IR-3.1   **Methodology on Environmental and Natural Resource Accounting reflecting Global and International Issues (Final Report)**

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Abstract Environmental and natural resource accounting (ENRA) attracts more and more attention from the world. United Nations adopted the System of integrated Environmental and Economic Accounting(SEEA) as a part of 1993 revision of the System of National Accounts(SNA). In order to respond to international and domestic requirements to develop Japanese system of environmental accounting, an inter-Ministry research project was organized. A feasibility study revealed that global and international aspect of environmental changes was important for Japanese accounting system, because our country produces large amount of global environmental loads and highly depends on imported natural resources. Thus, this sub-theme put focus on physical and economic accounting methodology for global and international environmental changes. The study includes following issues: (1)Follow up of international activities on ENRA, by participating to meetings of the OECD etc; (2)Design of "A Complete System for integrated Environmental and Economic Accounting" as a theoretical framework for accounting environmental impacts by international money flow; (3)Survey of problems and data availability in applying the SEEA to international and global issues; (4)Survey of relationship between environmental changes in foreign countries and final usages of imported natural resources in particular forest resources; (5)Calculation of international balance of embodied GHG emission through trade; (6)Development of information system for graphic presentation of international and inter-sectoral flow of natural resources; (7)Assessment of the effectiveness of Green-GDP as a tool for stabilizing climate change and moderating international relationship.

1. Introduction
        Environmental and natural resource accounting (ENRA) attracts more and more attention from the world. Most of the high level international conferences on the environmental issues (e.g. UNCED, OECD) clearly emphasized the importance of environmental and natural resource accounting, and requested the promotion of research works for developing methodologies and data bases for the accounting. Several countries and international organizations have been carrying out conceptual and practical case studies on environmental accounting of various types, including physical natural resource stock accounting, material balance accounting, environmental expenses accounting, satellite accounting, environmental adjustments of macro-aggregates of national accounts , etc. United Nations adopted the System of integrated Environmental and Economic Accounting(SEEA) as a part of 1993 revision of the System of National Accounts(SNA).
The Japanese Basic Environmental Plan established in 1994 refers explicitly to the importance of promotion of research works on environmental accounting for integration of environmental and economic decision making. In order to respond to both international and national

requirements to develop a Japanese system for environmental and natural research accounting, a three years' research project was organized after a feasibility study on 1991.

2. Research Objective

The feasibility study revealed that it was important to take international and global aspect of environmental changes into accounting system, because our country produces much global environmental loads like Green House Gases, and highly depends on imported natural resources. Thus, this sub-theme aims at physical and economic accounting methodology for global and international environmental changes, such as global warming and trade-related issues. To fulfill this objective, this study includes the review of international activities, design of theoretical framework to reflect international issues into accounting system, practical case studies on international physical flow of natural resource and environmental loads to be reflected in accounting system, as well as an assessment of effectiveness of macro aggregates of environmental accounts in international decision making on environmental-economic integration.

3. Research Methods, Results and Discussions
(1)Review of the definition and goals of "Sustainable Development"[1]

"Sustainable Development" has received global acceptance as a concept for promoting policies that integrate economic activities and environmental protection. It is now a key word in the environmental protection debate. However the term is thought of differently, depending upon the time, place and perspective of the term's user. As environmental issues became more complicated and international in scope, the use of the term has broadened and conflicts have arisen over its meaning. So we reviewed the definitions of the term, attempted to classify the definitions and made recommendations for further refining the concept to make it more useful.

A review of the literature found there were three main kinds of definitions. The first puts much emphasis on maintaining natural conditions and restricting human activities to within those limits, so that systems can regenerate and wastes can be assimilated. The second type emphasizes intergenerational equity and ensuring current economic activities do not reduce the choice of succeeding generations. The third kind emphasizes social justice and quality of life, as basic prerequisites for the development of a sustainable society.

Conventional methods used for measuring the achievement of sustainable development were reviewed chronologically and four main streams were found. The first is that promoting physical accounting to find the most effective way to maintain or restore environmental or resource availability conditions within particular levels. The second attempts to modify economic indicators such as GNP to evaluate environmental pollution and degradation. The third stream seeks to measure sustainability by including a measure of natural resource depreciation in national accounts. The fourth promotes monetary measurement of environmental degradation and welfare conditions. The techniques and problems involved in the use of these methods of measurement are discussed.

It was concluded that the concept of sustainable development needs further study and refinement. A strong theoretical base that can be applied regionally and globally, protection of the rights of future generations and methods for eliminating poverty and social injustice must all form part of the fundamental concept. Also, substantial modifications are needed to the methods for measuring sustainable development. Any measurement index must be global; intergenerational equity must be able to be assessed, as we should progress towards social justice; the relationships between the local and global environment must be explained; and, existing measurements need to be unified into a new framework.
(2) Review of activities on environmental accounting and classification of methodologies

In many countries and international organizations, new attempts for environmental and

natural resource accounting are going on. In order to reflect outcomes from these up-to-date activities to our study, information on current activities has been corrected through participation to international meetings mainly by OECD. During the last three years' research period, we participated three times in the meeting on environmental information, indicators, and accounting organized by the Group on the State of the Environment of the OECD. In particular, a special seminar on environmental accounting held on September 1994
at Paris provided an essential opportunity to exchange useful information based on experiences of many different approaches. Dutch accounting system named NAMEA drew special interest as it attempted to make linkages between the monetary accounting and physical environmental indicators through physical accounting. NAMEA also attempted to include international flow of embodied environmental loads, from the same viewpoint as our recognition as an importer of natural resources.

As a consequences of the review of recent studies, we propose a classification of accounting approaches which is slightly different from the conventional one: A)Natural resource accounts mainly physical, and focusing on stock changes; B)Resources and pollutants flow accounts; C)Environmental expenditure accounts; D)Monetary valuation of environmental changes; E)Alternative, environmentally adjusted macro-aggregates of national accounts.

(3) Review of problems and data availability in applying the SEEA to practical issues

In order to understand the possibility and limitation of the SEEA proposed by the UN, problems and data availability were reviewed by taking several practical environmental issues as examples. Out of international issues of our interest, the SEEA is able to handle foreign environmental changes by economic activity, like tropical deforestation by timber trade. However, non-economic trans-boundary movements of environmental pollutants can not be described in the SEEA, typically exemplified by long range transport of acid air pollutants and global accumulation of Greenhouse gases. It is also difficult to quantify the cost of "additional" change of environmental quality to be imputed to the specific economic activity, because of the uncertainty in natural mechanism, in particular, uncertainty in threshold or critical loads beyond buffering capacity. How to link the SEEA as "economic" statistics and "natural" mechanism of environmental changes is an essential point to be discussed. We also pointed out possible biases originating from temporal or geographical aggregation of parameters used for evaluation method link Hedonic approach.

(4) Alternative framework of satellite accounts to include international environmental issues[2]

As pointed out above, the current SEEA has limitations in applying to environmental changes in international or global scale. We are also interested in the foreign or global environmental changes caused by international money flow, that is neither treated by the SEEA. In order to respond better to international issues, an attempt was made to propose an alternative framework of satellite accounts, by expanding the current SEEA. What we call "A Complete System of integrated Environmental Economic Accounting" was proposed with several specific versions to treat different aspects of international issues. These versions include the Complete SEEA with extension to: A) international linkages by subdividing "rest of the world" sector, which enables to describe relationship between international money flow and environmental changes; B) the global environment as an explicit dummy sector, which enables to describe global atmosphere and oceans as recipients of environmental loads; C) development assistance; D) "Debt-for-Nature Swaps:DNS"; E)fishery and marine pollution; and F) the Complete SEEA which can describe cumulative aspect of environmental degradation.

(5) Analysis of environmental changes imputed to imported resources and products

Japan imports large amount of natural resources and products including fossil fuels,

UNIT : ton

	roundwood
	sawnwood
	pulpwood
	pulp

50000~100000
600000~800000
100000~200000
800000~1000000
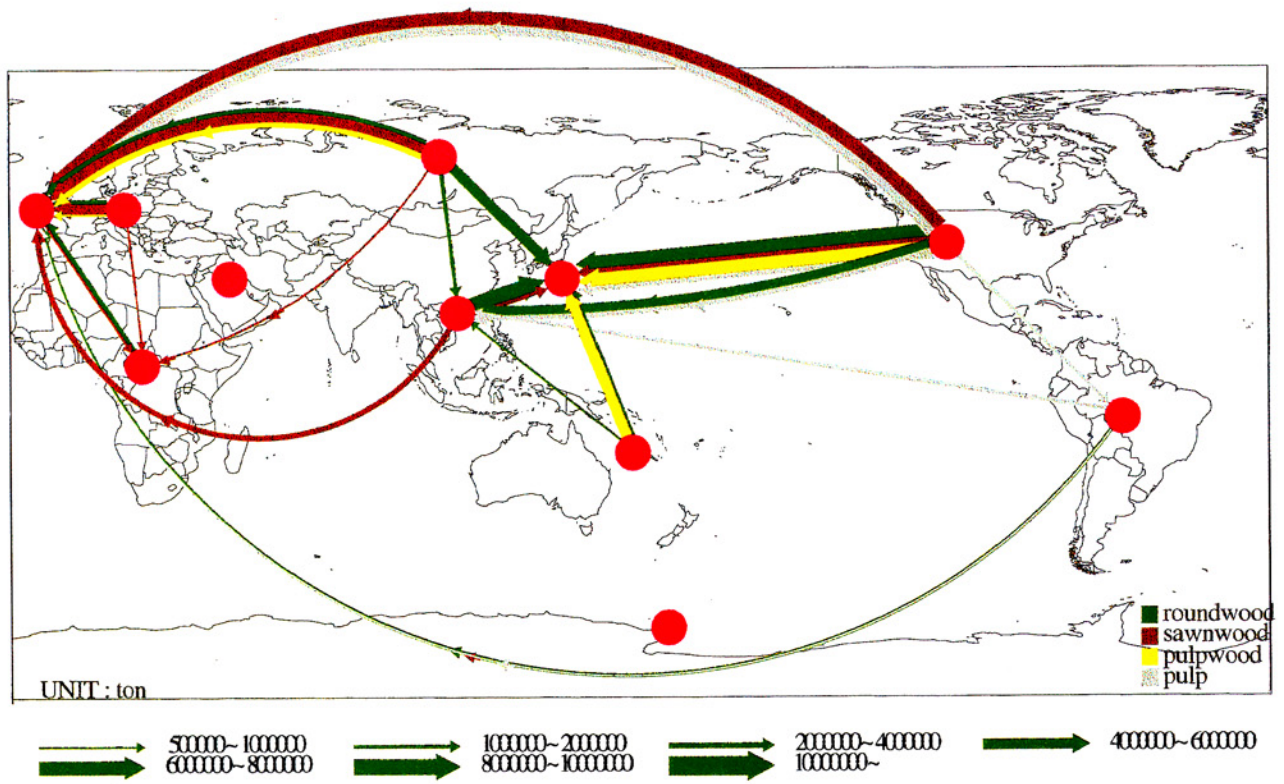200000~400000
1000000~
400000~600000

Fig. 1 International trade of forest products (1988, based on the UN trade statistics)
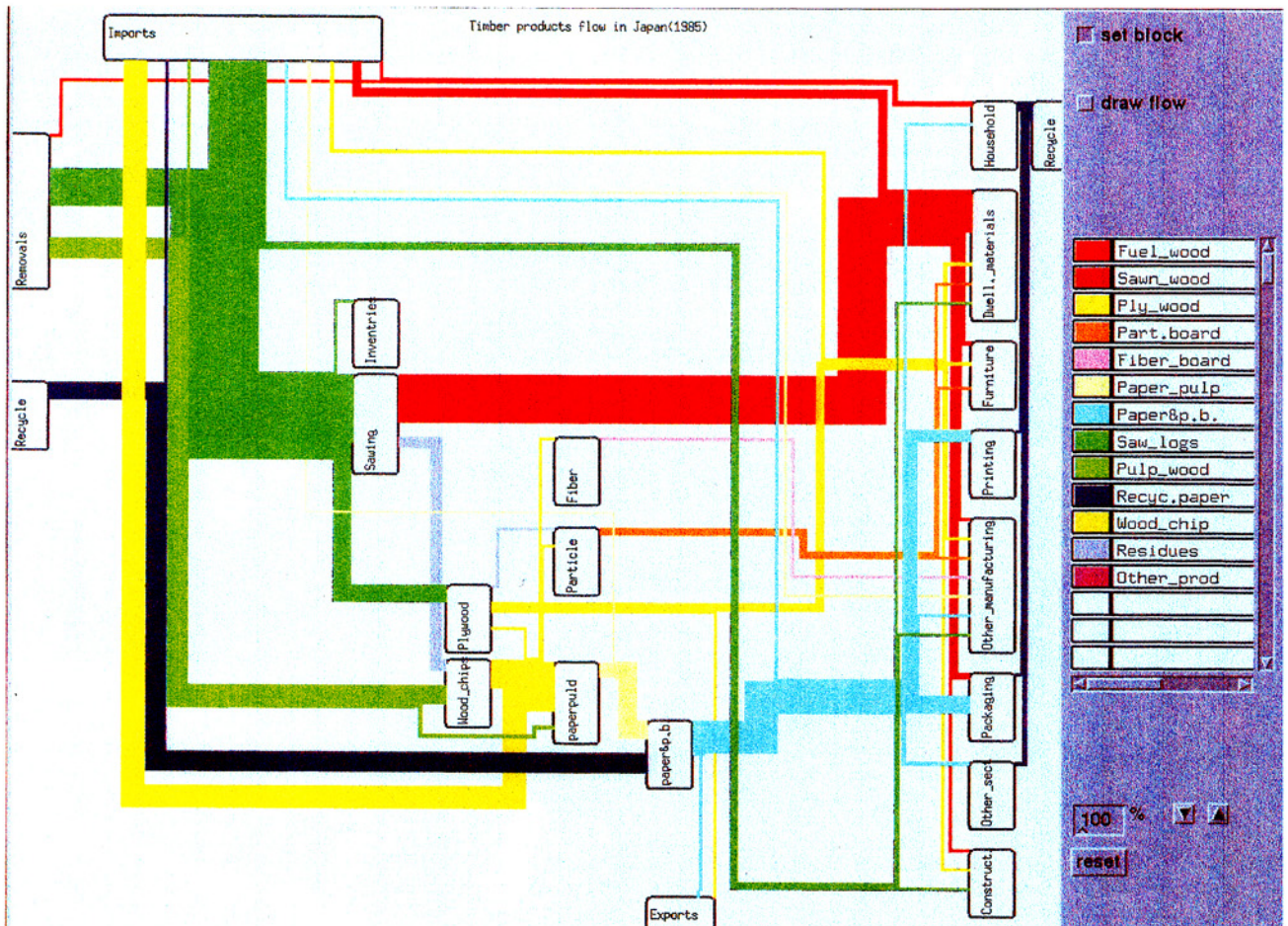

Fig. 2 Flow chart of sector/commodity balance of forest resource in Japan (1985)

agricultural and forestry products, and so on. Imports of these primary products may cause environmental degradation in foreign countries, and such environmental changes have to be reflected as imputed costs to international trade.

As a first step, the state of the Japanese trade and possible accompanying environmental issues were surveyed in order to identify major issues to be reflected in Japanese environmental accounting system. As a database for this analysis, trade matrices of commodities (level of Standard International Trade Code revision 2) were compiled based on the international trade statistics of the UNSTAT. Major imported commodities of forestry, wildlife, mining, agriculture and fisheries were listed up, and possible environmental issues related to these commodities were surveyed as well. Analysis of international flow of these commodities revealed that Japanese import was dominant for tropical woods and forestry products, some metal ores, etc.

Secondly, domestic flows of these imported commodities were analyzed to identify intermediate and final usage of resources, namely in order to identify to whom possible costs should be imputed. Focus was put on forestry products. We compiled sector–commodity material balance accounts of forest resources, of which format was compatible with OECD pilot study on natural resource accounts. This material balance table was prepared by the origin of resources, Japan, North America, Tropical area, and North Pacific. These tables shows usages of tropical wood are much different from those of wood produced by Japan and "North" countries.

In order to support data interpretation in these analyses, an information system was developed to automatically produce graphic presentation of resources' flow. The system can describe international flow of resources on world map based on trade matrix, as well as domestic inter–sectoral flow of resources based on sector–commodity balance table. Fig. 1 shows the international flow of forest products, and Fig. 2 shows domestic inter–sectoral flow of forest resources.[3]

In addition, data concerning the relationship between deforestation area and produced wood were collected, in order to link traded amounts and environmental changes quantitatively. Although cost data for deforestation is still missing, combination of all these data enables the estimation of environmental cost to be imputed to the use of forest–related products.

(6) Calculation of international balance of embodied GHG emission through trade[4]

As other practical examples of the environmental implication of international trade, emission of Greenhouse Gases (GHGs) for producing traded commodities was estimated.

International balance of CO_2 emission embodied in traded commodities was analyzed by combining trade matrix and input–output analysis. Firstly, direct CO_2 emission intensity(d_i) by sector i of I–O table was calculated, by multiplying emission factors by sectoral consumption of fossil fuels and lime stone, described in a physical unit table attached to the I–O table. Then total embodied emission intensity (t_i) was calculated employing inverse matrix of $(I-A)^{-1}$ type.

Calculation of international balance was made using two different assumptions. The first (case A) applies emission intensity t_i for all regions, this means that we assumed the same industrial structure and the same energy efficiency as those of Japan for all over the world. In the second case (case B), t_i was adjusted according to the ratio of region specific CO_2 emission factor per unit GDP to Japanese emission factor, in order to reflect the differences of energy efficiency among countries and regions. Fig. 3 shows schematic balance of embodied emission in international trade. In the case A, Japanese exports and imports of embodied emission are almost balanced. In the case B, Japan is a big importer of embodied emission.

In addition to the macroscopic analysis stated above, several case studies on GHG
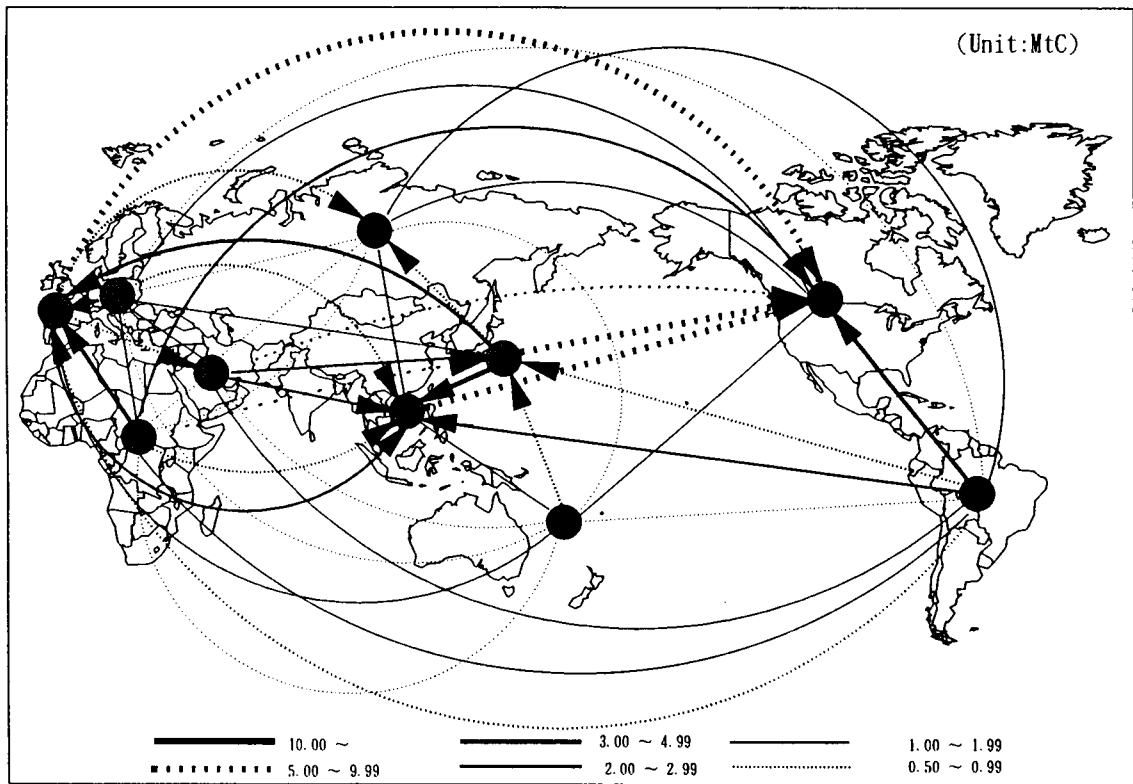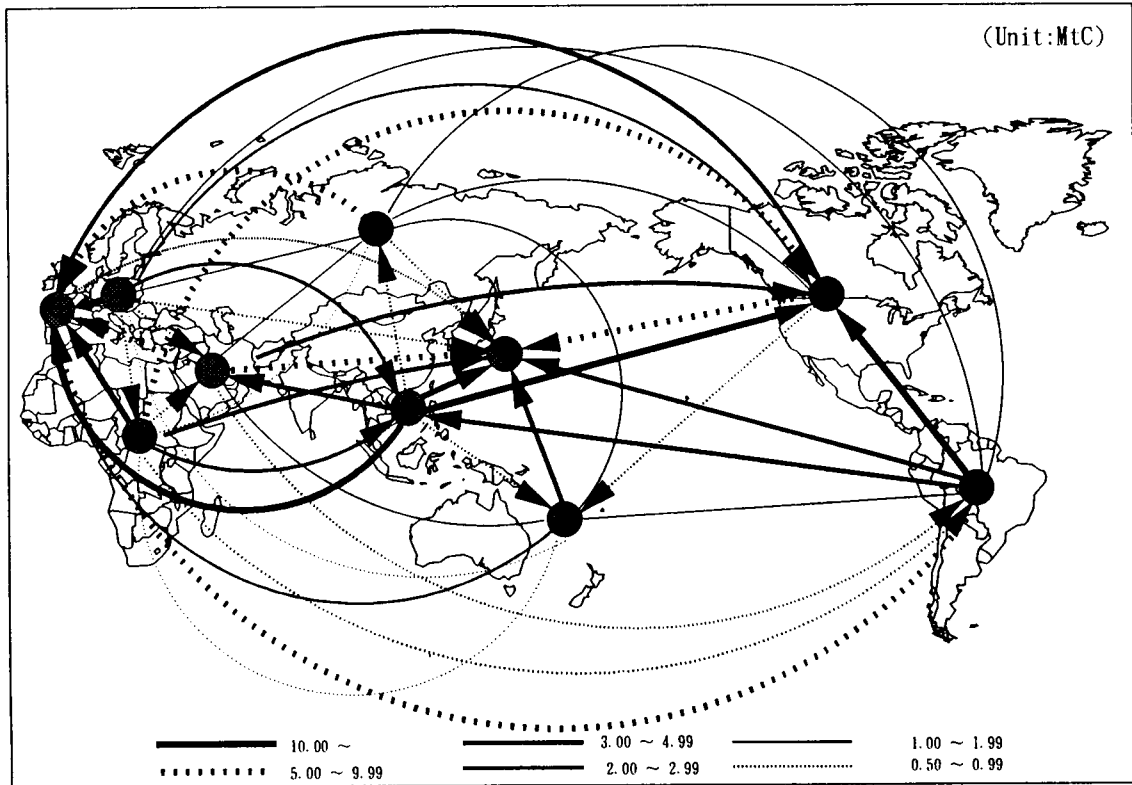
(Unit:MtC)

—— 10.00 ~	—— 3.00 ~ 4.99	—— 1.00 ~ 1.99
■■■■■■■■ 5.00 ~ 9.99	—— 2.00 ~ 2.99	········ 0.50 ~ 0.99

Fig. 3 International balance of CO2 emission embodied in trades
(case A) same emission intensity as Japan for all countries

(Unit:MtC)

—— 10.00 ~	—— 3.00 ~ 4.99	—— 1.00 ~ 1.99
■■■■■■■■ 5.00 ~ 9.99	—— 2.00 ~ 2.99	········ 0.50 ~ 0.99

(case B) region-specific emission intensity adjusted by gross emission per GDP

emission embodied in Japanese imports were made. A study on primary aluminum production revealed that imports of aluminum from Australia embodies much bigger CO_2 emission than other regions, as Australia mainly uses (coal) electricity for electric smelter process, whereas others more or less uses hydro-electricity. Another case study was made on methane emission originating from mining and agricultural activity. Imports from Australia plays a big role again, because sheep breeding for wool production and coal mining accompanies considerable amount of methane emission.

(7) The impact on sustainable development policies of "Green Accounting".

The use of an adjusted economic indicator, such as Green GDP, to reflect the environmental impact of economic activities has been expected to help the world's leading nation's to develop more environmentally-friendly economic policies. However, as these policy effects have not been estimated quantitatively, the importance of Green Accounting is not well understood in the context of policy development. This study tried to estimate these impacts using a modified world economic model. The model applied to this analysis is a modified Global 2100, which was originally developed by Alan Mann as a dynamic-optimization model.

For our analysis, Japan is treated separately as one region in a 6 region world model, and we introduce a new economic accounting method (Green Accounting), that includes a Global Warming Cost Factor. This comprises consumption plus investment minus the environmental cost of global warming.
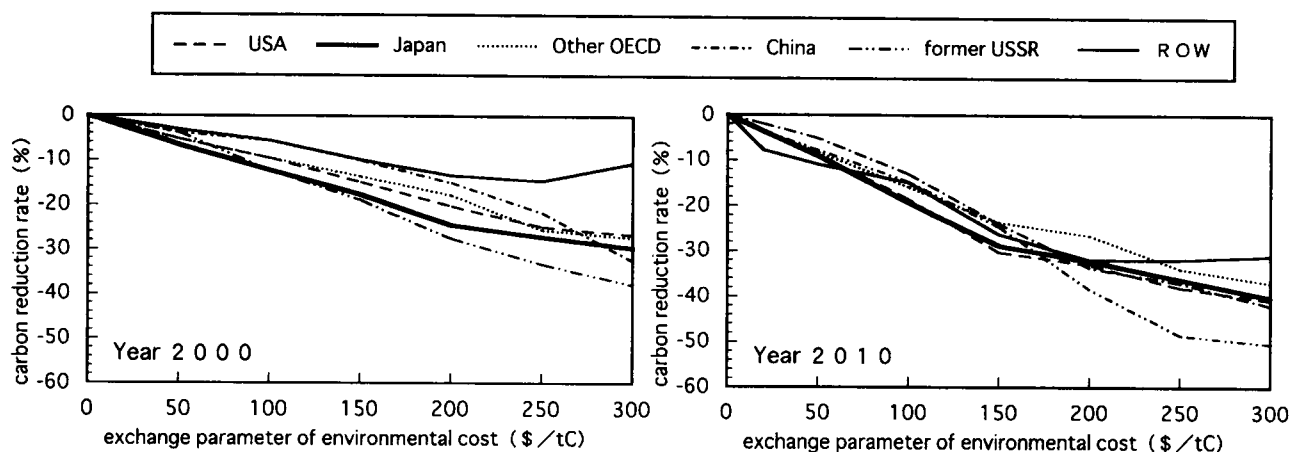

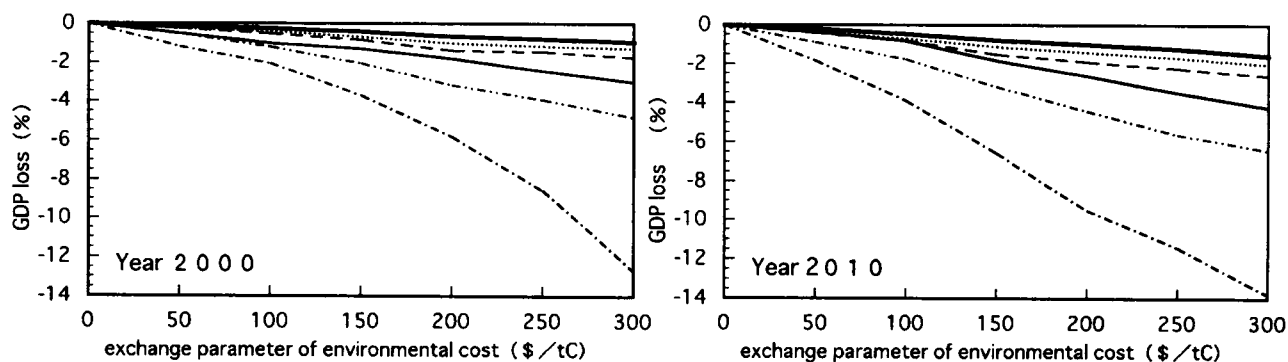Fig. 4 Relationship between exchange parameter of environmental cost and carbon reduction rate

Fig. 5 Relationship between exchange parameter of environmental cost and GDP loss

The environmental cost is estimated by multiplying CO_2 emissions by an exchange parameter. Fig. 4 show the effect of Green Accounting at the year 2000 and 2010. The horizontal axis shows the changing exchange parameter in relation to environmental cost ($ per tonne carbon). The vertical axis is the level of CO_2 reduction. The estimated relationships between the exchange parameters are plotted for the USA, Japan, the former soviet Union, other OECD countries, China and the Rest of the World.

This figure shows that if Green Accounting is introduced, CO_2 levels will definitely be reduced. In order to stabilize CO_2 emissions at the 1990 level, the environmental cost is estimated at more than $200 per tC. Fig. 5 shows the estimated decline in GDP caused by this. The loss in GDP for the Soviet Union is greater than other countries. In spite of this, the level of green accounts will increase because of the reduction in environmental protection costs. This suggests that Green Accounting is a much better index for a nation's economic policy than what currently exists.

Fig. 5 also shows the same exchange parameter of environmental cost causes different economic losses for each region. The introduction of a common exchange parameter for environmental costs is not efficient from the economic viewpoint. In order to alter this inefficient situation, the use of a new adjustment mechanism through environmental accounts was modelled using a decomposition algorithm.

We estimated the use of such an adjustment mechanism would save US$ 1.1 – 2.6 trillion in comparison with a common global exchange parameter. This suggests that Green Accounting is an effective tool for international economic adjustments.

4. Conclusion

There exists wide variety of approaches to environmental and natural resource accounting. Our attempts to reflect international and global aspect of environmental changes into accounting system provided with extra approaches to this issue. Review of literatures and ongoing activities contributed to classify widely spread approaches of environmental accounting as a measurement tool towards sustainable development. From conceptual aspect, we pointed out the limitation of the current framework of the SEEA in application to international issues, and proposed an alternative framework to treat international money flow, global environment, development assistance and so on. From practical aspect, case studies of real as well as embodied flow of natural resources related to international trade provided with major topics to be reflected in environmental and natural resource accounting system in Japan, as a big importer of resources. In addition to these studies from the producer side of accounts, study on the impact on sustainable development policies of "Green Accounting" shows a concrete example of the usefulness of environmental accounting from users side. We believe that these outcomes from this study will contribute to the compilation and use of the environmental and accounting system in Japan.

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