

Criteria for evaluation for eco-material and the case study in Japan

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Abstract. Criteria for evaluation for eco-material and the case study in Japan. An environmental performance of the material is described clearly from the viewpoint of international mutual agreement with the environmental label of ISO. The eco-material is evaluated with Law on Promoting Green Purchasing and the ISO environmental label, etc. in Japan. However, the doubt is caused in the validity of the united evaluation of all materials by the same functional processing module. However, enough inventory data doesn't exist to evaluate the material and the product under the present situation. Moreover, the difficulty of what the life time of the product uniformly defines is pointed out. Then, it is necessary to choose the proper procedure from social and a scientific viewpoint to make the criteria of the eco-material. The validity of the criteria is referred in the this study, and the note to make a fairer criteria is presented. The relation to the general person's recognition to the criteria and this was shown by using the method of Analytical Hierarchy Process(AHP). In addition, we introduce the evaluation scheme of the eco-material based on the LCA technique of the Ministry of Land, Infrastructure and Transport.

Introduction

Global environmental concerns become serious, and the appropriateness of the environmental assessment of the resource (material) is asked in the resource and energy problems with a large influence on the economic society. In other words, the material with few environmental impacts that exert a bad influence on the environment is demanded in the market. It is defined with the eco-material in our country, "It is necessary to be able to manufacture from few environmental impacts and to use it. The recyclability must be possible. The effect when it uses it must be expanded". That is, the eco-material is a material that became more useful at the same time as the reduction of environmental impacts more than in the past. Here, it is a basic, important item to consider the meaning of "Eco" of the word eco-material. If the character of Eco shows an environmental performance, we should quantify the performance and evaluate the performance. Figure 1 showed a grand design that meant eco of the eco-material. As for the quantification to evaluate eco, the analysis of the environmental impact by life cycle assessment (LCA) is general now. The technique of LCA is issued as ISO14040, and evaluated by quantifying the environmental impact of the product in each stage of manufacturing, transportation, sales, use, abandonment, and recycling. The procedure of LCA by ISO14040 is composed of four stages of the setting of the purpose and the range of the evaluation, the inventory analyses, the impact statements, and the interpretations. That is, this method is work to quantify the amount of the environmental impact of the object based on data, and to do the evaluation and the interpretation based on the result. And, the grade ranking is done as an evaluation method. The advantage of ranking is to be able to present the content of the LCA evaluation that needs the exclusive knowledge to understand to a general consumer plainly. The eco-mark of Japanese Environment Association, the criteria of Law on Promoting Green Purchasing, and CASBEE for the building evaluation are the ranking cases in Japan. In these grade ranking, there are a method judged by 0 or 1 and a method to set two or more grades. The eco-mark and Law on Promoting Green Purchasing are the formers, and CASBEE is the letters. Recently, the idea of local production for local consumption besides evaluating it to the judgment LCA has been introduced. As for this, the focus is hit to the point where the eco-material is used from the problem what the eco-material. Of course, there is an advantage that the amount of the environmental impact generation by transportation is suppressed to the minimum if produced

places and consumed places are adjacent. A recent trend concerning the LCA technique application in the Ministry of Land, Infrastructure and Transport was examined in the study. Moreover, the current state of the evaluation ranking technique for seeing from the standpoint of the market was examined.

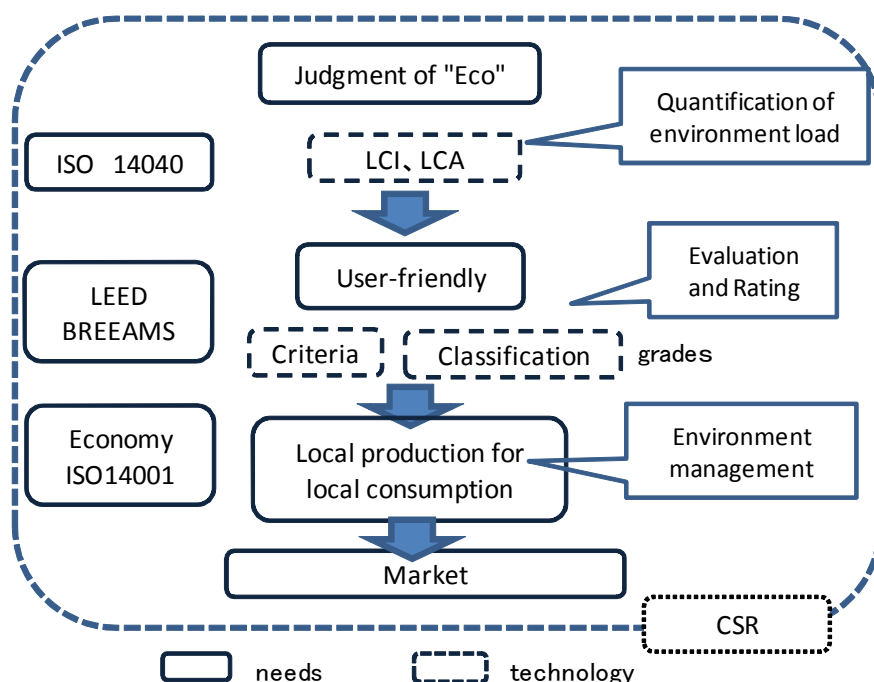


Fig.1 Grand design for eco evaluation

Methods

LCA of infrastructure. Effectiveness by the environmental impact reduction of the structure in the provision of social overhead capital comes to be appreciable by the use of LCA. In addition, the intellectual production technology is expected to come to be able to be evaluated by this. However, enough inventory data doesn't exist to do LCA of the infrastructure. We are in the current state that LCA that accuracy is high cannot be done for that. The method of making the data base of the existing life cycle inventory is an inter-industry relations table method and a product raising method. The inter-industry relations table method is a method of using this table that Ministry of Public Management, Home Affairs, Posts and Telecommunications Statistics Bureau is collected data and made public. It is data to distribute the environmental impact according to the productive activity of the entire Japan by sale proceeds. The environmental impact basic unit of the object can be calculated. There are covering and a list in data because the data of each section that classifies the productive activity of the entire Japan from this inter-industry relations table is calculated. Oppositely, because this has only the data of each section, it means a detailed analysis cannot be done. Moreover, because this data is updated once every five years, it is not possible to follow to the phenomenon that changes every year. On the other hand, the Buildup method is a method of calculating the environmental impact of the product by adding the environmental impact generated by the manufacturing process of the material. The environmental impact basic unit of the article subdivided by this method is computable. Moreover, the latest data can be reflected in this environmental impact information at any time. However, it is necessary to unite the calculation methods so that the difference by those who collect data is not included. The Ministry of Land, Infrastructure and Transport is using the technique for uniting the inter-industry relations table method and the buildup method now.

It is a method of uniting a detailed classification of covering, the list, and the buildup method of the inter-industry relations table with the latest of data. This method also has details and the latest at the same time as covering and having a look at data. That is, the data of the inter-industry relations

table can be used when there is no data of the buildup method. Figure 2 is a conceptual diagram of this uniting method. However, data for free of charge and the inverse onerous contract (waste and by-product, etc.) is not included in the inter-industry relations table. Figure 3 showed LCA in the maintenance of the infrastructure about the technical breakthrough of the introduction and the effect. A general structure can be compared with the environmental impact when the design, construction, and the product are devised. This performance differentiates when handling it when buying it.

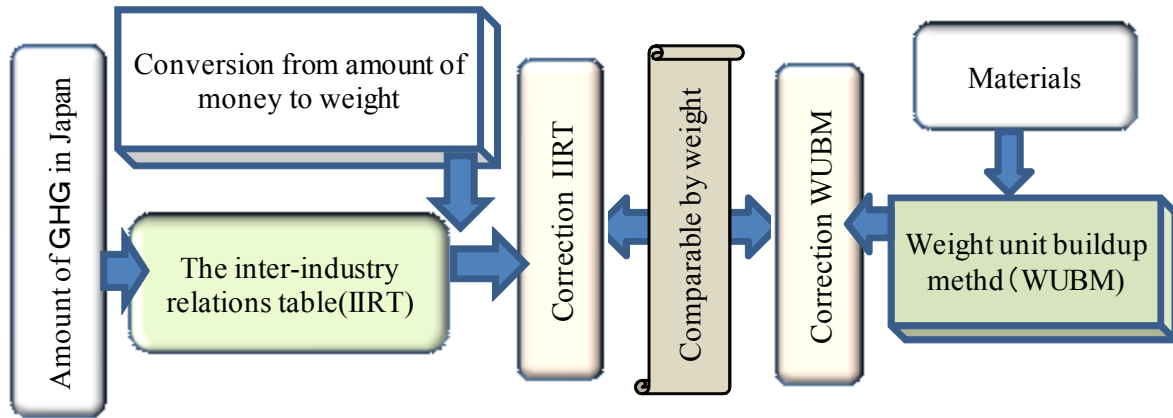


Fig.2 Technical breakthrough of infrastructure LCA technique

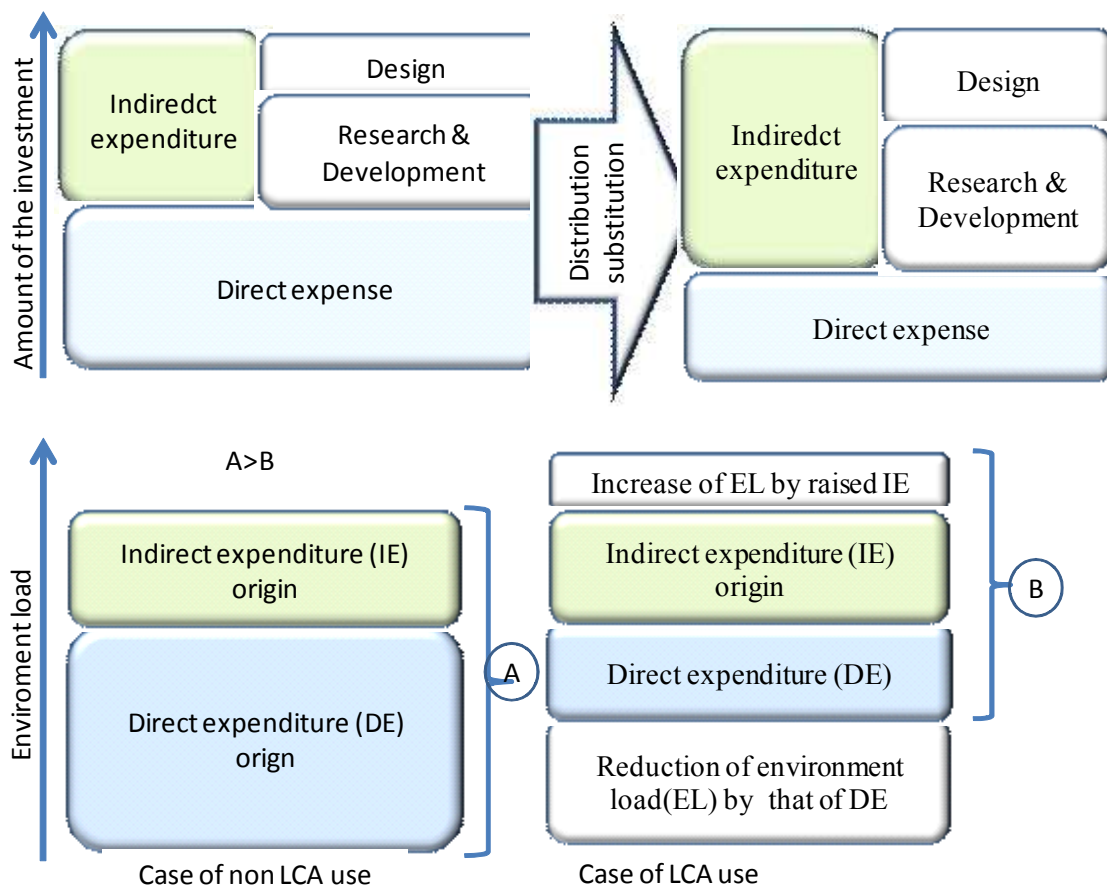


Figure 3. Effect of LCA introduction: Evaluation of intellectual production technology

Influence that inventory data gives environmental impact (sensitivity analyses sensibility analysis). Calculating the amount of the environmental impact of all materials spends a big labor. Then, the work was simplified by extracting only the material with a large influence that it had on

the result of the inventory analysis. To specify the material with a large influence, the elasticity of the amount of the environmental impact (sensitivity of the coefficient of fluctuation) was analyzed based on the inter-industry relations table. The input coefficient of the environmental impact basic unit that used the inter-industry relations table was examined about the section of public works related to the road of the Ministry of Land, Infrastructure and Transport. At the same time, elasticity concerning the amount of the environmental impact was calculated directly by the following equation.

$$\text{The elasticity ratio} = (\Delta B/B) / (\Delta A/A). \quad (1)$$

Here, A: input (input coefficient procession) and B: The output (environmental impact unit requirement vector). First of all, the amount of an increase of the environmental impact unit requirement when an input coefficient or a direct environmental impact coefficient was independently increased respectively by 1% was calculated.

$$\text{That is, it is } \Delta A/A=0.01 \quad (2)$$

The environmental impact basic unit was requested by the following equation.

$$\varepsilon = e^T (I - M)^{-1} \quad (3)$$

Here, n is a number of classifications. ε is the environmental impact basic unit vector of each classification. e is direct environmental impact coefficient vector (amount of the resource use and amount of the CO₂ exhaust) from each classification. M forms a line the input coefficient ($n \times n$ square matrix).

The CO₂ emission amount basic unit is assumed as an output. The CO₂ emission amount basic unit vector that these correspond is assumed to be ε_0 directly respectively as e_{i0} and a_{ij} with the CO₂ emission amount vector and the element of the input coefficient procession when putting it regularly in there is no change. Elasticity was standard of CO₂ emission amount basic unit (ε_k) of k material changed directly along with the change of the change of the amount of the emission (Δe_i) and the input coefficient (Δa_{ij}) assumed to be a ratio to the coefficient of fluctuation. That is, these are shown by the following equations.

$$\begin{aligned} S_{i \ k} &= (\Delta \varepsilon_k / \varepsilon_k^0) / (\Delta e_i / e_i^0) \\ &= (\varepsilon_k^1 - \varepsilon_k^0) / \varepsilon_k^0 / 0.01 \\ &= 100 (\varepsilon_k^1 / \varepsilon_k^0 - 1) \end{aligned} \quad (4)$$

$$S_{i \ j \ k} = (\Delta \varepsilon_k / \varepsilon_k^0) / (\Delta a_{ij} / a_{ij}) \quad (5)$$

Evaluation ranking analysis by AHP. The environmental performance evaluation system of the building is a lead as for "BREEAM (Building Research Establishment Environment Assessment Method)" of Britain developed in 1990. Besides this, there are "LEED (Leadership in Energy and Environmental Design)" of the United States, "GBTool" of EU, and "NABERS" of Australia. A big flow whose "BREEAM" of early Britain and "LEED" of the United States are two is made under the present situation. "CASBEE" developed in Japan also plays an important role, and the system of "GOBAS" of China developed for the evaluation of the Beijing Olympics facilities adopts CASBEE basically. The key word of the attracting movement was "LEED", and presentation of evaluating all constructed facilities by LEED and considering the environment became a big point to decide the venue though the Olympic Winter Games venue of 2010 was Vancouver in Canada. The evaluation concretely gives LEED of USA to "Nearby materials are used". Similarly, "Material of local" is put and the definition is put in CASBEE of our country. Then, the feature of these evaluation approaches has been extracted from a new aspect by using the Analytical Hierarchy Process (AHP) method. The AHP method is advocated by T. L. Saaty, and is a decision making technique in the evaluation with an uncertain situation and diversity. Our aspect was decided from the questionnaire survey result by 87 university students who were finishing an environmental subject. Criteria for evaluation by the next four kinds of periods were used as an evaluation target. The evaluation items adopted with the green purchase standard by LCA of the Ministry of Land, Infrastructure and Transport, the green purchase standard of the Ministry of the Environment, the eco-mark standard of Japan, and CASBEE in the building was used. The

evaluation items concerning the environment was greatly classified and assumed to be global warming, a resource, energy, and waste and recycling.

Result and consideration

Elasticity modulus (sensitivity) analysis. Table 1 showed the value of the elasticity calculated by using the amount of money display of the inter-industry relations table of the road of public construction. Therefore, when it is difficult to manage all materials, it is possible to manage efficiently by giving priority to the material that elasticity is high (The elasticity value is large).

Table 1. Elasticity calculation result of environmental impact basic unit (Sequentially describe from the high rank).

Public construction use material of road	Elasticity
Cement	0.268
Freshly mixed concrete	0.217
hot rolling steel material	0.177
crude steel (bof)	0.177
Pig iron	0.168
Electric power for business	0.101
cement manufacture	0.092
Metal products for construction	0.082

Table 2 showed the elasticity modulus concerning some construction materials. The elasticity of the emission was personally 0.24 of the cements. The elasticity of the pig iron and the electric power was 0.16 and 0.12 respectively. The elasticity of other main materials was 0.06 or less. In public construction related to the road in the construction field, it has been understood that the value of cement and the steel material is extremely growing compared with other materials. This calculation is a research on the construction material, and the possibility being found for a similar tendency is high in a general material. In LCI, it is thought that environmental impact management enough by the management only of the material with a predominant influence for the generation of the environmental impact but targeting all materials to manufacture a certain product becomes possible.

Table 2. Value of elasticity to select object materials that should be examined

Materials	Elasticity of direct CO2 emission
Cement	0.24
Pig iron	0.16
Electric power for business	0.12
Private freight transportation	0.06
Private power generation	0.05
Petroleum product	0.03

We should select the element that elasticity is high because the accuracy of the inventory analysis is improved and the variability (The uncertainty is included) is high. It is an input coefficient as understood from the result in Table 1 and Table 2. And, it was shown that the elasticity of the amount of the CO2 emission and the amount of the natural resources turning on was 0.015(1.5%) enough if only the above-mentioned flow was handled.

Evaluation ranking structure of eco-material. The order of the importance obtained by result of the questionnaire by the student was the order of the resource, energy, waste, recycling, and global warming. They caught the resource and energy problems as a public concern number one. Table 3 showed the evaluation result to each evaluation ranking method by the AHP method. Law on Promoting Green Purchasing in the country is 0.425. The LCA evaluation method of the Ministry of Land, Infrastructure and Transport is 0.194. The evaluation method of the eco-mark is 0.216. The evaluation method of CASBEE was 0.166. Weight with the highest content of the evaluation based on Law on Promoting Green Purchasing (JLPGP) in the country was obtained. It was the order in eco-mark, Ministry of Land, Infrastructure and Transport (MILT) LCA, and building CASBEE following Law on Promoting Green Purchasing. The reason why the order in building CASBEE was low is that this is evaluated besides an environmental performance. Especially, the focus might not have been able to be squeezed because there were a lot of evaluation items of the indoor condition. The evaluation by LCA of MILT is considered that there was a part where the mechanism is not understood easily for the student. The focus only of the standard of the road making has been applied, and it is incontrovertible that it was not an evaluation of the entire standard either. The criteria of the eco-mark was half weight of JLPGP though resembled JLPGP by it. There seems to have been a side of not comprehending the criteria of the eco-mark easily. However, this result is a judgment of each evaluation ranking technique when seeing from university student's environmental feeling. That is, when the eco-material is evaluated, it agrees to the evaluation result according to the understanding level to the criteria for evaluation. In this, the improvement in the future is a necessary point we execute the investigation.

Table 3. Evaluation of criteria by AHP analysis that uses result of the questionnaire

Student's criteria	Global warming	Resource & energy	Waste & recycle
Global warming	1	0.33	3
Resource & energy	3	1	5
Waste & recycle	0.33	0.20	1

Organization with the criteria for evaluation	Weight: Judgment to criteria
Law on Promoting Green Purchasing	0.42
the Ministry of Land, Infrastructure and Transport	0.19
Eco-Mark(Iso14040)	0.22
CASBEE (building design)	0.17

Important thing when eco is defined. The Fair Trade Commission in Japan made "Actual condition report concerning an advertising display of the commodity that considered environmental preservation" public in consideration of the rise of the concern to consumer's environmental problems in March, 2001. The idea on the Act against Unjustifiable Premiums and Misleading Representations (truth-in-advertising laws) of an advertising display was arranged based on the investigation of actual conditions result of an advertising display that showed that environmental preservation was considered. And, five points of concern of an advertising display that shows that environmental preservation is considered are presented.

- i) The range of the object that the display shows must be clear.

Display it to understand whether it is the one that lies the one the content of an advertising display concerning the effect of environmental preservation that lies partial of the commodity such as wrapping or the entire commodity clearly.

ii) Display the use ratio such as emphasized raw materials clearly.

For instance, it is necessary to specify the use ratio such as "Recycled paper 60% use".

iii) Necessity of proof of display by proof data etc.

When an advertising display is done emphasizing the possession of some effects for environmental preservation by the element of the commodity, the proof data that shows that this is effective is necessary according to the use of goods in question by the ordinary condition.

iv) Do not do vagueness or an abstract display alone.

When vagueness or an abstract display such as "It is environment friendly" is done, it is necessary to describe the explanation of the matter that becomes grounds of environmental preservation in parallel.

v) Note in environmental mark display

When the third-party institution accredits the mark display for the mark display that shows that it is a commodity that considers environmental preservation, it is requested to display it like clearly understanding the accreditation reason. Moreover, it is necessary to describe the explanation in parallel in the entrepreneur to be adjacent to the position of the mark, and to understand the accreditation reason clearly.

Summary

We proposed a grand design of the eco-material in the this study. And, the definition of eco of the eco-material was reconsidered. When the eco-material in the future was developed, it proposed that the key word of local production for local consumptions become important. We introduced the model that the industrial relation method and the buildup method unite as a new attempt of LCI. Moreover, it introduced sensitivity analyses of LCA of which the index was elasticity based on the examination case in the Ministry of Land, Infrastructure and Transport. When the eco-material was evaluated, the possibility that the mismatch had been generated was shown by using the AHP method among the evaluator and purchasers. Moreover, what to the eco-material had to be displayed appropriately and impartially was shown when seeing from the side of the market. We think that it was one result to be able to present a part of a changing social need in Japan for the eco-material from the above-mentioned.

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