Economic Assessment of Ecosystem Services Provided by the *Satoyama* and *Satoumi*

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Abstract

The study applied the framework of the Millennium Ecosystem Assessment for assessing the economic values of ecosystem services derived from the *satoyama* and *satoumi* to provide policy options for a nature-harmonious society. Using a regional CGE (computable general equilibrium) model, we quantitatively evaluated the effects on the conservation and utilization of the *satoyama/satoumi* of 1) a *satoyama* stewardship policy, 2) a trade liberalization policy and 3) a high brand-value policy for domestic agricultural products. We used a static single-country model, with 23 sectors and eight domestic regions and the Interregional Input-Output Table for Japan 2005 as the benchmark data. GDP increases when a stewardship policy is introduced, but the equivalent variation decreases unless the cost of stewardship is reduced to half of the reference case. A trade liberalization policy increases the welfare and GDP in Japan as a whole even if the effect of externalities on *satoyama* services is included. A high brand-value policy increases GDP and GDP per capita, particularly in Hokkaido, Tohoku and Kyushu. These findings indicate the effectiveness of this method for providing policy options for reconstruction of the *satoyama* and *satoumi* with a clear demonstration of the costs/benefits of ecosystem services.

Key words: ecosystem service, externality, multi-regional CGE model, *satoumi*, *satoyama*

1. Introduction

Historically, human activities have existed in harmony with the environment in the *satoyama* and *satoumi* in Japan. However, in recent years, depopulation and an aging society as well as mass imports of inexpensive agricultural and fishery products have accelerated a decline of management, resulting in a degradation of the harmonious relationship. Furthermore, in addition to global changes such as climate change, the Great East Japan Earthquake and the nuclear power plant accident have had a significant impact on production activities in the *satoyama* and *satoumi*. Japan and international society are urgently pressed to overcome these situations and scientifically set out methods for making effective use of natural resources without impairing the wide variety of benefits provided to human society by biodiversity and ecosystems. Using the conceptual framework of the Millennium Ecosystem Assessment, this study has defined various benefits provided to human society by the

satoyama and *satoumi* as ecosystem services in order to evaluate the provisioning services (*e.g.*, food production function and water supply function), regulating services (*e.g.*, atmosphere/water purification, soil erosion prevention and flood control), and cultural services (*e.g.*, spiritual well-being and ecotourism). Moreover, it has also established a multi-regional computable general equilibrium model that enables comprehensive assessment of impacts exerted on human societal well-being by direct and indirect exogenous drivers through changes in ecosystem services. At a time when the risks of an import-dependent food system have emerged as an issue and when the desire of consumers has obviously shifted to cohabitation with the nature and ensuring a secure and safe life, this study proposes the policy option of rebuilding a symbiotic society in harmony with the natural environment. This policy option would decrease external dependency and clarify the degree of human intervention which allows for the maintenance of provisioning, regulating and cultural services without destroying

biodiversity. It would also allow the *satoyama* and *satoumi* to maximize those values which cannot be assessed by the market economy, including regulating and cultural services.

2. Methodology

The following four exogenous drivers have significant impacts on ecosystem services: (1) export/importation of goods from/to foreign countries, (2) consumer orientation (desire to consume high value-added goods), (3) pressure for urbanization and changes in land use, and (4) ensuring a strong labor force. There is a need for an analysis technique for comprehensively assessing the selection of policies such as one for enhancing the market value of *satoyama* and *satoumi* areas based on their location, according to changes in exogenous drivers, or one for sharing environmental conservation costs across the entire society. This study has adopted a computable general equilibrium model as an analysis technique. Computable general equilibrium models are very commonly used for policy analysis in the context of international trade and the environment. Traditionally, these models have tended to deal with Japan as a single country. The model developed by Takeda and Ban (2010), however, constitutes a multi-regional computable general equilibrium model that enables the representation of transactions between regions by dividing Japan into eight areas. It was established on the basis of the model developed by Ban (2007) with reference to the Monash-MRF (Multi-Regional Forecasting) invented by Peter, *et al*., (1996). This model makes it possible to conduct a detailed analysis of the impact of policy changes such as tariffs on regional economies. The fact that this model incorporates land as a production element conforms to the purposes of analyzing ecosystem services in the *satoyama* and *satoumi*. The current study selected the model developed by Takeda and Ban (2010) as the basic model and extended it in order to incorporate (1) ecosystem services into production efficiency, (2) external economics of ecosystem services, and (3) the shift in preference from imported agricultural products to domestic agricultural products as a change in brand value (consumers' preferences).

The 2005 interregional input-output table was divided into 52 sectors where the agriculture, forestry, and fisheries industries were consolidated into the single sector of the agriculture-forestry-fisheries industry. On the other hand, in the 2000 interregional input-output table, the single sector of the agriculture-forestry-fisheries industry was divided into separate sectors of agriculture, forestry and fisheries (Arai and Masayuki, 2006). Then, an aggregate calculation was performed according to this categorization. For this reason, in this analysis, the ratio of agriculture, forestry and fisheries in 2000 was applied to the 2005 data in order to recalculate the figures for agriculture, forestry and fisheries. As a result, the following 26 industrial sectors have been included in our analysis, as shown in Table 1. In addition, in order to build a benchmark dataset and perform a policy analysis, Japan was categorized into eight geographical divisions: Hokkaido, Tohoku, Kanto, Chubu, Kinki, Chugoku, Shikoku and Kyushu/Okinawa.

Table 1 Classification of sectors and goods.

Symbol		Description	Sectors in the original IO table (52 sectors)
1	agr	Agriculture	Agriculture
2	frs	Forestry	Forestry
3	fsh	Fisheries	Fisheries
4	min	Mining	Mining
5	fue	Coal,crude petroleum and natural gas	Coal,crude petroleum and natural gas
6	foo	Food, tobacco and beverage	Food, tobacco and beverage
7	tex	Textile products	Textile products
8	wap	Wearing apparel and other textile products	Clothing and other textile products
9	woo	Timber, wooden products and furniture	Timber, wooden products and furniture
10	ppp	Pulp, paper and publishing	Pulp, paper, paperboard, paper products + publishing and printing
11	chm	Chemical products	Basic chemical products + synthetic products + final chemical products + medications + plastic products
12	pc	Petroleum and coal products	Petroleum and coal products
13	scp	Stone and clay products	Stone and clay products
14	fem	Iron and steel	Iron and steel
15	nfm	Nonferrous metals	Nonferrous metals
16	met	Metal products	Metal products
17	mac	Machinery	General machinery + office and service industry machinery + household electronic and electric appliances + electric computing equipment + communication equipment + other electronic and communication equipment + heavy electrical equipment + other electrical machinery + precision instruments
18	tmc	Transportation equipment	Transportation equipment
19	oip	Miscellaneous manufacturing	Miscellaneous manufacturing products and recycled products
20	cns	Construction	Construction and repairs + public construction + other construction
21	egw	Electricity, gas, water supply	Electricity + gas and heat supply + water supply and waste management services
22	trd	Commerce	Commerce
23	fin	Financial and insurance	Financial and insurance, real estate + house rental services and real estate
24	trn	Transport	Transport
25	pse	Personal services	Personal services
26	ser	Other services	Communication and broadcasting + public administration + other public services + research and information services + other business services + other services

2.1 For the agriculture, forestry and fisheries industries that utilize water resources for production, water resources have been incorporated as a production element.

2.2 *Satoyama* services have been incorporated into production efficiency, and efficacy of external economies has been introduced.

An increase/decrease in *satoyama* services (ecosystem services provided by the *satoyama*) in *satoyama, satochi* and *satoumi* areas (sites of production) results in an increase/decrease in production efficiency. Due to each industrial sector benefiting from *satoyama* services, an increase/decrease in the amount of *satoyama* services leads to an increase/decrease in productivity in each sector. This study assumes that *satoyama* services depend on the quality of the *satoyama* (when this value = 1 for benchmark equilibrium, there has been no decline in *satoyama* services; when this value > 1, it indicates an increase in *satoyama* services and production; when this value < 1, a decline in *satoyama* services is indicated) . Net production from sector *i* has been defined as the production from sector *i* subtracting the loss incurred by sector *i* as the result of a decline in *satoyama* services. The external economies have been defined as losses incurred by each sector which depends on the total value and share of *satoyama* services. Assuming that the share of *satoyama* services and value of the same are fixed, with benchmark values, the qualitative level of the *satoyama* determines the loss incurred by each sector.

2.3 Introduction of *satoyama* stewardship

This study has introduced an activity for enhancing the quality of the *satoyama*, called "*satoyama* stewardship." For example, traditionally the forest in *satoyama* areas was maintained in good condition at the original level of the *satoyama* by collaborative labor shared by community members in the village. In this model, this activity is initiated by inputting labor and capital at a fixed ratio (Leontief production function). The costs of the activity are collected from households in each region as a form of lump-sum tax.

The net production in sector *i* ($\tilde{Y}_{ir}$) can be expressed as follows,

$$\tilde{Y}_{ir} = Y_{ir} - \sum_s D_{ir}^S \qquad (1)$$

$$D_{ir}^S = (1 - \varepsilon_r)\theta_{ir}^S V_r^S \qquad (2)$$

where Y_{ir} is production in sector *i*, D_{ir}^s is loss due to degradation of *satoyama* service S, ε_r is the qualitative level of the *satoyama* (initial value = 1), θ_{ir}^s is the share of *satoyama* service S received by sector *i*, V_r^s is the total value of *satoyama* service S. If θ_{ir}^s and V_r^s are fixed as benchmark values, D_{ir}^s is determined by the qualitative level of the *satoyama*. According to formulas (1) and (2),

if the qualitative level of the *satoyama* increases, the productivity of each sector will rise. At the benchmark equilibrium, it is assumed that the activity cost is 0.5 yen per increase of *satoyama* service by 1 yen.

2.4 Introduction of trade liberalization

In this model a small country assumption is applied and the terms of trade are exogenously constant, as in the Ban model (2007). Trade liberalization means the removal of import tariffs.

For trade, the Armington assumption is applied. Goods from eight domestic regions are aggregated with the CES function. Then, domestic goods and imported goods are aggregated. In regard to elasticity of substitution, there is an assumption that it is easier to substitute domestic goods for domestic goods than to substitute imported goods for domestic goods. Armington goods where domestic goods and imported goods have been aggregated are used for consumption, investment, government expenditure and Intermediate Input in the region.

In the analysis of trade liberalization, there is a postulation that the qualitative level of the *satoyama* changes in proportion to production from the agricultural sector. Trade liberalization exerts the following effects:
– Liberalization → Expansion of manufacturing production + Decrease in agricultural production → Changes in GDP and income (direct effect);
– Decrease in agricultural production → Decline in the qualitative level of the *satoyama* → Decline in productivity in each section → Decrease in GDP and income (external effect).

Usually, only the effects of liberalization itself are considered, but this model also incorporates the external effect on the *satoyama*.

2.5 Introduction of brand value as a result of an increase in *satoyama* services

The introduction of brand value (consumers' preference) has been dealt with in a scenario in which a rise in brand values of domestic agricultural products results in a shift in preference from imported agricultural products to domestic agricultural products. In this model, the Armington assumption has been made and domestic goods and imported goods are aggregated through the CES function.

The study performed the brand value (consumers' preference) simulation based on a scenario in which brand values of domestic agricultural products had been enhanced, shifting consumers' preference from imported agricultural products to domestic agricultural products. Specifically, the brand value of agricultural products was incorporated by changing the weight parameters of the Armington aggregation function α_r^M and α_r^{AD}. Decreasing α_{ir}^M (increasing α_{ir}^{AD}) led to an increase in the purchase of domestic goods (Table 2).

This study examined the following three scenarios: (1) the value of α_{ir}^M for agricultural products is decreased

by 10% from the benchmark value, (2) it is decreased by 20%, and (3) it is decreased by 30%.

2.6 Ecosystem service value assessment data

This study considered only flood control services and temperature adjustment services among the ecosystem services assessed by Okadera and Watanabe (2012). This is because the values of other services are so small that it is difficult to interpret them in the model. These flood control and temperature adjustment service data represent the value of services that are provided to the entire region. This value is indicated as total value of *satoyama* services in each region and allocated to each sector according to the share of the monetary amount of production to obtain the amount of *satoyama* services provided to each sector in each region (Table 3: unit 10 billion yen).

3. Results

3.1 Efficacy of a *satoyama* stewardship policy on the conservation and utilization of the *satoyama* and *satoumi*

This study introduces an activity for enhancing the quality of the *satoyama*, called "*satoyama* stewardship." This model assumes that an input of labor and capital at a

fixed rate generates this activity (Leontief production function). The cost of the activity is collected from households in the form of a lump-sum tax. An increase in the quality of the *satoyama* results in an increase in productivity in each sector. As a standard case, an increased rate of *satoyama* services has been set at 30%, assuming that an increase of *satoyama* services by 1 yen costs 0.5 yen as an activity cost. For *satoyama* services, this study examined the following three scenarios: (1) only the flood prevention function has increased by 30%, (2) only the temperature adjustment function has increased by 30%, and (3) both functions have increased by 30%. The introduction of *satoyama* stewardship increases GDP while the equivalent variation becomes negative (Fig. 1). It is thought that the negative equivalent variation results from costs of stewardship that are collected from households.

Furthermore, this study also examines the case in which the cost of enhancing *satoyama* services through *satoyama* stewardship is changed (increase of 30%). The study compares the situation of the cost of the standard case with one in which the cost is reduced to 1/2 times the standard case and one in which the cost is twice the standard cost. As a result, this analysis reveals that reducing the cost of enhancing *satoyama* services (which are increased by 30%) by one half leads to a positive

Table 2 Benchmark values of α_{ir}^{M} for agricultural products.

Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyushu
0.43	0.43	0.45	0.45	0.45	0.44	0.43	0.44

Table 3 Economic value of ecosystem services in the form of flood prevention and temperature adjustment in each region of Japan (unit: 10 billion yen).

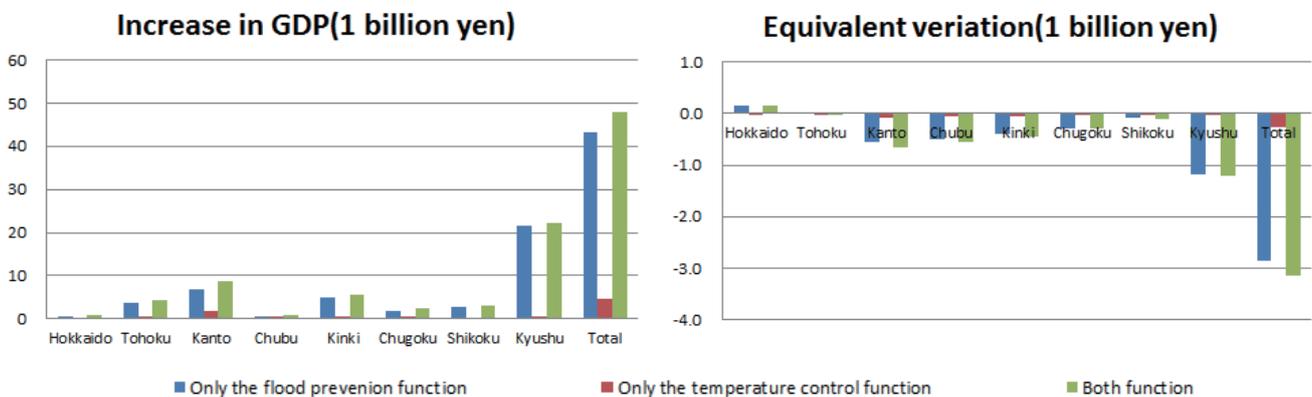|	Hokkaido	Tohoku	Kanto	Chubu	Kinki	Chugoku	Shikoku	Kyushu	Total
Flood prevention	2	13	25	2	18	7	9	76	153
Temperature adjustment	1	2	6	2	2	2	1	2	17

Fig. 1 Increase in GDP (monetary amount) and equivalent variation for *satoyama* stewardship (standard case). (Flood prevention only: only the flood prevention function has increased by 30%; temperature adjustment: only the temperature adjustment function has increased by 30%; both functions: both functions have increased by 30%.)

equivalent variation (Fig. 2). On the other hand, doubling the cost gives a significantly negative equivalent variation.

This indicates that if the cost effectiveness of *satoyama* enhancement is 1:4 or more, an increase in GDP and a positive equivalent variation will be achieved at the same time. Thus, this study has demonstrated that it is possible to propose an optimal solution for the effectiveness of the *satoyama* stewardship policy in terms of conservation and utilization as well as effective investment.

3.2 Efficacy of an import tariff abolition policy on the conservation and utilization of the *satoyama* and *satoumi*

In the case of the abolition of import tariffs, this study has examined the following scenarios: the case in which the effect of *satoyama* services is not considered (no external effect) and the case in which an external effect, i.e., "trade liberalization → change in agricultural production → change in the level of the *satoyama* → change in *satoyama* services → change in productivity in other sectors," is considered (with external effect). In the case of "no external effect," there is an increase in GDP in each region, with an increase of 682.3 billion yen indicated for all regions (Fig. 3). The equivalent variation also increases by almost the same amount. However, in some regions, it decreases. In the case of "with external effect," tariff abolition results in a decline in the quality of the *satoyama*, negatively affecting production in other regions. Therefore, the benefit of tariff abolition (increase of 670.7 billion yen) is smaller than in the case of "no external effect." As a result, the external effect of a decline in the quality of the *satoyama* is extremely small compared to the benefit of tariff abolition. This results from the fact that the original value of *satoyama* services (flood control and temperature adjustment) is not high and the produced capital over which the ripple effect of the decline in *satoyama* services has been evaluated is limited, indicating the possibility of an underestimated result. This indicates that the value of *satoyama* services tends to be high if the ripple effect of decline in *satoyama*

services propagates to other production sectors. As has been observed through the disruption of automobile parts supply caused by the Great East Japan Earthquake and the interruption of the parts supply in Japanese companies due to the large flood in Thailand, in parallel with economic globalization, damage to supply chains caused by the ripple effect of decline in *satoyama* services has become incomparably greater than ever. In the future, in order to assess the ripple effect of a decline in *satoyama* services, extensive discussion will be necessary that incorporates produced capital, including impacts on global supply chains. In addition, it will be necessary to assess impacts on social capital as well to evaluate an external economy that better reflects reality.

3.3 Efficacy of a policy for enhancing brand values of domestic agricultural products for consumers on the conservation and utilization of the *satoyama* and *satoumi*

This study has simulated a scenario in which the brand value of domestic agricultural products is increased, resulting in a shift in consumers' preferences from imported agricultural products to domestic agricultural products. The weighting parameter regarding imports of agricultural products in each region in the standard case is set at 0.43-0.45. In this scenario, the weighting parameter regarding imports of agricultural products is reduced from the standard case by 10%-30%.

As a result, in the 30% case, the average GDP per capita in Japan increases by 16,600 yen (Fig. 4). Particularly, a significant increase is indicated for Hokkaido, Tohoku and Kyushu/Okinawa, with the amount of increase slightly more than 30,000 yen. It has been revealed that an increase in brand values of domestic agricultural products among consumers (shift in preference toward domestic agricultural products) brings greater benefits particularly to Hokkaido, Tohoku and Kyushu/Okinawa which are the major regions supplying domestic agricultural products.
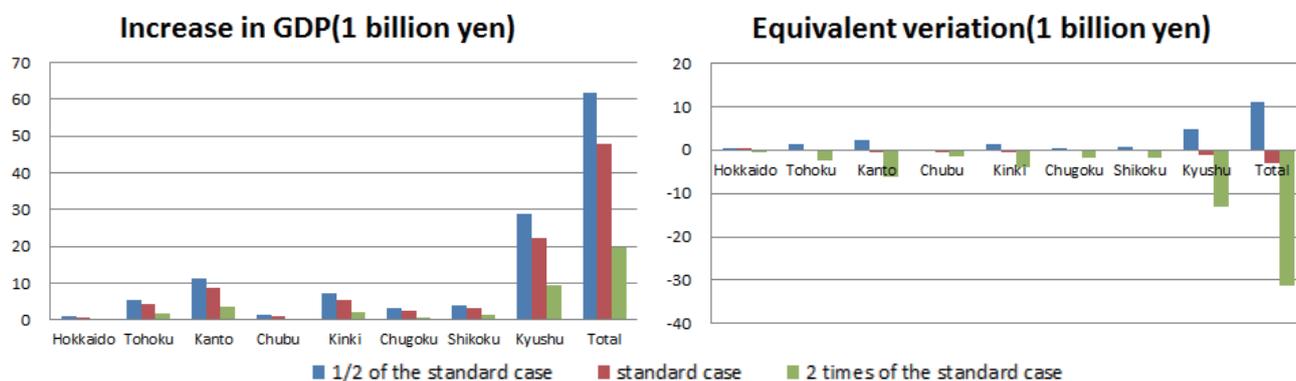

Fig. 2 GDP and equivalent variation due to a change in the cost of *satoyama* enhancement (1/2 of the standard case: cost of 1/2 times that of the standard case; standard case: situation the same as in the standard case; 2 times the standard case: cost twice that of the standard case).
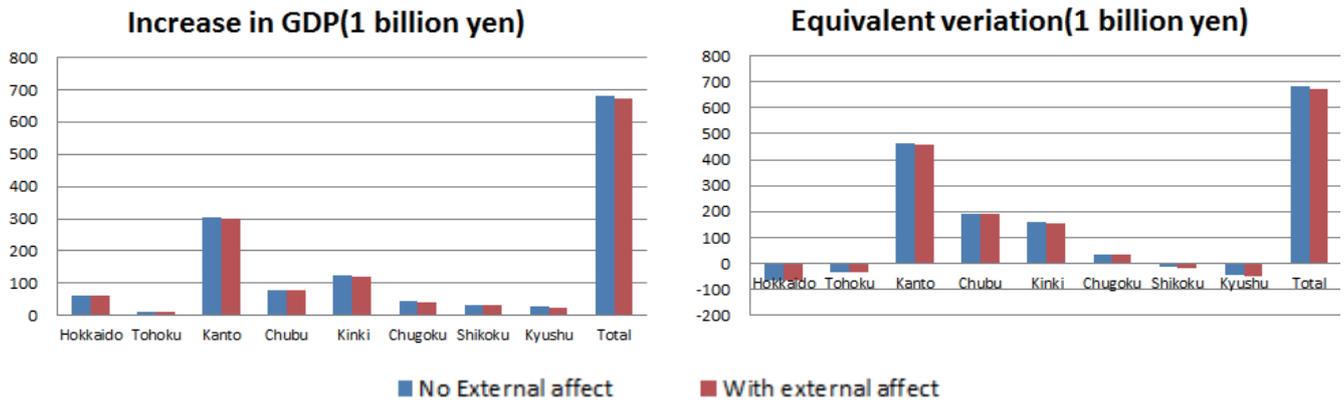
Fig. 3   GDP and equivalent variation due to trade tariff abolition (comparison between the case of "no external effect" and the case of "with external effect").
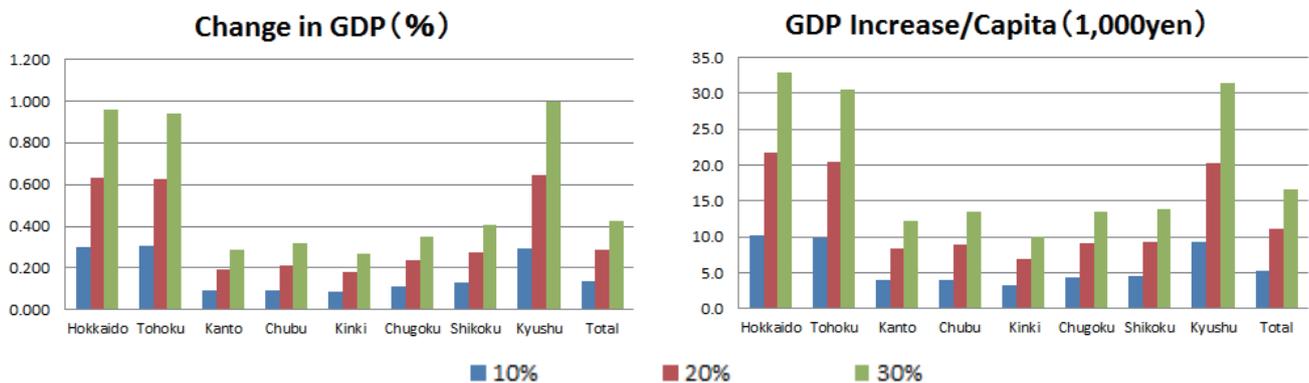

Fig. 4   Change in GDP and increased amount of GDP per capita due to an increase in brand value.

4. Discussion

With the objective of promoting the conservation and utilization of the *satoyama* and *satoumi*, this study performed a quantitative evaluation of the value of ecosystem services provided by the *satoyama* by applying the Millennium Ecosystem Assessment technique. This study also analyzed the efficacy of the following three policies on the conservation and utilization of the *satoyama* and *satoumi* while incorporating economic ripple effects, including external economies and the impact of consumers' choice: (1) a policy for collecting the costs of the activity for enhancing the level of the *satoyama* (*i.e.*, *satoyama* stewardship) from households in each region as a lump-sum tax, (2) a policy for abolishing trade tariffs, and (3) a policy for enhancing brand values of domestic agricultural products. As a result, this study proposes a policy that clarifies the design of a *satoyama* stewardship program for implementing policies for promoting the conservation and utilization of the *satoyama* and *satoumi*, the financial cost of the program and the cost effectiveness as well as burdens to the shift of consumers' preferences toward domestic agricultural products. This would make it

possible to implement a strategy for conserving and utilizing the *satoyama* and *satoumi* based on the assessment of the economic value of ecosystem services provided by the *satoyama* and *satoumi*.

This study has demonstrated the high degree of effectiveness on the conservation and utilization of the *satoyama* and *satoumi* that is exerted by a *satoyama* stewardship policy that generates cost effectiveness for increasing *satoyama* ecosystem services at 1:4 or more. It has also demonstrated the high degree of effectiveness of a policy that enhances brand values of domestic agricultural products. However, the current assessment of the economic value of ecosystem services poses the risk of underestimation and furthermore, as the greatest damage has been incurred by social capital, it is possible that the lack of the assessment of impact on social capital has induced some degree of underestimation. Thus, the future necessity has been raised for developing a practical way of assessing the economic value of ecosystem services provided by the *satoyama and satoumi* by incorporating more extensive impacts on produced capital and social capital.

References

Peter, M.W., M. Horridge, G.A. Megher, F. Naqvi and B.R. Parmenter (1996) *The Theoretical Structure of MONASH-MRF, Working Paper #OP-85*, Centre of Policy Stdies, Monash University.

Ban, K. (2007) *Development of Multi-region Dynamic CGE Model for Japan*. RIETI Discussion Paper Series 07-J-043, September. (in Japanese)

Takeda, S. and K. Ban (2010) *Regional Effects of Trade Liberalization in Japan: A CGE Analysis based on an Inter-regional Input-Output Table*. RIETI Discussion Paper Series 08-J-053, April.

Arai, S. and O. Masayuki (2006) Summary of inter-regional input–output table for Japan 2000. *Economic and Statistical Research*, 34 (3): 1-22. (in Japanese, Heisei 12 nen sisan chiikikan sangyou renkanhyou no gaiyou, keizai toukei kenkyu)

Okadera, T. and M. Watanabe (2012) Regional value of provisioning and regulating services from water in Japan. *Global Environmental Research*, 16: 197-203.

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