助成番号	09－017

松下幸之助記念財団 研究助成

研究報告

【氏名】李 召羅

【所属】東京大学 アジア生物資源環境研究センター

【研究題目】Monetization analysis of environmental impacts and damages in the production and use of biofuels

【研究の目的】

Biofuels are widely considered one of the most promising sources of renewable energy by policy makers and environmentalists alike. However, unless principles and standards for production are developed and implemented, certain biofuels will cause severe environmental impacts and reduce biodiversity – the very opposite of what is desired. There exist a number of LCA methods and tools. In fact, even if in literature some studies on this specific field can be found, very little research on the integrated assessment of environmental impacts and damages has been achieved, although it has a potential to evaluate specific systems such as renewable energy efficiently.

From these motivations, the objectives of this study are to develop evaluation methods by introducing the integrated assessment of environmental impacts and damage focusing on source-oriented emissions during Well-to-Wheel, and to define the perspectives of sustainable biofuels based on the interpretations of environmental impacts and damage.

【研究の内容・方法】

Integrated factors based on LIME (Life-cycle Impact assessment Method based on Endpoint Modeling) was applied to this study. The monetized damage factors (Table 1) were also used with LIME model, meaning an economic valuation. This was useful for two different scenarios of biofuels to be compared by integrating different categories. In case the damage indicators for biofuels A and B were conflicting (A was higher on human health and B was higher on biodiversity), the answer was dependent on the monetization factors for four safeguards. Considering the feasibility of biofuels in Japan, alternative scenarios are considered for two kinds of feedstocks from “Khon Kaen Area in Thailand” and “Country-Side (Satoyama) Forest in Japan” during Well-to-Wheel. This study introduces two kinds of source-oriented environmental impacts and damage, meaning biofuels emissions and avoided emissions. This study suggested that there were no or less damages offset by avoided impacts in terms of regional and local scales, because safeguards affected by on-site or off-site emissions would be different. Monetization analysis as an integration way was performed for four safeguards, dividing into global, regional and local scales.

.

Table1 Monetization factors for four safeguards adapted from LIME model

Endpoints	Unit	Factor
Human health	USD/DALY	9.70E+04
Social asset	USD/USD	1.00E+00
Biodiversity	USD/EINES	4.80E+10
Primary plant production	USD/kg	2.02E-01

The questionnaire for a comparison between midpoint and endpoint decision-making tools was improved based on the pilot survey, and it was used to survey 1000 Seoul metropolitan area (SMA)

residents by using the Internet. The respondents were randomly recruited by Korean Survey Company (World survey: www.wsurvey.net/) and included residents in Seoul City and Gyonggi Province (including 31 administrative cities). Data management and frequency/nonparametric analyses of the survey results for all the respondents were conducted using SPSS ver. 18.

【結論･考察】

This study suggests major potential sources of biofuels, e.g., grass-type and woody biomass. Their relative impacts on the environment in terms of water and fertilizer use and other criteria should be calculated the both approach of each source. As well as comparing potential biofuel feedstocks, this study also recommended a number of major principles for governing the development of environmentally friendly biofuels. Feedstocks should be grown according to sustainable and environmentally safe agricultural practices with minimal ecological footprints (the area of land required to grow and support sufficient amounts of the crop). In particular, emphasis should be placed on biofuels that can sequester carbon or have a negative or zero carbon balance.

The results of this study illustrate the differences in the LCA outcomes with respect to the midpoint and endpoint approaches (Table 2). By introducing a new impact category for endpoints, the results were changed dramatically in comparison to the results of midpoints. In addition, it would be possible to interpret the effect of each indicator on safeguards by integrating separate midpoints. The key advantage with respect to grouping impact categories in the midpoint and endpoint approaches can be described as “the simplification of midpoints and the segmentation of endpoints.”

Table 2 Framework of LCA interpretation at midpoints and endpoints

Category	Midpoint	Human health	Social assets	Biodiversity	Primary plant production
Global impact					
Global warming	*	*	*		
Ozone-layer depletion	*		*		*
Resource consumption	*		*	*	*
Regional impact					
Acidification	*		*		*
Human toxicity	*	*			
Eco-toxicity	*			*	
Eutrophication	*		*		
Local impact					
Photochemical oxidant	*	*	*		*
Waste	*			*	*
Urban air pollution		*			
Land use				*	*

The respondents were asked to identify the approach that they preferred. Noteworthy is that 68.2% preferred the midpoint approach for evaluating environmental systems. According to the cross-tabulation analysis, individualist group (76.3% of this group) was more likely to prefer the midpoint approach than the other groups, but none of the differences were statistically significant (Asymp. Sig. 2-tailed: 0.091). In terms of the subjective questions, the respondents provided two types of answers regarding why they preferred the midpoint approach. In the first type, the respondents explained that the midpoint approach consisted of familiar words such as “global warming” and “acid rain.” Such words were familiar (and thus easy to understand) because the respondents encountered them through the Internet, television, radio, newspapers, and other publications, among others. In the second type, the respondents noted that it would be better to evaluate environmental impacts (midpoints) first because environmental impacts would lead to environmental damage.

Noteworthy is that the respondents’ preference for midpoint and endpoint decision-making tools is not consistent with that in previous studies. The midpoint approach is limited in its ability to integrate separated midpoints because of different units, whereas the endpoint approach is limited in its ability to facilitate a clear understanding of detailed interpretations of LCA results because of unfamiliar categories.

It would be beneficial to investigate the suitability of midpoints and endpoints for different stakeholders with a low or high level of environmental expertise by comparing previous studies. In addition, much work is needed to compare social preferences of each scenario based on midpoint and endpoint interpretations to generate useful information for decision making purposes.