IR-1.2 Methodology for the Integration of Environmental Accounting and Environmental Indicators for Setting and Reviewing Policy Targets (Final Report)

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Abstract: The purpose of the study is to develop a framework and methodologies of environmental accounting in physical term, on which environmental indicators for setting and reviewing policy performance targets can be developed and calculated. International activities on environmental indicators, indicators of sustainable development, and environmental accounting were reviewed, and characteristics of major methodologies and their relationship with others within these fields were identified. Amongst them, this study focused on physical material flow accounting as a methodological framework. A Japanese material flow account was compiled along with the harmonized framework for international comparison study with the United States, Germany and the Netherlands. In this international joint study, direct inputs of resources from the nature to an economy as well as so-called "hidden flows" behind direct flows were quantified. Indicators such as DMI (Direct Material Input) and TMR (Total Material Requirement) were proposed, and their trends in past 20 years were presented and inter-compared among four countries. An overview of Japanese material flows, which includes inputs, outputs and their balances, was also figured out. A framework of three dimensional, environmentally extended Input-Output table was designed towards a more comprehensive physical account for the next phase of the study. Case studies of physical accounting in municipal level were also carried out.

Key Words Sustainable development, Environmental indicators, physical accounting, material flow

1. Introduction

Development of methodologies for environmental indicators and environmental accounting was regarded as an international priority area of research, since mandated from chapters 8 and 40 of the Agenda 21, in order to provide with appropriate information for better integrated economic-environmental decision making towards the sustainable development. The Basic Environmental Plan in Japan, established by cabinet decision in 1994 based on the Basic Law on Environment, mandated the government to develop comprehensive indicators for implementing and reviewing the Plan towards four long-term policy goals set by the Plan. Although considerable outcomes were obtained from a research project on environmental accounting since 1991 by the Global Environmental Research Funds, much yet to be studied for responding to requirements from both international and domestic policy needs. In particular, linkages between indicators and accounting system have to be strengthened for the better establishment of environmental accounting system as a firm statistical basis of the development and calculation of environmental indicators and/or indicators of sustainable development.

2. Research Objective

In order to respond to policy needs stated above in the introduction, this study aims at firstly developing a framework and methodologies environmental accounting in physical term which can systematically quantify flows of natural resources and environmental burdens, secondly proposing and calculating a set of indicators based on the account. The study should contribute to setting and reviewing policy performance targets of environmental management towards sustainable development.

3. Research Methods, Results and Discussions

(1) Review of international research activities on environmental indicators and accounting

Since the first phase of research project on environmental accounting started in 1991, members of the project have been actively involved in international activities on environmental indicators and environmental accounting, and have contributed to them. In this study, we continued exchange of information through participation in international conferences and workshops, visits and interviews to international experts and institutions. Major approaches in the field of environmental indicators, environmental accounting in physical and monetary term, as well as indicators/indices of sustainable development were reviewed. Then they were classified from two viewpoints, firstly from environmental-economic-social-institutional dimensions that the sustainable development consists of, secondly from level of aggregation of information. Results from the review are as follows.

Environmental indicators, which had been firstly used as metrics of pollution, expanded their scope to incorporate resources issues to cover both "source" and "sink" functions of the environment. A Pressure-State-Response (PSR) framework, which represents a causal chain of environmental issues, was used in many studies. Environmental accounting in physical term dealt with not only natural resources, which had been covered by so-called natural resource accounting, but also environmental burdens, which had been covered by emission inventories.

An essential point of the sustainable development lies in recognition of the "finite" environment and minimization of its irreversible changes. Many studies on indicators of sustainable development have focused on this point. However, as the concept of sustainable development became broader since the adoption of Agenda 21, some sets of indicators are designed to cover all aspects of sustainable development, consequently consist of large number of indicators. On the other hand, studies to develop a single number, namely an index to measure the level of sustainable development have also been undertaken. These attempts include environmentally adjusted aggregates of economic accounts, so-called green-GDP, social indicators, as well as more sophisticated indicators such as the Index of Sustainable Economic Welfare (ISEW). There is another group of methodologies, which try to measure all human impacts to the environment by a single physical index, and present gaps between present figure of the index and a quota assuming equal distribution of environmental capacity among all people on the earth. This includes material intensity, ecological footprint, and eco-space.

Such a wide variety of methodologies for measuring the sustainable development reflect diversity of its concept and definition. At this stage, research should focus on methodologies to measure economic, social and institutional "development", and those to quantify "finiteness" of the natural environment.

(2) Framework and methodologies of Material Flow Accounting

Amongst variety of approaches reviewed above, this study focused on physical

material flow accounting as a methodological framework. Material Flow Accounting (MFA) is a kind of environmental and natural resources accounting in physical term, with emphasis on flows rather than stocks, to quantify material inputs from the nature to an economy, material outputs from the economy to the nature, as well as material throughputs within the economy. The origin of the MFA can be found in so-called "Material Balance Approach" of environmental (ecological) economics and extension of Input-Output analysis for environmental analysis since early 1970s. Nowadays, this approach draws attention again, as mass-production, mass-consumption and mass-disposal of industrialized economies is regarded as a driving force of various environmental impacts, and quantification of these bulky flows of materials is essential towards sustainable use of natural resources and environmental services. A typical approach of MFA deals with aggregated total of all material flows accompanied with national economy. Another approach of MFA in broader sense traces flows of specific substances of priority (e.g. heavy metals, toxic chemicals, nutrients, etc.), which is often called as SFA (substance flow accounting) in order to distinguish from bulk-MFA. An approach similar to the MFA can also be found in Life Cycle Assessment, in which inputs of energy and resources and outputs of pollutants and wastes are inventoried for products, raw materials, industrial processes, etc. Thus the concept of the MFA can be applied not only for a national economy as a whole, but also for a region, an industrial sector, a process, a product, a household, and so on.

In spite of differences in the objectives of analyses and subjects to be analyzed, MFA and these other system-analytical tools can share a common framework. It can be presented in a form of three-dimensional, environmentally extended Input-Output table as shown in Figure 1., in which environmental sectors as a source of resources are positioned below economic sectors, and environmental sectors as a sink of wastes are positioned right-hand to economic sectors. Such presentation as Figure 1 can be easily transformed to matrices compatible with conventional input-output analysis, material balances in a specific sector, and environmental accounting in monetary term.

(3) Compilation of Japanese MFA and international comparison of MFA-based indicators

1) Framework of international joint study

In November 1995, the SCOPE scientific workshop for Indicators of Sustainable Development was held in Wuppertal Institute in Germany. At this workshop, it was agreed to start a joint study on MFA among Germany, Japan, the Netherlands and the United States. International harmonization of MFA methodologies has been much improved by this study. First phase of the joint study put emphasis on inputs of materials, though MFA should ultimately include both of inputs and outputs as well as their balances. The first result from the four countries' study was jointly published in April 1997 by the Wuppertal Institute, the World Resources Institute, Dutch Ministry of Housing, Spatial Planning and Environment, and the National Institute for Environmental Studies[1].

Although the Environment Agency had made rough estimates of Japanese material balance before this joint study, a framework of MFA for the study, which was based on the framework of Wuppertal Institute, covered much broader subjects. In particular, inclusion of "Ecological rucksacks (or hidden material flows)" was the most essential point of the study. Ecological rucksack means indirect material flow, which do not enters the economy but occurs when providing those commodities that do enter the economy. This includes ancillary flows as well as excavated or disturbed flows to obtain natural resources.

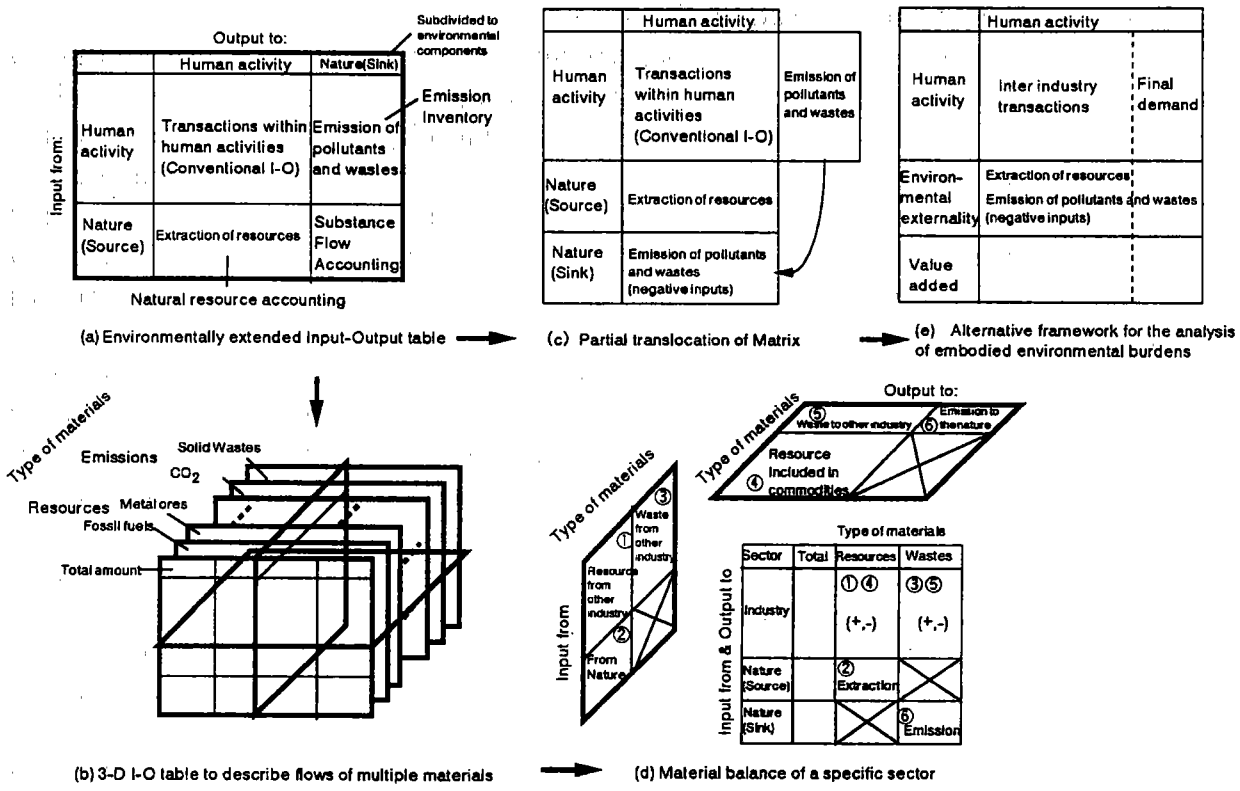

Figure.1 Framework of extended physical I-O table for Material Flow Accounting

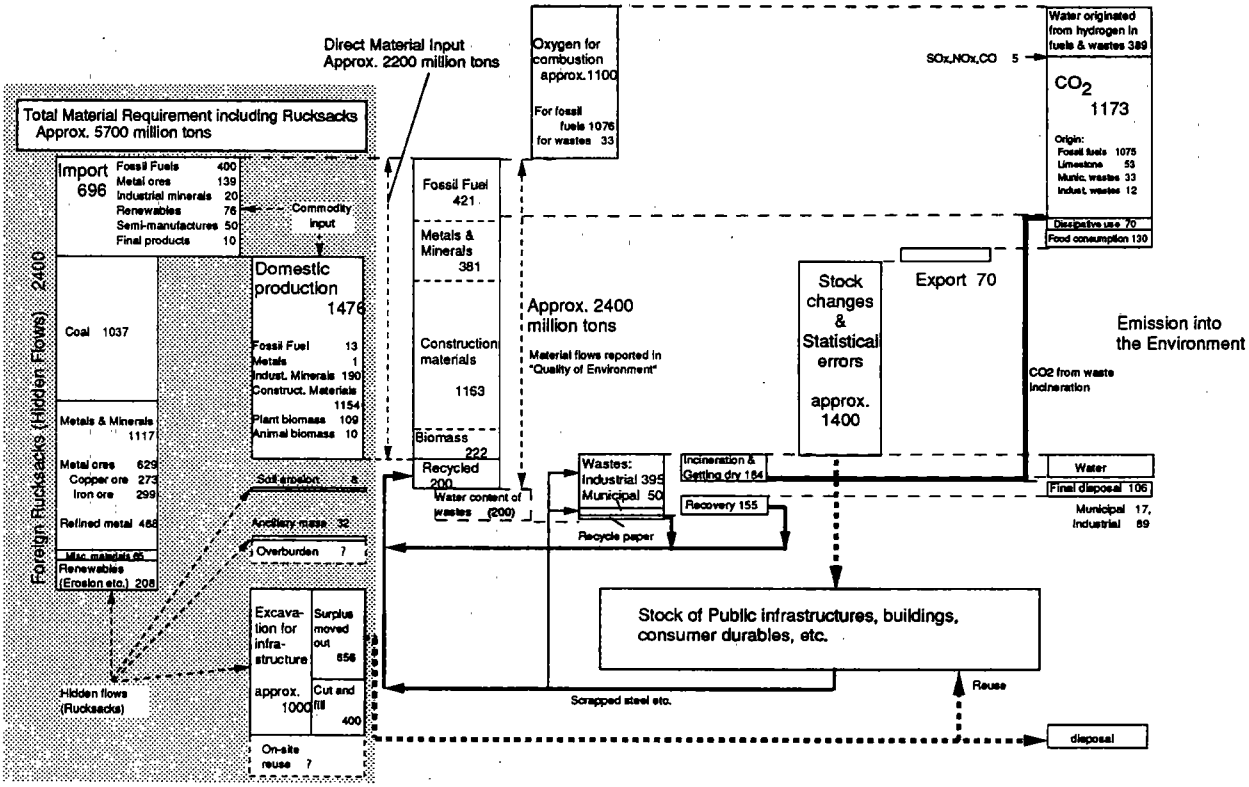

Figure 2 Extended Material Flow in Japan (1990) Unit:million tons

2) Characterization of Japanese material flows

Figure 2 shows an overview of Japanese material flows. Material flows supporting Japanese economy are both from domestic and foreign origin, characterized by high dependency on the import of natural resources. Commodity mass of imported materials accounts for about one third of total input, whereas import flows are larger than domestic ones if ecological rucksacks are included. Imports provide our economy with various basic materials, including fossil fuels, metal ores, agricultural and forestry products. Dependency on imports is particularly high for metal ores and fossil fuels. Recent trends revealed that materials tend to be supplied more manufactured form, typically exemplified by refined metal rather than metal ores. Imports of semi-manufactures and final products have been increasing. Large ecological rucksacks are associated with metals (particularly with copper and iron), coal, as well as agricultural and forestry biomass products. Domestic material flows, both commodity mass and rucksacks, are dominated by construction activities, nearly 90% in 1991.

Not only inputs, but also output flows of materials are described in Figure. 2. Water content of wastes is considered to keep balances of calculation between inputs and outputs. More than half of direct material inputs are added to the stock of infrastructures. It should be noted that the emission of carbon dioxide (CO_2) derived from fossil fuels is as large as inputs of construction materials.

Comparison of trends in MFA-based indicators with trends in CO_2 emission revealed that DMI and CO_2 emissions moved almost in parallel up to 1990, but there found increase of CO2 emission after 1990 despite of stable or decreasing figure of DMI.

3) International comparison of MFA-based indicators

In the four countries joint study, TMR (Total Material Requirement), which is the sum of Direct Material Input (DMI) and ecological rucksacks, was proposed as an aggregated indicator to measure the dependency of industrial economies on huge material resources. Japanese TMR is about 45 tons per capita, which is much lower than other three countries (around 85 tons per capita), as shown in Figure 3. This is mainly because smaller energy consumption and lower dependency on coal. In terms of DMI per capita, Japanese figure is only slightly smaller than Germany and the United States.

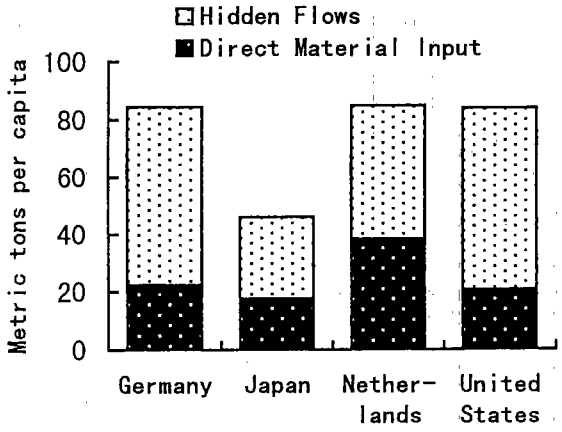

Figure 3 Direct inputs and hidden flows as a proportion of TMR

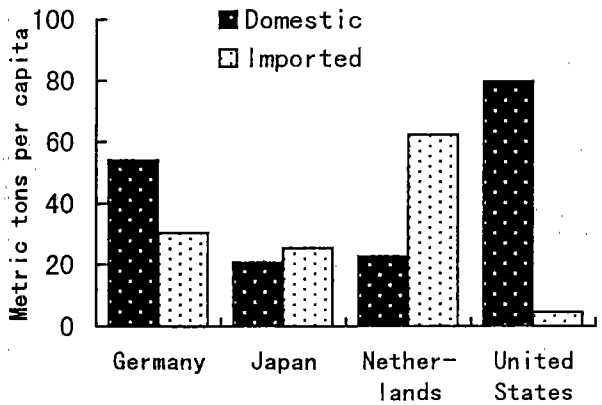

Figure 4 Domestic and foreign components of TMR (1991)

Dependency on imported material flows varies largely among countries, from less than 10 % for the United States to 70 % for the Netherlands, as shown in Figure 4. Ecological rucksacks accompanied by imports imply various environmental impacts in trade partners. More specific analysis will be necessary to identify individual problems behind ecological rucksacks.

According to the analysis of historical trends of indicators, TMR per capita has been slightly decreasing in the United States, whereas increasing trends were found in other three countries. TMR per unit GDP and DMI per GDP, indicators of material intensity, showed decreasing trends in all of four countries, but their decreasing trends slowed down recently.

(4) Development of environmental accounting system in municipal level

The objective of this study is to present a framework of environmental resource accounting which is useful for environmental management at the local level. The study presents a physical accounting system focusing on the amount of energy and materials used for economic activities in a specified area or a city and the wastes generated from them. The system is applied to actual local areas, i.e., built-up areas in Fukuoka City and Kita-kyushu City, to examine its applicability.

Main concerns of the studies on the concept and framework of environmental resource accounting have been how to integrate environmental resources into the system of national accounting. They have mainly discussed in the national economic context, and few studies made on the systems from a local viewpoint. However, many environmental problems are local in nature and they are taking place as a result of irrational use of natural resources at the local level. Environmental resource accounting, therefore, is perceived to be a tool to provide an integrated environmental and economic data set which can assist local environmental authorities to formulate better policies and plans for the rational use of natural resources. Local approaches are not only useful for practical management purposes, but have advantages in utilizing more concrete environmental data available at the local level.

The present study estimates the amount of materials and energy flowing into and flowing out from an area by using two methods: top-down and bottom-up approaches. The top-down approach using aggregate statistical data is applied to Fukuoka City for energy, water and basic materials that are associated with the construction of buildings and urban infrastructures and the use of durable consumer goods. The environmental loads pertinent to the resource input are also estimated in terms of CO_2, SOx, NOx, BOD, COD, T-N, and T-P. The bottom-up approach is developed by using GIS and detailed city maps indicating the location and type of buildings. It is applied to estimate the life-cycle energy (LCE) required for the construction of the buildings and other urban infrastructures. The materials stocked in various physical structures are also estimated. Then the relationship of LCE and total material stocks with the land use characteristics such as land use categories, zone designation and building size restriction are examined.

Reference:

1)A. Adriaanse, S. Bringezu, A. Hammond, Y. Moriguchi, E. Rodenburg, D. Rogich, H. Shuetz: source Flows - The Material Basis of the Industrial Economies- , World Resources Institute, 66p,(1997)