reducing CO_2 emissions.

As explained above, BEE (Building Environmental Efficiency), using Q and L as the two assessment categories, is the core concept of CASBEE.

BEE is an indicator calculated from Q (building environmental quality) as the numerator and L (building environmental load) as the denominator.

$$BEE = \frac{\textbf{Score for Environmental Quality (Q)}}{\textbf{Score for Environmental Load (L)}}$$

Equation 1 Built Environment Efficiency

In order to provide a more clear analysis of the city's environmental policies efficiency, a 2D graph is provided in the CASBEE manuals, with Q on the vertical axis and L on the horizontal axis. The gradient of the straight line joining the origin (Q=0, L=0) to the point with the coordinates defined by the Q and L values is the BEE value. The higher the Q value and the lower the L value, the steeper the gradient and the more sustainable the subject is. The illustration plots L and Q values in a scale from 0 to 100 points as shown in Fig. 3. City's performance is summarized by an overall environmental rating of "C", "B-", "B+", "A" or the highest "S" (Sustainable)[5]. By comparing the past, current and future projected values, CASBEE-City quantitatively evaluates the potential effectiveness of city policies [4], as seen in Fig. 5.

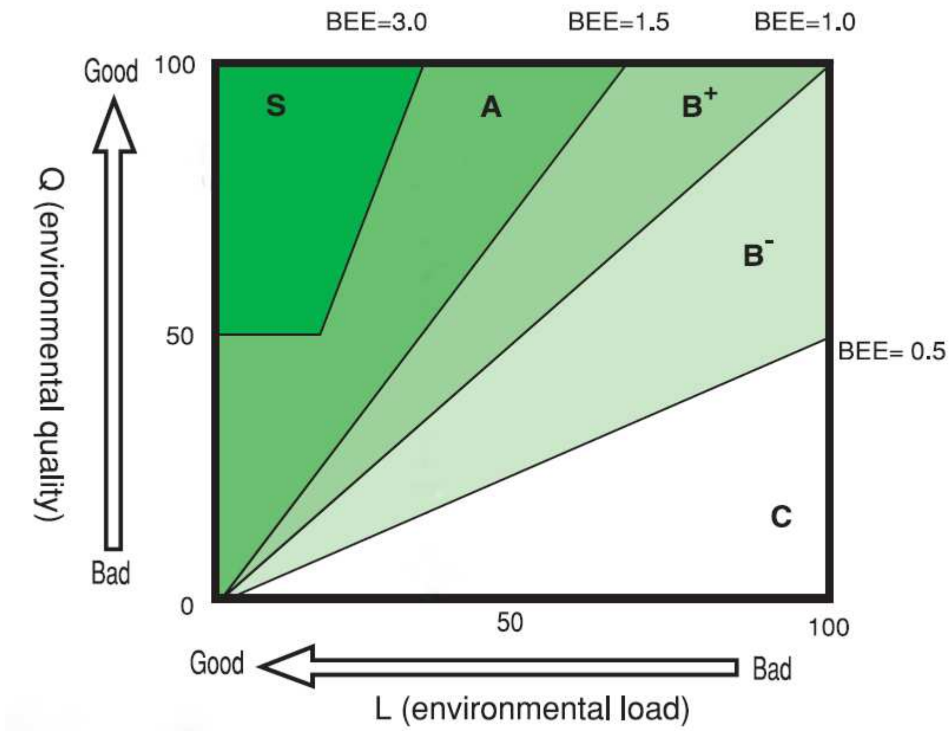

Fig. 3 BEE 2D graph

Ranks	Assessment	BEE value, etc.	Expressions
S	Excellent	BEE=3.0 or more, Q=50 or more	★★★★★
A	Very Good	BEE=1.5~3.0	★★★★
B+	Good	BEE=1.0~1.5	★★★
B-	Fairly Poor	BEE=0.5~1.0	★★
C	Poor	BEE=less than 0.5	★

Fig. 4 Correspondence between ranks based on BEE values

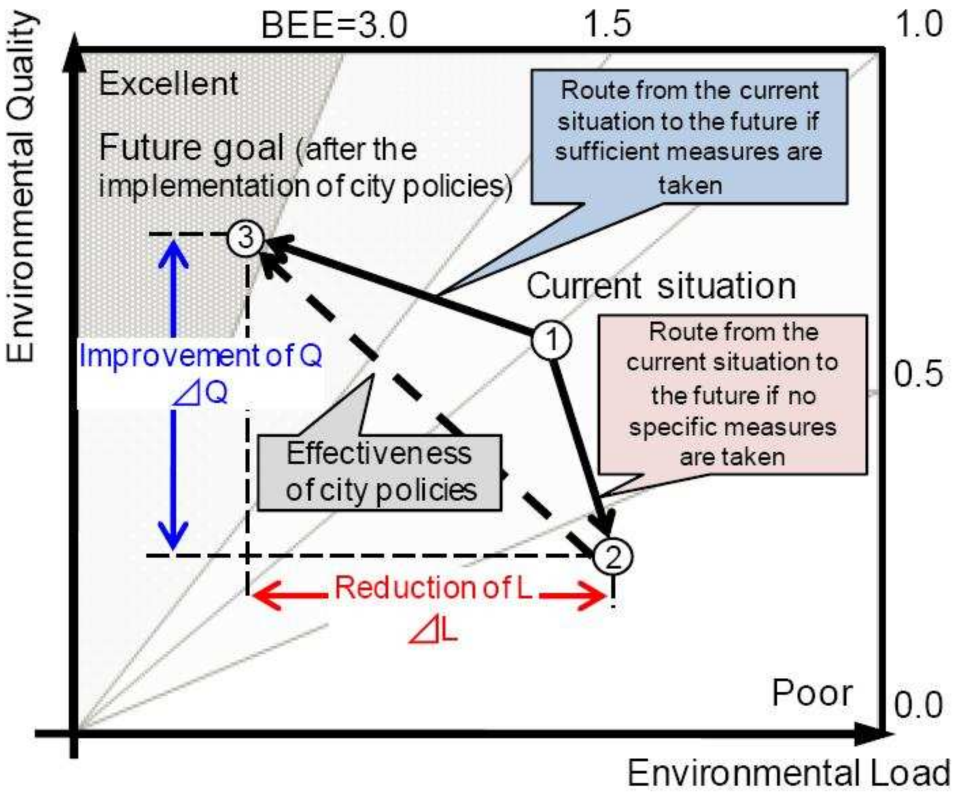

Fig. 5 Visualization of assessment results for a city

5.2.2. List of indicators analyzed

CASBEE covers the following four assessment fields: (1) Energy efficiency (2) Resource efficiency (3) Local environment (4) Indoor environment. These four fields are largely the same as the target fields for the existing assessment tools described above in Japan and abroad, but they do not necessarily represent the same concepts, so it is difficult to deal with them on the same basis. Therefore the assessment categories contained within these four fields had to be examined and reorganized.[7]

Since 2008 the CASBEE-City Development Committee has been developing the list of indicators that should be taking into account when calculating the BEE score value of a city. First of all, a list of 1030 environmental, social and economic indicators was categorized from assessment existing tools. From this list, 630 indicators were gathered from worldwide data bases and the other 400 indicators were belonging to Japanese data base. In order to reduce the list of indicators to a more reasonable number of aspects to consider, a group of Japanese local and national government officers, construction companies employees, professors, students and urban planners settled a schedule of meetings. The first phase of the meetings took place in December 2008 and June 2009 and the list of indicators was reduced to the number of 36. The second phase of meetings, which is still under development, took place in July 2009, October 2009, February 2010 and May 2010. At the moment this thesis is written the list of indicators selected during the second phase meetings is the one showed below.

Q1.Environmental aspects
1-1 Nature conservation 1-1-1 Natural land use
1-2 Environmental quality 1-2-1 Air quality 1-2-2 Water quality 1-2-3 Noise 1-2-4 Dioxines
1-3 Resource recycling 1-3-1 Recycling of waste
1-4 Environmental measures 1-4-1 Efforts and policies for the environment and biodiversity
Q2. Social aspects
2-1 Living environment 2-1-1 Quality of housing 2-1-2 Parks and other facilities 2-1-3 Sewage systems

2-1-4 Traffic safety 2-1-5 Crime prevention
2-2 Social services 2-2-1 Education services 2-2-2 Cultural services 2-2-3 Medical services 2-2-4 Child care services 2-2-5 Services for the disabled 2-2-6 Services for the elderly
2-3 Social vitality 2-3-1 Rate of population change due to births and deaths 2-3-2 Rate of population change due to migration 2-3-3 Rate of informatization 2-3-4 Efforts and policies for injecting vitality into society
Q3. Economic aspects
3-1 Industrial vitality 3-1-1 Gross regional products 3-1-2 Number of employees
3-2 Economic exchanges 3-2-1 Number of visitors 3-2-2 Public transportation
3-3 Financial viability 3-3-1 Tax revenues 3-3-2 Outstanding local bonds
L1. GHG emissions
1-1 CO2 from energy sources 1-1-1 Industrial sector 1-1-2 Residential sector 1-1-3 Commercial sector 1-1-4 Transportation sector 1-1-5 Energy conversion sector
1-2 Industrial processes
1-3 Waste disposal sector
1-4 Agriculture sector
1-5 Other GHGs (HFCs, PFCs, SF6)

Table 1 List of selected indicators

5.2.3. Scoring methodology

In order to calculate the BEE value and therefore the Quality(Q) and Load(L) values, each main indicator category (Q1, Q2, Q3, L1, L2 and L3) was given a relevant weight. This weight was decided after an Analytic Hierarchy Process (AHP) that provided an external company from the CASBEE-City Development Committee. During the AHP study, 25000 Japanese government officers, workers and citizens were asked to score the significance of each one of the indicators according to their own criteria. From the AHP study conducted, the following weight values were obtained.

Q1.Environmental aspects	0,45
Q2.Social aspects	0,30
Q1.Economic aspects	0,25
TOTAL	1

L1. GHG emissions	1
TOTAL	1

Table 2 Indicators weighting coefficients

Each one of the main indicators was studied taking into account subindicators previously and accurately organized (third category indicators such as 1-1-1 Natural land use). Grading is on five levels 1-5, with level 3 as the reference score.

- Level 1: The minimum required conditions stipulated by related laws and ordinances are satisfied.
- Level 3: Judged to be generally equivalent to the technical and social level at the time of assessment.
- Level 5: Judged to be generally equivalent to the highest technical and social level at the time of assessment.

Levels 2 and 4 are interpolated between 1 and 3, and between 3 and 5, respectively.

According to the data analysis of 1800 Japanese cities, the benchmarks levels were decided using the histogram (see Fig. 6) and the pertinent accumulative curve of the data.

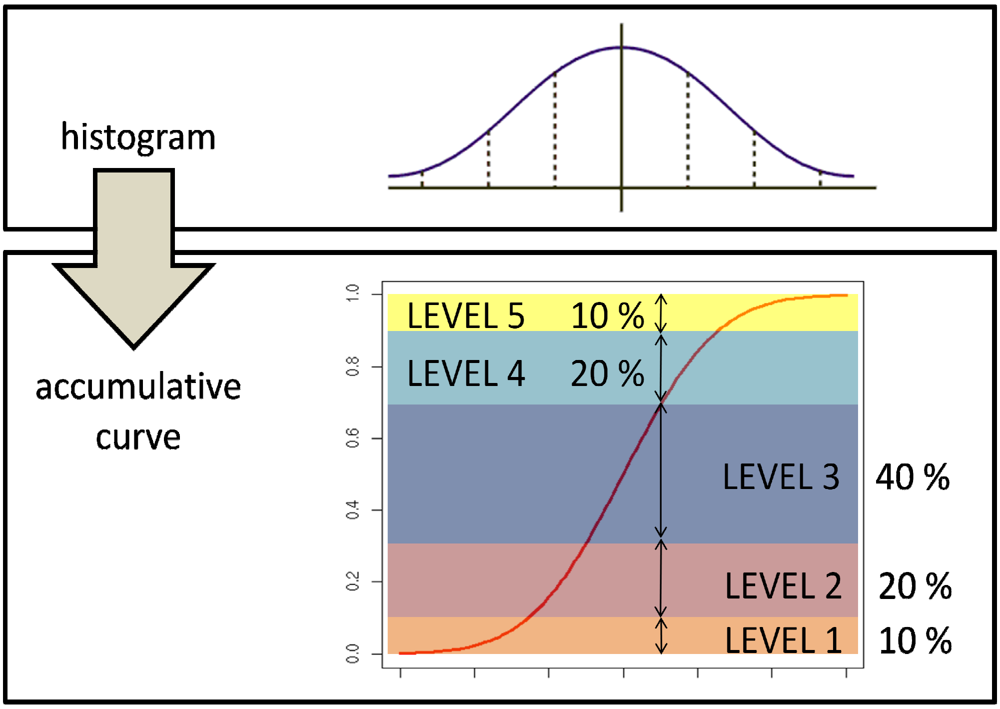

Fig. 6 Level benchmarks

The results of the data analysis and the explanation of the level benchmarks for the subindicators are explained below. The following study of the Spanish cities refers to the Japanese benchmarks due to the impossibility to gather and create the necessary data to set the Spanish benchmarks levels.

Q1.Environmental aspects

1-1 Nature conservation

1-1-1 Natural land use

The sum of the total green area in the city among the total city area.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
<30.0	30.0 - 57.5	57.5 - 82.5	82.5 – 90.0	> 90.0

1-2 Environmental quality

1-2-1 Air quality

The air quality indicator considers the levels monitored by air control stations of dioxide of nitrogen, dioxide of sulfur, suspended particulate matter and photochemical oxidants. The environmental standard ceiling legal values of NO_2, SO_2, SPM and OX based on the Japanese Basic Law and Environmental Pollution Control, "Environmental Quality Standards for air pollution" are considered. The level score shows the number of items beyond the following legal values.

① NO_2 (nitrogen dioxide): 98% of annual average daily value is less than 0.04ppm.

② SO_2 (sulfur dioxide): the annual average daily value is less than 0.1ppm.

③ SPM (suspended particulate matter): the annual average daily value is less than 0.20mg/m^3

④ OX (photochemical oxidants): the maximum average hourly value is less than 0.06ppm.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
NO_2, SO_2, SPM and OX levels				
0	1	2	3	4

1-2 Environmental quality

1-2-2 Water quality

The water quality score system is strictly linked to the country of study. Therefore, the ISQA indicator methodology is used in this thesis in order to score the level of the Spanish cities water's quality. Scale 0(worst)-100(best) and level 1 to 5 correspondence is shown below.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
ISQA				
0 - 25	25 - 50	50 - 70	70 - 90	90 - 100

1-2 Environmental quality

1-2-3 Noise

Percentages of people suffering from noise problems.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
< 9.8	9.8 - 22.9	22.9 - 29.4	29.4 - 32.7	> 32.7

1-2 Environmental quality

1-2-4 Dioxins

Index of the achievement of environmental standards for air and water quality by dioxins measurement. The level score shows the number of items (air, waste water) that meet environmental standard values.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
number of items that meet environmental standard values				
0	-	1	-	2

1-3 Resource recycling

1-3-1 Recycling of waste

The level represents the rate of municipal solid waste recycling. The percentage includes different kinds of recycle processes: incineration, composting, anaerobic digestion, etc.)

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
< 10.0	10.0 - 15.0	15.0 - 25.0	25.0 - 37.5	> 37.5

1-4 Environmental measures

1-4-1 Efforts and policies for the environment and biodiversity

Subjective personal assessment from level 1 ~ level 5 regarding efforts and policies led by city. The level score shows the number of items achieved or under development. The items analyzed are the following:

① Existence of basic environment actions and plans (Local Agenda).

② Set the target values, the number of indicators and the measures associated to the environmental policies. The results should be public.

③ ISO 14000 certification or existence of city's own environmental management system.

④ Planning and development for specific environmental guidelines.

⑤ Support efforts for small business or home environment sector through financial mechanisms.

⑥ Encourage and support the environmental education and environmental school action.

⑦ Encourage mutual cooperation between stakeholders, local governments and citizens. There is a mechanism to reflect citizens' opinion.

⑧ Listed species at risk of extinction (Red List).

⑨ Running appropriate management measures for the elimination of exotic species in the city.

⑩ Biodiversity monitoring management.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
number of items achieved or under development				
< 3	3 - 5	5 - 7	7 - 9	> 9

Q2. Social aspects

2-1 Living environment

2-1-1 Quality of housing

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
m2/person				
< 34.0	34.0 - 38.0	38.0 - 44.0	44.0 - 49.0	> 49.0

2-1 Living environment

2-1-2 Parks and other facilities

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
m2/capita				
< 6.50	6.50 - 8.50	8.50 - 12.0	12.0 - 14.0	> 14.0

2-1 Living environment

2-1-3 Sewage systems

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
< 20.0	20.0 - 40.0	40.0 - 75.0	75.0 - 95.0	> 95.0

2-1 Living environment

2-1-4 Traffic safety

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
accident/1000·capita				
> 9.0	9.0 - 6.5	6.5 - 5.0	5.0 - 3.5	< 3.5

2-1 Living environment

2-1-5 Crime prevention

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
crime/1000·capita				
> 17.0	17.0 - 12.0	12.0 - 9.0	9.0 - 7.0	< 7.0

2-2 Social services

2-2-1 Education services

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
students/teacher				
> 18.0	18.0 - 16.0	16.0 - 14.0	14.0 - 12.5	< 12.5

2-2 Social services

2-2-2 Cultural services

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
visitors/modified population				
< 0.55	0.55 - 0.75	0.75 - 1.35	1.35 - 1.85	> 1.85

2-2 Social services

2-2-3 Medical services

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
beds/1000·modified capita				
< 3	3 - 8	8 - 18	18 - 28	> 28

2-2 Social services

2-2-4 Child care services

This indicator was not used in order to calculate Spanish cities score due to the impossibility to compare the data obtain with the data for Japanese cities. According to the CASBEE-city manual still under development, in Japan the level of the child care services indicator evaluates the ratio of children waiting for admission to nurseries.

2-2 Social services

2-2-5 Services for the disabled

Disabled facilities, psychiatric and physical rehabilitation facilities.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
total capacity/1000·capita				
< 0.75	0.75 - 1.5	1.5 - 4	4 - 10	> 10

2-2 Social services

2-2-6 Services for the elderly

Health and nursing care and sanatorium medical facilities.

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
total capacity/100·capita				
< 2.00	2.00 - 2.75	2.75 - 4.00	4.00 - 6.00	> 6.00

2-3 Social vitality

2-3-1 Rate of population change due to births and deaths

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
(Number of births – Number of deaths)/Total population				
< (- 0.70)	(-0.70) - (- 0.25)	(- 0.25) - 0.30	0.30 - 0.65	> 0.65

2-3 Social vitality

2-3-2 Rate of population change due to migration

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
(Number of immigrants – Number of emigrants)/Total population				
< (-1.4)	(-1.4) - (-0.95)	(-0.95) - (-0.35)	(-0.35) - 0.2	> 0.2

2-3 Social vitality

2-3-3 Rate of informatization

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
computers/100·students				
< 8	8 - 12	12 - 22	22 - 35	> 35

2-3 Social vitality

2-3-4 Efforts and policies for injecting vitality into society

Subjective personal assessment from level 1 ~ level 5 regarding efforts and policies led by city. The level score shows the number of items achieved or under development. The items analyzed are the following:

① There is a mechanism to reflect citizens' opinion.

② Efforts are made to open review committee to local residents

③ There is a digital mechanism for local residents to express opinions

④ There is a promotion for regulating the accountability by affiliated organizations

⑤ More than 5 concrete measures to conduct non-profit-organizations support

⑥ Concrete supporting measures for community business about biodiversity

⑦ Promoting gender equality

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
number of items achieved or under development				
< 3	3 - 4	4 - 6	6 - 7	> 7

Q3. Economic aspects

3-1 Industrial vitality

3-1-1 Gross regional products

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
十万円 (base year 2000)/modified population				
< 12.50	12.50 - 22.50	22.50 - 55.00	55.00 - 110.0	> 110.0

3-1 Industrial vitality

3-1-2 Number of employees

Percentages of the employees per total population of working age

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
< (-3.0)	(-3.0) - (-1.8)	(-1.8) - 0.4	0.4 - 1.0	> 1.0

3-2 Economic exchanges

3-2-1 Number of visitors

Number of employees service sector / total population

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
(%)				
< 5.25	5.25 - 7.25	10.25	10.25 - 13.5	> 13.5

3-2 Economic exchanges

3-2-2 Public transportation

The rate of utilization of public transportation (car users must be deducted)

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
%				
< 3	3 - 5	5 - 10	10 - 25	> 25

3-3 Financial viability

3-3-1 Tax revenues

Tax revenues per total population

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
万円/total population				
< 7.5	7.5 - 10.0	10.0 - 15.0	15.0 - 20.0	>20.0

3-3 Financial viability

3-3-2 Outstanding local bonds

Amount of outstanding local bonds per capita. This indicator was not used in order to calculate Spanish cities score due to the impossibility to compare the data obtain with the data for Japanese cities. According to the CASBEE-city manual still under development, in Japan the level of outstanding local bonds evaluates the degree of financial independence of local governments. The amount of financial resources and autonomy, local taxes, dues and contributions, fees and charges, property income, donations and money transferred are took into account.

L1. GHG emissions

To calculate the score for the CO_2 emissions (see appendix), this study follows the CASBEE-city methodology described in the manual under development. The national average of CO_2 emissions in tonnes CO_2-eq/capita·year (hereinafter "reference value") is considered to be score 50. The "a" value or "gain" is calculated taking into account the national target (x) and national average (μ =9.86).

$$Score = \frac{100}{1+\exp(-aX)};$$

$$1+\exp(-aX) = \frac{100}{S};$$

$$\exp(-aX) = \frac{100}{S} - 1;$$

$$\exp(-aX) = \frac{100-S}{S};$$

$$-aX = \log_e\left(\frac{100-S}{S}\right);$$

$$a = \frac{\log_e\left(\frac{100-S}{S}\right)}{-X}; \quad \text{where} \quad \begin{cases} X = x - \mu \\ x = 0.2 \cdot \mu \\ S = 20 \end{cases}$$

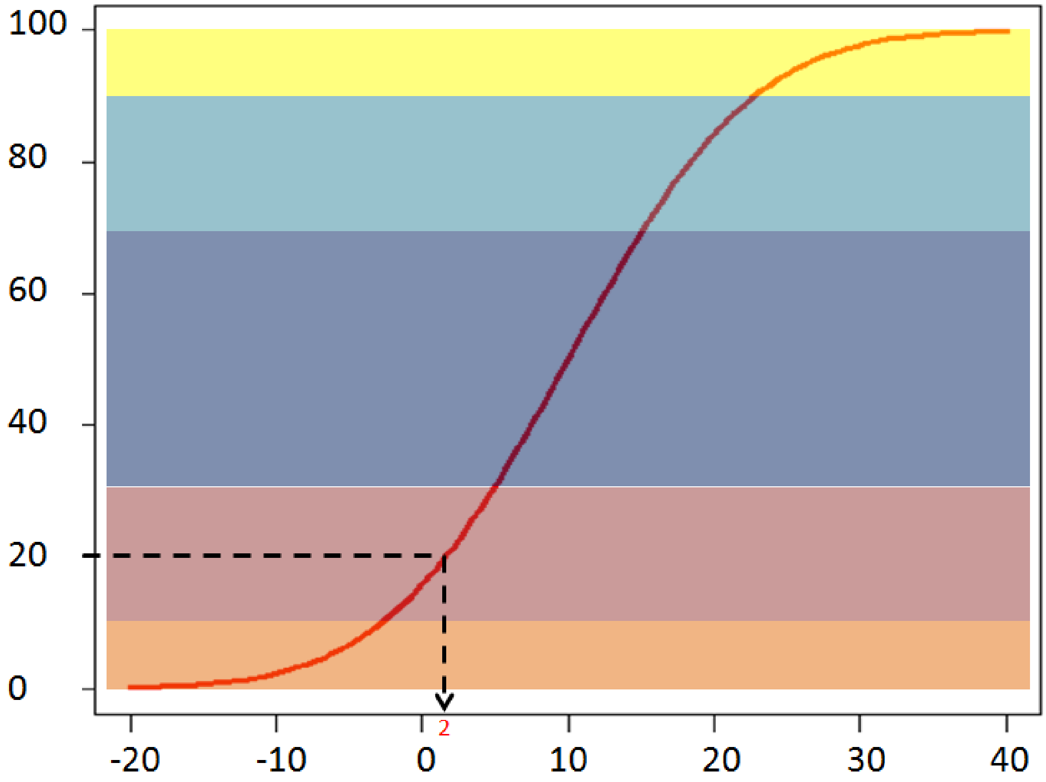

Fig. 7 Gain value calculation

Then,

$$a = \frac{\log_e 4}{-(-0.8\mu)}$$

Equation 2 Gain or "a" value

6. Case of study

6.1. Presentation

Climate change is one of the main threats for sustainable development and Spain, because of its geographical location, is very vulnerable to it. The climate scenarios prepared by the Spanish National Institute of Meteorology demonstrate that in Spain the average temperature could increase between 4ºC and 8ºC and precipitation could reduce up to 40%. This will result in a reduction of water resources, a regression of the coastline and a loss of biodiversity among other effects. That is the reason why in the last decade in Spain there has been a great effort to reduce greenhouse gas emissions from industries as well as from the diffuse sectors. The Spanish Kyoto's Protocol commitment, limits the increase of emissions to 15% in relation to the baseline year, although since the adoption of the Protocol in 1997, the emissions have been increasing due to the economic development and the population growth. It is a priority for the Spanish Government to correct this rising tendency in order to guarantee the compliance of the Kyoto Protocol.[6]

6.2. Madrid and Barcelona profile

The study of this thesis will be the environmental efficiency for the cities of Madrid and Barcelona applying the CASBEE-City methodology. In order to perform this evaluation, statistical indicators data have been collected and analyzed according the CASBEE-City outline. The score for each one of the Quality(Q) and Load(L) subindicators analyzed are referred to the Japanese benchmarks.

These two cities were selected as the best options to analyze and apply the CASBEE-City methodology for several reasons. First of all, for being the most populated cities in Spain, hosting together more that 32% of the Spanish population. And secondly, they were chosen because of their local governments' recent efforts to improve the environmental, social and economic aspects of these cities. These efforts are also reflected in the annual publications of the indicators values and its evolution.

In order to have an idea about what kind of cities are analyzed in this study, a list with the main statistics data of Madrid and Barcelona is provided below.

	Madrid	Barcelona	Units
Population	3,2	1,6	million habitants
Land Area	605,77	101	km^2
Density	5282,5	15841,6	hab/km^2
Green area	16,8	18	m^2/hab
Districts	21	10	

Table 3 Statistics data of Madrid and Barcelona (year 2009)

Madrid is the capital of Spain and has a population of just over 3.2 million. Madrid has a vibrant service sector, along with a relatively modest industrial and construction sector. Within the industrial sector, paper and graphic arts, clothing and leather, transport equipment and food and drink are the most important industries. Tourism is also an important feature of Madrid's economy. The city is composed of 21 districts and 131 neighborhoods. Madrid is the seat of Spain's three levels of administration: national, regional and municipal. The municipal authority has its offices throughout the city with every district being represented by the 'Juntas Municipales de Distrito' responsible for a range of public services.

The City Council of Madrid, by resolution of the Plenary Council in September, 27th 1996 adhered to the Aalborg Charter and started the process of Local Agenda 21 as a tool for participatory planning of municipal management to enable the City Council and the social individuals to work together towards sustainable development of the city.

Barcelona is the capital of the autonomous community of Catalonia situated in the north-east of Spain, and has a population of 1.6 million. The economic structure of Barcelona is characterized by a pre-eminence of the service sector. Barcelona has a high concentration of high added value activities, based on information and telecommunication technologies. Greater Barcelona maintains an important industrial base focusing mainly on the metallurgical industry and the chemical and pharmaceutical sectors. The city is divided into 10 districts. The city council has offices throughout the city with every district represented by the 'Gerències de districte' responsible for a range of public services. The seat of the regional government is also located in Barcelona.

Barcelona started the process of promoting the Agenda 21 in the year 1995, with the formal and unanimous commitment of the Plenary Council to the Aalborg Charter, a document that has provided great impetus to the Local Agenda 21s in the European setting, ratified by 1200 cities. Therefore, it has been formed as a strategic plan for sustainability that combines the social, economic and environmental dimensions, and is characterized by the basic principles for working horizontally, with participation, knowledge and correspondence. The process of Agenda 21 of the city of Barcelona has a system of indicators related to the Citizen Commitment to Sustainability. This system is updated annually to point out the improvements that occurred during the year using comprehensive, quantitative and objective data. Barcelona City Council performs this technical monitoring in collaboration with the Polytechnic University of Catalonia.

6.3. Data and scores

The necessary data gathered for both cities and the score sheet are included as an appendix at the end of the document. The Results Sheet presents the results for the Quality, Load and BEE value. Related information and web sources are presented on this sheet.

The main information sources from where the data was obtained are the following:

- The National Statistics Institute (INE)
- City Council of Madrid
- Statistics Institute of the Region of Madrid
- Agenda 21 Barcelona
- City Council of Barcelona
- Statistics Institute of Catalonia

7. Analysis of results

7.1. Madrid

The results for the city of Madrid are show in the Fig. 8 below. In the 2D chart the evolution of the BEE value between 2000 and 2005 is shown. A little improvement had occurred during these 5 years. The Load in the city has decreased while the Quality, specifically the score for Education services(2-2-1) and Services for the elderly(2-2-6) indicators have improved.

The city of Madrid has several indicators with the highest score punctuation (value = 5) like Air quality(1-2-1), Efforts and policies for the environment and biodiversity(1-4-1), Quality of housing(2-1-1), Parks and other facilities(2-1-2), Cultural services(2-2-2), Efforts and policies for injecting vitality into society(2-3-4), Number of visitors(3-2-1) and Public transportation(3-2-2).

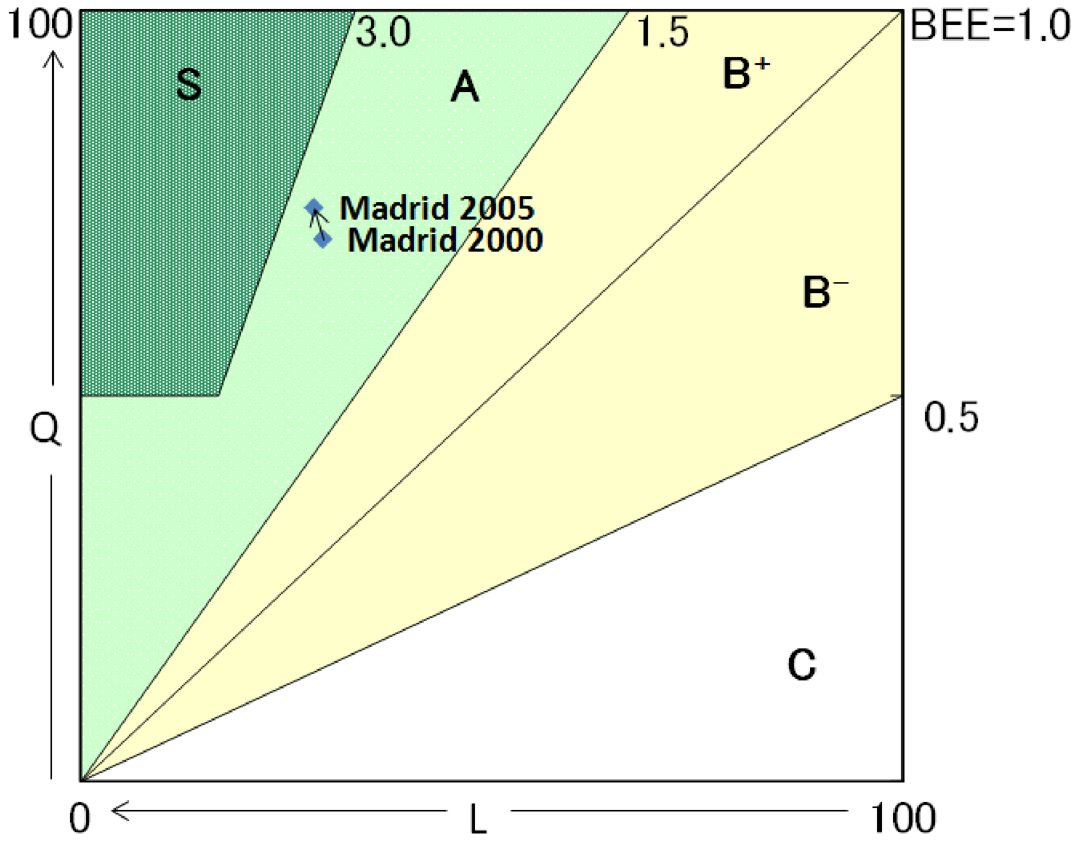

Fig. 8 Madrid BEE chart

The population growth, from 2.882.860 habitants (2000) to 3.155.359 habitants (2005), affects the results of those indicators that integrate the population on its calculation. For some indicators, the modified population is taken into account in order to balance the results. The modified population defines the average between the day population and the night population. See the appendix 1 for data details.

The points for the six categories from Q1.1 to Q3.3 are shown together in a radar chart, to give an immediately clear presentation of the characteristics of environmental considerations in the designated area.

Q1.Environmental aspects
Q1.1 Nature conservation
Q1.2 Environmental quality
Q1.3 Resource recycling
Q1.4 Environmental measures
Q2. Social aspects
Q2.1 Living environment
Q2.2 Social services
Q2.3 Social vitality
Q3. Economic aspects
Q3.1 Industrial vitality
Q3.2 Economic exchanges
Q3.3 Financial viability

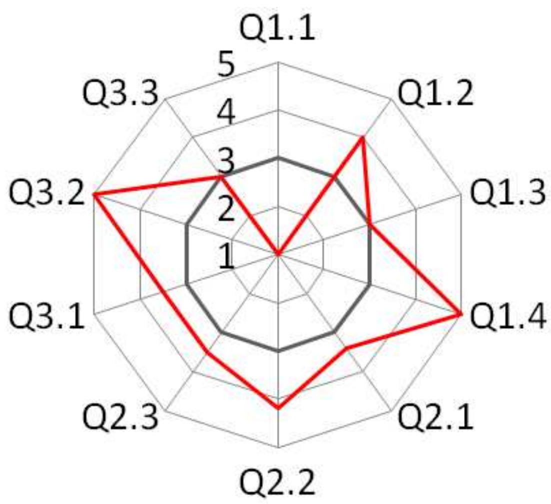

Fig. 9 Madrid radar chart

If the Quality and Load values are analyzed for both years, a significant improvement of the Quality value is seen. This change is the main positive cause of the highest score of the BEE value in 2005.

Year	Quality value	Load Value	BEE value - SCORE
2000	70	29	2.4
2005	74	28	2.6

Table 4 Madrid BEE values

7.2. Barcelona

The results for the city of Barcelona are show in the Fig. 10 below. In the 2D chart the evolution of the BEE value between 2000 and 2005 is shown. Again, a little improvement had occurred during these 5 years. The Load in the city hasn't change, but the Quality, specifically the score for Recycling of waste(1-3-1) and Services for the elderly(2-2-6) indicators have improved.

The city of Barcelona has also several indicators with the highest score punctuation (value = 5) like Air quality(1-2-1), Efforts and policies for the environment and biodiversity(1-4-1), Parks and other facilities(2-1-2), Sewage systems(2-1-3), Education services(2-2-1), Cultural services(2-2-2), Efforts and policies for injecting vitality into society(2-3-4), Number of visitors(3-2-1) and Public transportation(3-2-2).

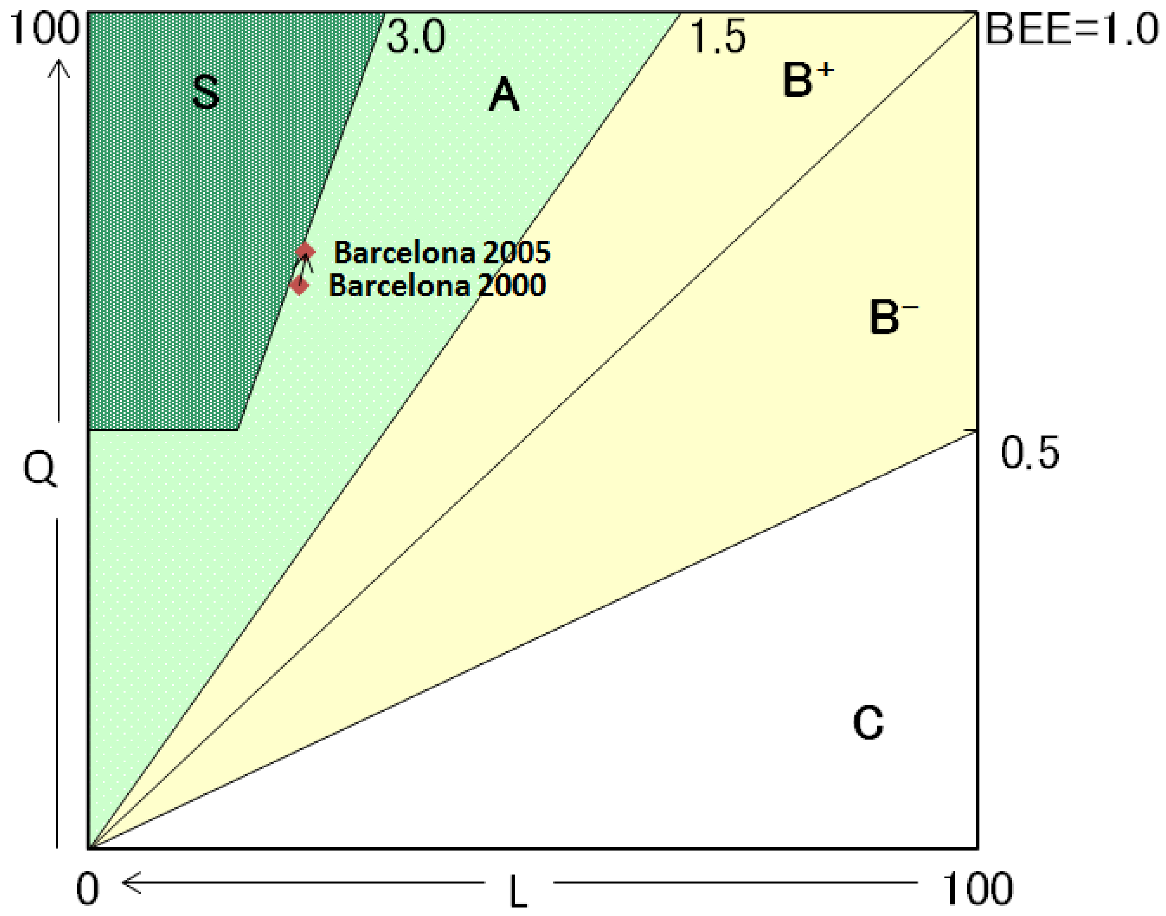

Fig. 10 Barcelona BEE chart

The points for the six categories from Q1.1 to Q3.3 are shown together in a radar chart, to give an immediately clear presentation of the characteristics of environmental considerations in the designated area.

The population growth, from 1.496.266 habitants (2000) to 1.593.075 habitants (2005), affects the results of those indicators that integrate the population on its calculation. For some indicators, the modified population is taken into account in order to balance the results. The modified population defines the average between the day population and the night population. See the appendix 2 for data details.

Q1.Environmental aspects
Q1.1 Nature conservation
Q1.2 Environmental quality
Q1.3 Resource recycling
Q1.4 Environmental measures
Q2. Social aspects
Q2.1 Living environment
Q2.2 Social services
Q2.3 Social vitality
Q3. Economic aspects
Q3.1 Industrial vitality
Q3.2 Economic exchanges
Q3.3 Financial viability

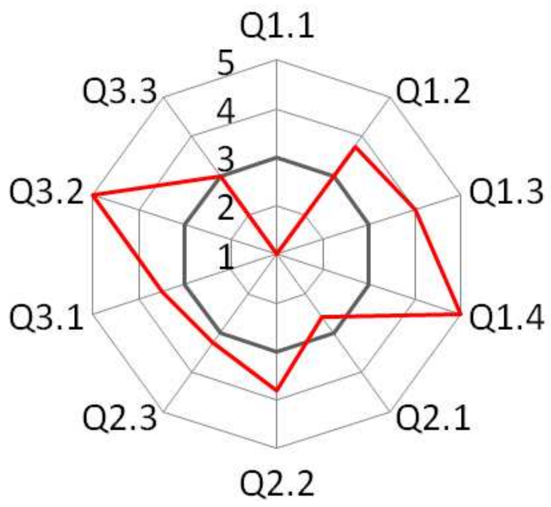

Fig. 11 Barcelona radar chart

While the Load value for the city of Barcelona has not change between 2000 and 2005 years, the value for the Quality has increased 4 points in the scale of 0-100 points.

Year	Quality value	Load Value	BEE value - SCORE
2000	67	24	2.8
2005	71	24	2.9

Table 5 Barcelona BEE values

The final step of the final thesis was to compare the results for both Japanese and Spanish cities in the same BEE chart. The Japanese cities score and representation showed in the figure below are the Eco-Model selected cities as mentioned before.

The Eco-Model cities are subdivided in three categories: Typical industrial cities, Typical commercial cities and Other kinds of cities.

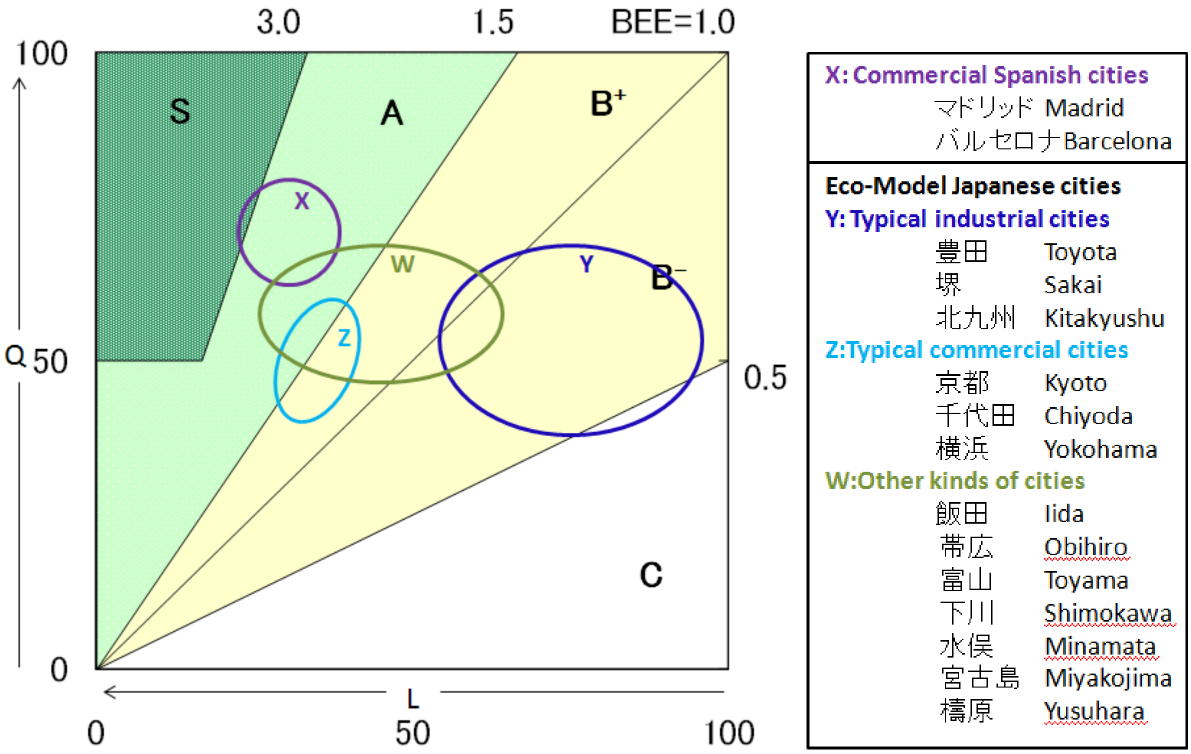

Fig. 12 BEE chart Spanish and Japanese cities

As shown in the Fig. 12, the Typical Industrial Japanese cities are the ones with a highest Load value, because of the large industrial sector located on them. The high emissions of CO_2 emitted on those cities are reflected into a very bad score for those cities. The highest the Load value, the lowest the BEE value. The Typical commercial Japanese cities achieve level B^+ and A due to low levels of Load, but better Quality score levels.

7.3. Environmental Load and the two principles concept

In Japan, Environmental Load is assessed by the amount of greenhouse gas emissions per capita, estimated by following the national manual.[8] As the range of greenhouse gas emissions differs from infinitely small to infinitely large when it takes account not only CO_2 emissions but also CO_2 absorptions, some kind of normalization is required. CASBEE-City uses a particular function to convert the amount of greenhouse gas emissions into a score from 0 to 100. A city that emits greenhouse gases at the amount for the nationwide city-average is assigned a score of 50.[9]

Naturally, greenhouse gas emissions are higher in industrial cities as the production process usually consumes a lot of energy and emits greenhouse gases. It is necessary for industrial cities to accept this fact and to make a greater effort toward low carbonization. However, it should not be forgotten that these cities contribute greatly to other cities through their industrial production. In order to assess a city from these two different viewpoints, CASBEE-City uses two principles for assessing Environmental Load.

- Principle 1) Emitter-pays-principle:

  Allocates all greenhouse gas emissions to producing areas

- Principle 2) Beneficiary-pays-principle:

  Reallocates greenhouse gas emissions to consuming areas

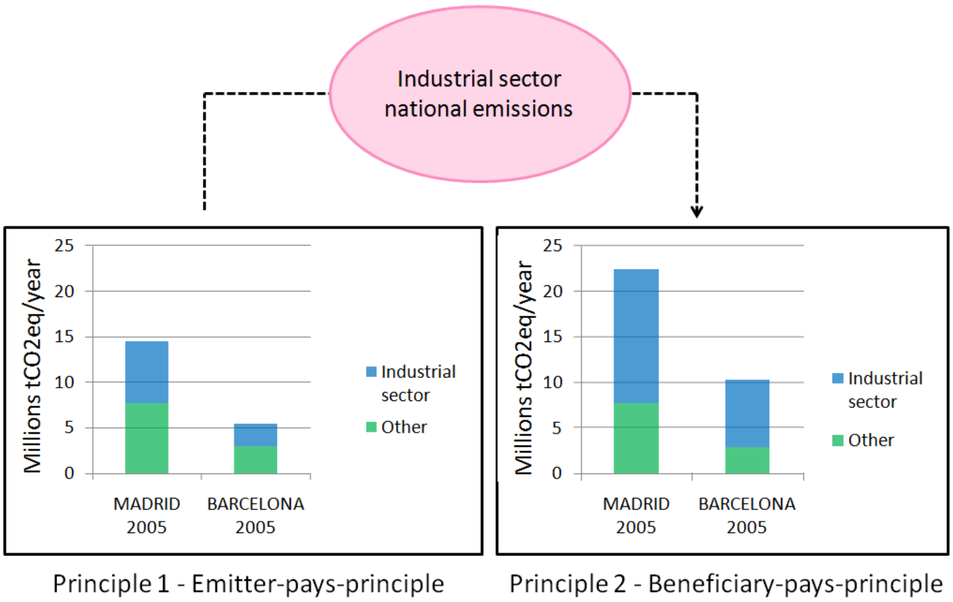

Fig. 13 Two principles concept

Principle 2 is based on the concept that areas consuming industrial products should share the burden of greenhouse gas emissions as a result of producing industrial products. The CO_2 emissions from the industrial sector of a region will be deducted and reallocated to the consuming areas (other regions nationwide).

Taking into account the annual national industrial emissions of CO2, and relocating these amount according to the city's population, the Load value and therefore the BEE score for both cities differs from the principle 1 score. The table below shows the values for the year 2005 according to principle 2.

	Quality value	Load value	BEE value - SCORE
Madrid	74	38	1.9
Barcelona	71	36	2.0

Table 6 Principle 2 BEE value

As a result of these new concept of calculation, the tones of CO_2 equivalent per capita also differs from the principle 1 values. Although the new values are higher than the previous ones, those are still lower than the national Spanish average of 9.86 tones CO_2-eq/capita. This is because of the low industrial sector of Madrid Barcelona

tonnes CO_2-eq/capita	Principle 1	Principle 2
Madrid	4.6	7.1
Barcelona	3.4	6.5

Table 7 tCO2-eq/capita. Principle 1 and 2

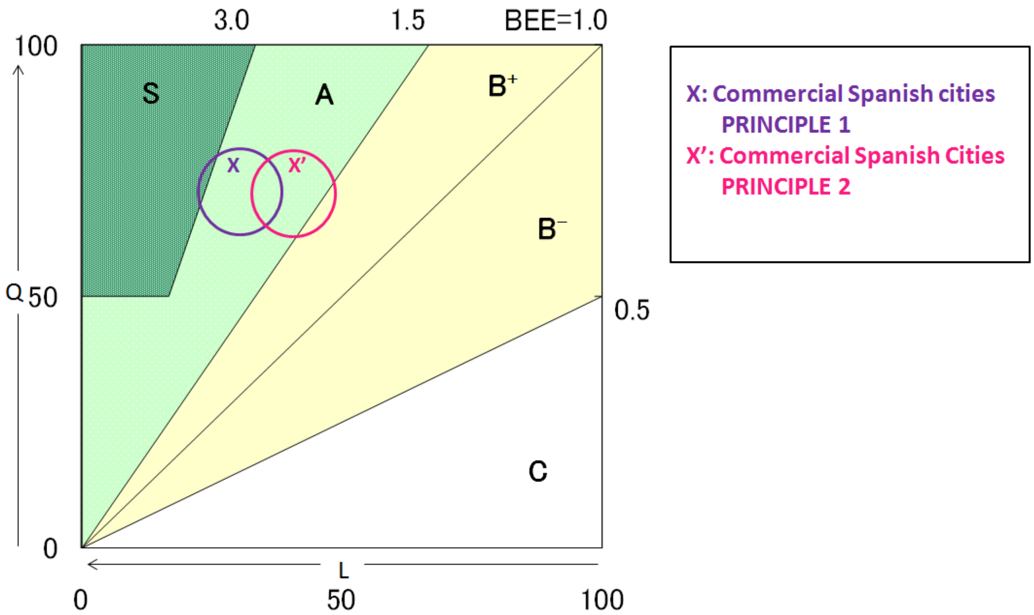

Fig. 14 Spanish cities. Principle 1 and 2

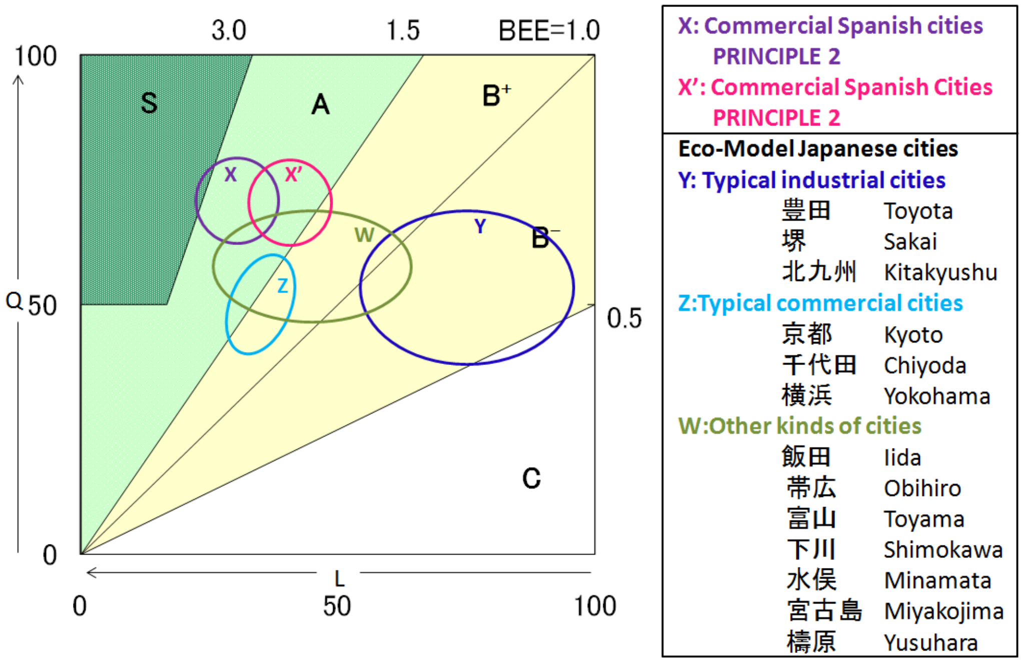

Fig. 15 Spanish and Japanese cities. Principle 1 and 2

8. Conclusions

As the title says, the aim of this thesis »Environmental Efficiency Assessment on Spanish Urban Settings Applying CASBEE methodology« is to apply the assessment tool CASBBE-City and analyze how successful is the assessment of non-Japanese cities like Madrid and Barcelona. The city evaluation consisted on giving a score for environmental efficiency based on CO2 emissions and environmental quality.

It is a priority for city governments to work with their citizens and community organizations towards a low carbon society. A world wide benefit from the CASBEE-city methodology is possible. Although the manual under development in this moment in Japan might need specific adaptations in order to be used in other countries, the assessment tool presents a clear methodology to identify environmental, social and economic characteristics of the cities and to quantify the effectiveness of environmental policies.

During this research, only two items of the list of indicators that must be evaluated under the CASBEE-city methodology were unable to be studied (Child care services and Outstanding local bonds) due to the impossibility to compare the data obtain with the data for Japanese cities. On the other hand, there are others indicators not included in the manual to date, that could be considered in the future such as urban renovation index, proportion of roads with priority to pedestrians, number of schools that participate in environmental education projects, number of organizations with environmental certification or the sum of water consumption per inhabitant.

Compact cities like Madrid and Barcelona are constantly working on reducing CO2 emissions. The advantages of cities with their density (although different sizes and shapes of cities imply different geographical advantages) are the heating, the cooling, the lighting and the public transportation management. As this research shows, the total emissions of greenhouse gases per person in cities are much lower than those produced nationally.

But, most of the emissions from manufacturing industries are allocated to the producing regions or countries rather than those where products are purchased and used. Cities that consume industrial products should share the burden of greenhouse gas emissions related to industrial areas as suggested in the two principles concept.

9. Acknowledgements

This final thesis represents the final step of my determination of becoming an engineer, but this research could not have been completed without the help and support of many people.

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Anna Blanch Vergés

10. Bibliography

[1] CASBEE website
http://www.ibec.or.jp/CASBEE/english/index.htm [accessed 01.05.10]

[2] J.COLE, RAYMON. Building Environmental Assessment Methods, 1st September 2008.

[3] JAPANESE REGIONAL REVITALIZATION BUREAU, CABINET SECRETARIAT. “Eco-Model Cities for the Low Carbon Society”.
〈http://www.kantei.go.jp/jp/singi/tiiki/kankyo/index.html> [accessed 01.05.10]

[4] Murakami, Shuzo. Concept and Framework of CASBEE-City: An Assessment Tool of the Built Environment of Cities, May 2010.

[5] Institute for Building Environment and Energy Conservation. IBEC 2003 publication.

[6] “Climatge change as a global challenge”, Thematic Debate of the General Assembly of the United Nations, New York, 31st July and 1st August 2007.

[7] CASBEE for Urban Development, Technical Manual 2007 Edition

[8] JAPANESE MINISTRY OF THE ENVIRONMENT, “Manual for planning local government’s action plan to address the issue of global warming” 2009.

[9] Kawakubo, Shun. Assessment Framework of CASBEE-City: An Assessment Tool of the Built Environment of Cities

10.1. Complementary bibliography

- Japan Sustainable Building Consortium, 2006, CASBEE Technical Manual; CASBEE for Home (Pilot version), (in Japanese) Institute for Building Environment and Energy Conservation

- Murakami, S. et.al., 2002, "Comprehensive Assessment System for Building Environmental Efficiency in Japan (CASBEE-J)," Proceedings of Sustainable Building 2002 International Conference.

- Japan Sustainable Building Consortium, 2006, CASBEE Technical Manual 2006 Edition; CASBEE for New Construction, CASBEE for Existing Building, CASBEE for New Construction (Brief version), and CASBEE-HI, CASBEE for Urban Development, (in Japanese) Institute for Building Environment and Energy Conservation.

11. Appendix 1: Madrid data

12. Appendix 2: Barcelona data