Ecosystem service valuation and ecosystem asset account in Japan

Takashi Hayashi
Policy Research Institute, Ministry of Agriculture, Forestry and Fisheries (PRIMAFF), Japan
Masayuki Sato
Graduate School of Human Development and Environment, Kobe University, Japan

Contact author: Takashi Hayashi
3-1-1 Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan
E-mail address: th8841@affrc.go.jp
Tel.&Fax: (+81)-3-6737-9082

Abstract

This paper aims to introduce Japan's current initiative of valuing ecosystem services and incorporate it to SEEA-EEA. Specifically, we evaluate ecological stocks (i.e. forest and wetland) and ecosystem services from them based on our economic valuations, and develop an accounting system to record these values. We also aim to apply the results to macro indicators such as a sustainability index.

Firstly, we estimate the unit value of forest and wetland by environmental-economic valuation techniques. Contingent valuation is applied to estimate welfare values for both forest and wetland. In addition, we estimate the exchange values of the stocks. For exchange values, a methodology applied in the TEEB study is used. The estimated values are incorporated in the ecosystem asset accounts in both physical and monetary term. The values are disaggregated into their functions to provide ecosystem services. The evaluations are conducted in each prefecture in Japan.

The ecosystem accounting in our study can provide useful datasets and information regarding ecosystems, and contributes to the policymaking as both surplus and exchange value of ecosystems are on the accounting, these two types of values can be used for different policy purposes, and we can apply the estimates to macro indicators such as Inclusive Wealth Index and the possibility of application are also mentioned briefly.

As the paper is not exclusively designated for the London Group (LG) meeting, we just introduce Japan's initiative of developing an ecosystem accounting. We think that the implementation of economic valuation is still minor in the global trend of developing the ecosystem accounting and in the LG discussions. We believe we can provide some useful information to the discussion in the LG, particularly that of economic assessment.

Keywords
SEEA-EEA; Ecosystem asset accounting; forest; wetland; Japan

1. Introduction

1.1. Backgrounds and purposes

As observed in the Millennium Ecosystem Assessment and the Economics of Ecosystem and Biodiversity (TEEB) reports, the awareness of the importance of assessing the value of ecosystem and its services is growing. For instance, Japan government is currently formulating policies aimed at achieving the Aichi Biodiversity Targets. At the same time, a variety of research and policy debates aimed at achieving sustainable development are underway. As a result, it has become urgently necessary to include the value and the role of ecosystem and its services in the development of sustainability indicators related to policy planning and evaluation. In the light of the efforts to establish a global framework for ecosystem accounting, such as the System of Environmental and Economic Accounting Experimental Ecosystem Account (SEEA-EEA), it is necessary to establish national accounting system which enables us to evaluate the value of ecosystem and its services in Japan.

We are conducting a research project which aims to assess the value of ecosystem services and develop an ecosystem accounting in Japan. The project also aims to apply the results to sustainability indicators. Although many studies which evaluate the value of ecosystem and its services have already done in Japan, studies on aggregating the values to accounting systems is inadequate. Therefore, in this research, we will attempt to aggregate the results of economic assessments that have been done so far using a SEEA-EEA framework.

This paper aims to introduce our current initiative of valuing ecosystem services and incorporate it to SEEA-EEA. Specifically, we evaluate ecological stocks (i.e. forest and wetland) and ecosystem services from them based on our economic valuations, and develop an ecosystem accounting system to record these values.

1.2 Contribution to the LG discussions

As the paper is not exclusively designated for the London Group (LG) meeting, we just would like to introduce Japan's initiative of developing the ecosystem accounting. Our approach is based on utilization of existing studies on ecosystem valuation and mainly focuses on economic valuation. We think that implementation of economic valuation is still minor in the global trend of developing the ecosystem accounting and in the LG discussions. We believe we can provide some useful information to the discussion in the LG, particularly that of economic assessment.

2. Accounting framework

Our fundamental approach to develop ecosystem accounting is to utilize previous studies on evaluating ecosystem services which have been made so far, and some of them conducted economic evaluations. Therefore, our accounting framework to be developed should include monetary accounts as well as physical accounts. In addition, ecosystem services are quite local

specific particularly in Japan, as land use is “mosaic” and various ecosystems co-exist together in a very small area. Local or regional assessment of ecosystem services is necessary as well as national assessment.

When developing the accounting systems, what to be considered first is the type of ecosystem to be assessed. In Japan, forest dominates roughly two thirds of national land. Therefore, we chose forest as an ecosystem services to be assessed. Another ecosystem to be assessed is wetland including rivers and lakes, this is because wetland is considered as one of the most important ecosystems in Japan. Therefore, in our study, forest and wetland are chosen as the ecosystems to be assessed. Although all types of ecosystem should be assessed comprehensively when developing ecosystem accounting, we chose these two ecosystems for the evaluation as the first approach due to data availability.

The second point to be considered is which accounts in the SEEA-EEA framework should be compiled. The SEEA-EEA has multiple accounts in the framework, and it is almost impossible to compile all of the accounts du to data availability. Additionally, some of the accounts are not necessary when considering the nature of ecosystems and policy priority in Japan. In our study, we compile ecosystem asset accounts because our evaluation of ecosystem is based on asset valuation. The asset accounts are compiled for all 47 prefectures to cope with local issues.

Thirdly, we have to consider time base: in what years the accounts should be compiled. Although annual assessment is desirable, it takes much time and workforce. We believe that ecosystems to be assessed in the study: forest and wetland do not change drastically in such short period as one or two years, so we compile ecosystem accountings with an interval of several years, considering the data availability of physical data.

Fourth, another important issue to be addressed for economic valuation is of which value should be applied, surplus value or exchange value. Exchange value can evaluate ecosystem services based on market value and is consistent with the System of National Accounts (SNA), but it cannot evaluate non-use value of ecosystem which is not transacted in markets. On the other hand, surplus value can evaluate externality and non-use value of ecosystem but it is inconsistent with current SNA. Both methods have strengths and weaknesses, and which approach should be applied depends on the purpose for the evaluation and use of its results. In this study, we apply both surplus and exchange value for the valuation, so that users can choose the proper approach depending on their purposes.

Based on the discussions above, in this study, we develop an integrated physical and monetary asset account. This is because the data recorded on a physical account are too minor to compile an individual physical account and most of the data is dominated by the monetary asset values. Table 1 shows the framework of forest asset accounting. It is developed based on SEEA-EEA framework and modified taking into account the discussions above and data constraint and availability in Japan. Row items include opening and closing stocks, addition to and reduction in stocks. These items are designated for recording change in stock of ecosystem

Ecosystem asset account

		Forest													
		Physical value		Monetary value											
				Exchange value						Surplus value					
		Total	Total	Total	Water strage	Land slide prevention	Mitigation of climate change	Conservation of ecosystems	Timber production	Total	Water strage	Land slide prevention	Mitigation of climate change	Conservation of ecosystems	Timber production
	Unit	Hectare	m^3	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY
		A	B	C	D	E	F	G	H	I	J	K	L	M	N
Opening stock of ecosystem assets (2000s)	1														
Addition to stock	2														
Regeneration - natural	3														
Regeneration - human activity	4														
Reclassifications	5														
Reduction in stock	6														
Reduction due to extraction and harvest of resources	7														
Reduction due to ongoing human activity	8														
Catastrophic losses due to human activity	9														
Catastrophic losses due to natural events	10														
Reclassifications	11														
Revaluation	12	－－	－－												
Net change in stock	13														
Closing stock of ecosystem assets (2010s)	14														

－－: Firgures not recorded on this cell conceptually

Source: Based on SEEA-EEA handbook Table 6.1

in a certain period. In this study, opening and closing years are 2000, 2007 and 2012 for forest accounting. Column items are divided into physical part and monetary part. Physical part can record physical data such as area and volume of forest resources and. Monetary part can record the values of forest wetland separately they are evaluated by both surplus and exchange approaches. The values are disaggregated by their functions like water storage, landslide prevention etc.

A similar accounting is developed for wetland. This also contains both physical and monetary parts; area of wet land is recorded in the former and the valuation results are recorded in the latter part respectively. The monetary part is divided into the part for exchange approach and for surplus approach. The years of valuation are 2000 and 2009 for wetland.

3. Valuation

3.1. Physical data

To compile a forest asset accounting, we collected physical data on forest. We compile a forest resource database to estimate the volume of forest in Japan. Two existing statistical datasets are used: the Report on Results of 2000 World Census of Agriculture and Forestry in Japan 2000 and the Report on forest resources (*Shinrin Sigen no Genkyo*). Data variable in these databases include forest area (in hectare), forest volume (in m^3), forest density (in m^3/ha), and average age of trees in forest (in year). Additionally, tree species (conifer or broadleaf) and nature of forest (natural or planted) are important factor to estimate the value of forest because expected ecosystem services from forest are diverse among them. Thus, using the data, we group forest into four categories: 1) planted conifer, 2) planted broadleaf, 3) natural conifer, and 4) natural broadleaf. These data are available by prefecture in the years 2000, 2007, and 2012. Therefore, we can consider the locality of forest status and change in forest resources by prefecture. As forest age and density can reflect the quality of the forest resources, the data is useful for the government and policymakers to design the effective forest management strategy and the policies to improve forest ecosystem with taking not only local characteristics but also qualitative information into account.

Furthermore, in this study, we conduct the evaluation of forest by its ecosystem function. Five ecosystem services from forest are identified: water storage, landslide prevention, mitigation of climate change, recreation and timber production. In this study, we define the ability to provide these services as function and disaggregate the value of forest into these five functions. Some of physical data for these functions are available in existing forest databases.

For wetland evaluation, generally, the same strategy with forest case is taken; we firstly capture the area of wetland by physical data. We use geographic information system (GIS) data to capture the area of wetland. We calculate the area of wetland in 1976, 1987, 1991, 1997, 2006, and 2009 at prefectural level.

3.2 Economic evaluation

In this study, for exchange approach, we apply the methodology used in TEEB assessment (van der Ploeg et al., 2010) which is close to market rent technique. For the evaluation with surplus approach, in this study, we apply the CV to estimate WTP as the basis of surplus value assessments.

The data used for forest valuation with surplus approach were obtained by a nation-wide social survey conducted from November 16 to December 4, 2015. In total, 192,704 people participated in the survey. The respondents of the survey were distributed across prefectures according to the population and the age distribution among/within each prefecture. In order to estimate annual WTP per household, we adopt the payment card method of CV. The target of evaluation is defined as one hectare of forest in the prefecture in which a respondent is living.

In order to value each ecosystem function of forest, we use choice experiment approach to value each ecosystem function. Based on Japanese Academic Council (2001), we targeted five functions of forest;

(1) water storage
(2) landslide prevention
(3) biodiversity conservation
(4) mitigation of climate change
(5) timber production

With these five functions, we define the level as 75% (down by 25%), 100% (status quo), 125% (up by 25%), 150% (up by 50%) comparing to the current situation after conducting environmental policy.

By combining each level of function, we made profiles of potential policies. In choice experiment, we use orthogonal planning to combine levels of each function, and randomly show two policy option and one “no-choice” option. The respondents reply five repetition of this choice task.

For wetland, we also conducted social survey of payment card CV to measure the unit value of wetland. Along with the valuation, we focused on seven functions of wetland as below.

(1) Adjusting climate change
(2) Water control
(3) Water purification
(4) Ecosystem and biodiversity
(5) Recreation
(6) Amenity
(7) Others

Using the WTP for one hectare of wetland, we conducted the regression analysis with socio-economic variables and characteristics of wetland. Using the equation and physical data of each prefecture, we calculate the unit value of wetland in each prefecture. Then, we multiply

with the size of wetland, we obtained the information of wetland stock which is introduced into the accounting framework.

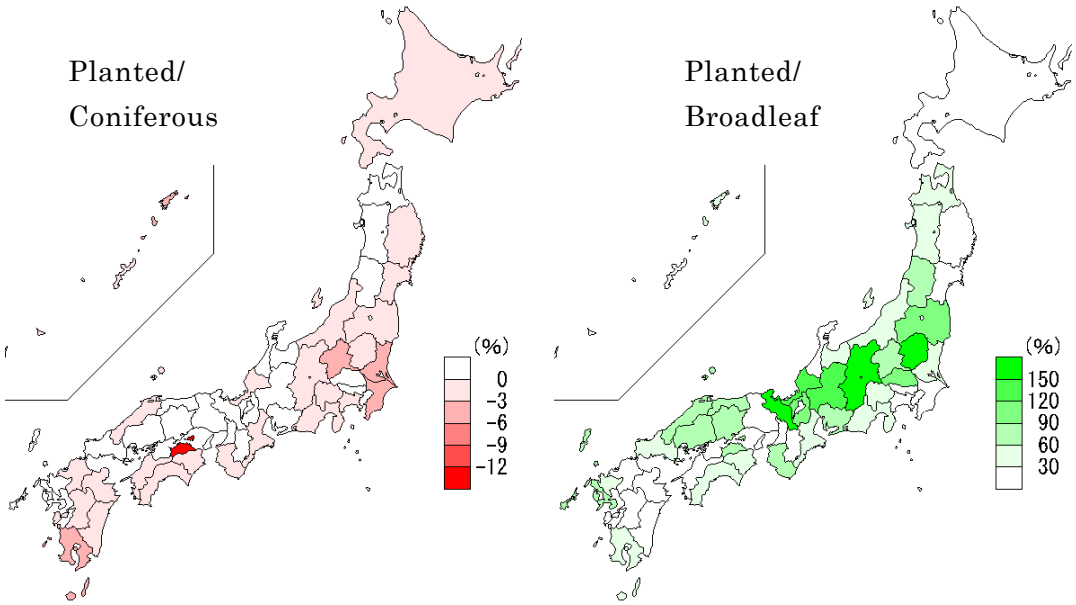
Note that some part of the evaluation is now underway. In addition, the economic evaluation of wetland with exchange value is currently underway.

4. Results

4.1. Physical data

Figure 1 shows change in forest area by category. Change in forest area varies by prefecture. Planted broadleaf is increasing in Nagano, Gifu, Kyoto and Chugoku-region which includes Okayama, Horoshima, Tottori and Shimane. Natural conifer is increasing in Chiba, Hokkaido and Tohoku-region which includes Akita, Yamagata, Miyagi and Fukushima.

In terms of the data of forest conditions, we focus on average forest age because it reflects the implementation of forest management such as replant and thinning. The older forest unlikely to store carbon, so in such forest, the function of mitigation of climate change is weaker than others.



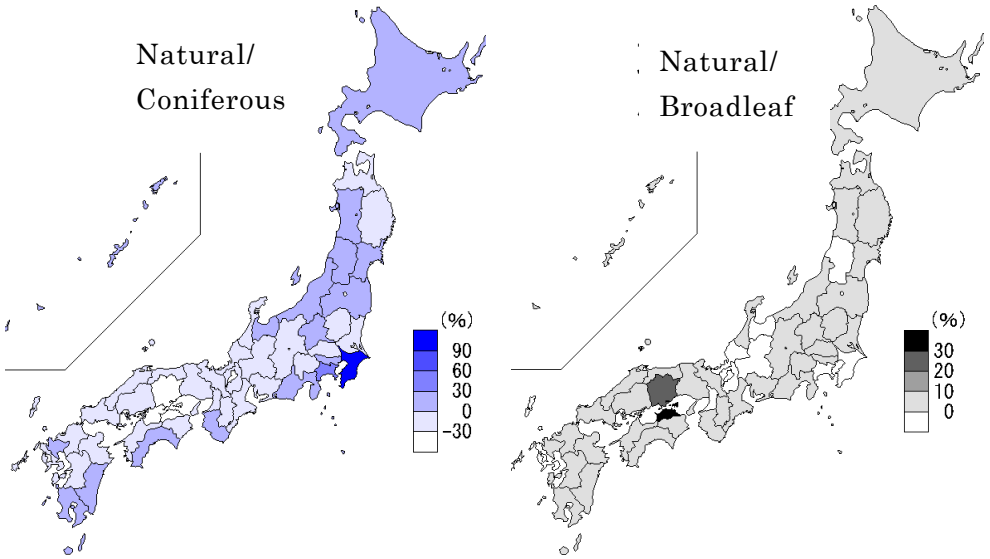


Figure 1. Change in forest area in each prefecture in 2000-2011

Source: Report on Results of 2000 World Census of Agriculture and Forestry in Japan 2000

Figure 2 suggests that although the age of planted forest is getting older, natural forest tends to be younger on the other hand. This may be because of the insufficient forest management in planted forest especially after 2000. When the planting started, large demand for construction used to be expected, but after the competition with imported timber, the Japanese forestry has not been profitable and has been drastically shrinking. As a result, it has become difficult to conduct an appropriate forest management.

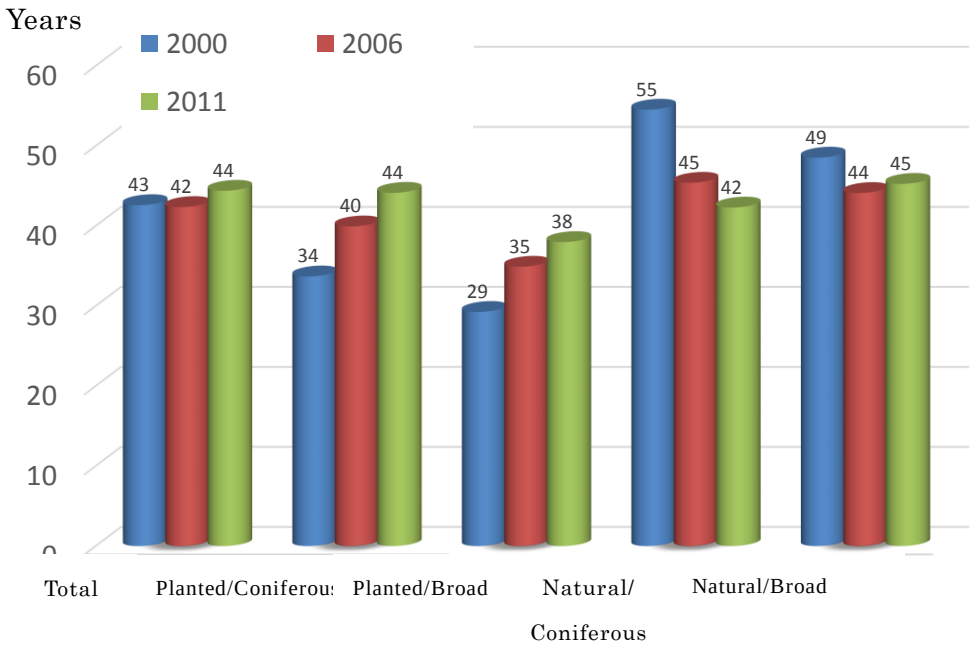


Figure 2. Forest age by type

Source: IBID

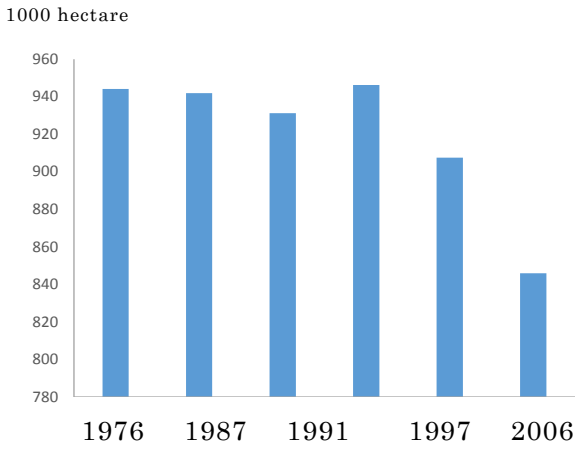


Figure 3. Change in wetland area in Japan

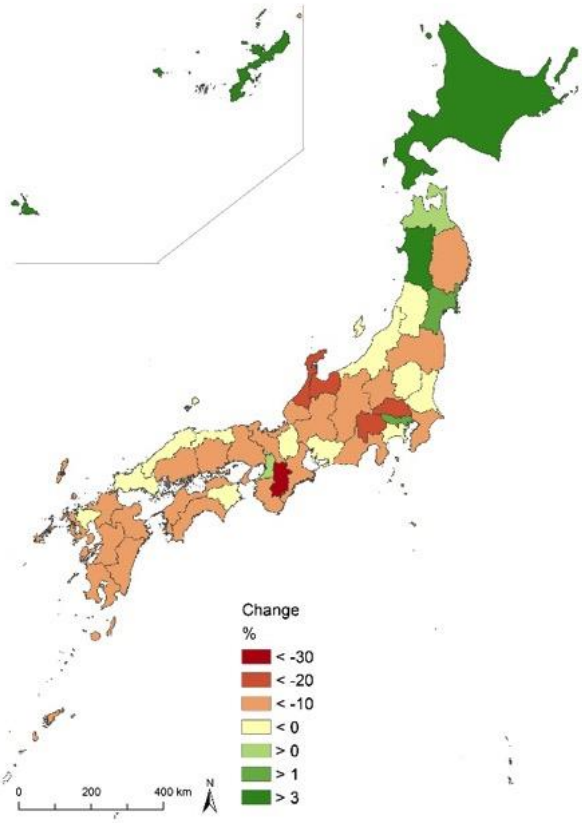


Figure 4. Change in wetland area from 2006 to 2009

The estimated area of wetland is illustrated in Figures 3 and 4. With the economic growth

and land development in Japan, the wetland area is decreasing by 10% in the past 22 years. This decrease should not be neglected and be recorded wetland asset accounting. Figure 10 shows change in wetland area by prefecture also varies by prefecture; some prefectures increase, some others decreases.

4.2. Economic data

The unit value of forest measured by exchange value accounts to 662 thousand JPY per hectare of forest. Although, at moment, we only estimated its value in whole Japan and one single value is applied to all 47 prefectures, we are going to estimate the value by prefecture as data will be available.

From the social survey, we collected data on the unit value of forest by prefecture. The results show that the average WTP for throughout Japan for one hectare of forest conservation is JPY 2,374 (SD = 175). At the prefectural level, the values vary; the highest value, JPY 2811 is observed in Tokyo and the lowest value, JPY 1964 is observed in Kochi. The results are shown in Figure 5.

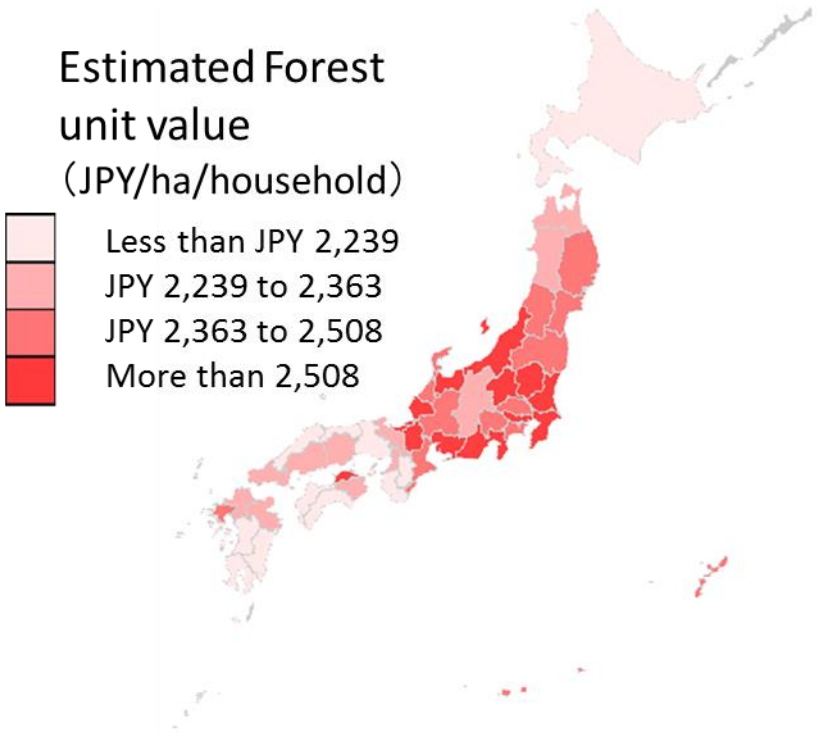


Figure 5. Unit value of forest with surplus approach

By multiplying the results above by number of household and area of forest, we estimate the total value of forest by prefecture. Figure 6 shows the value of forest measured by surplus value in 2012.

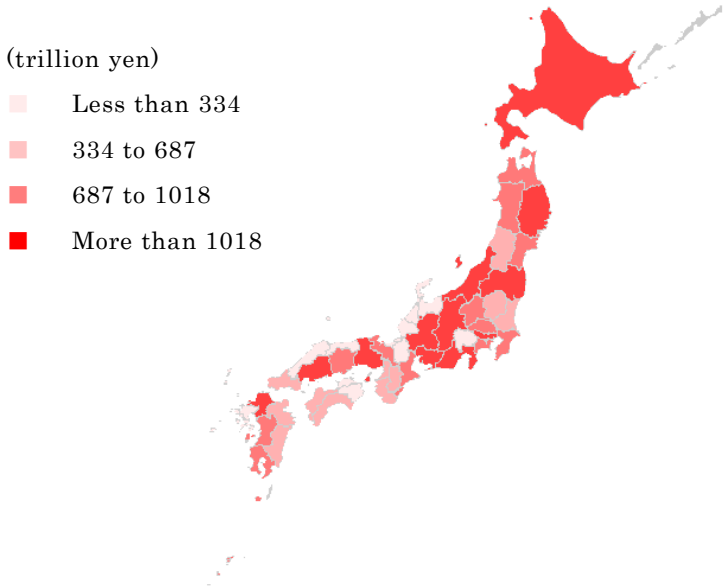


Figure 6. Forest stock value in 2012 measured by surplus value

Finally, mean WTP (MWTP) for each function is shown in Table 2. These results can be regarded as monetary value of 1% increase in each function. It can be also interpreted as the relative importance of the each function. It can also be regarded as weights of each function against total value of forest ecosystem people are currently receiving in their prefectures. Using the weights, we can distribute the value of forest to each ecosystem services.

Table 2 MWTP for each attribute
(JPY per % increase of each function per year)

	Number	Share
Water storage	52.93	35.8%
Land slide prevention	57.65	39.0%
Mitigating climate change	50.60	34.2%
Biodiversity conservation	28.89	19.5%
Timber production	10.82	7.3%

Estimated unit values of wetland measured by surplus value are illustrated in Figure 7. The values are higher in the eastern part of Japan than the western. Particularly prefectures around Tokyo metropolitan area have high values. This reflects is scarcity and higher recreational value of wetland around Tokyo. Note that it is unable to show other results because the analysis is now underway. However, the estimation of exchange value of wetland is currently underway.

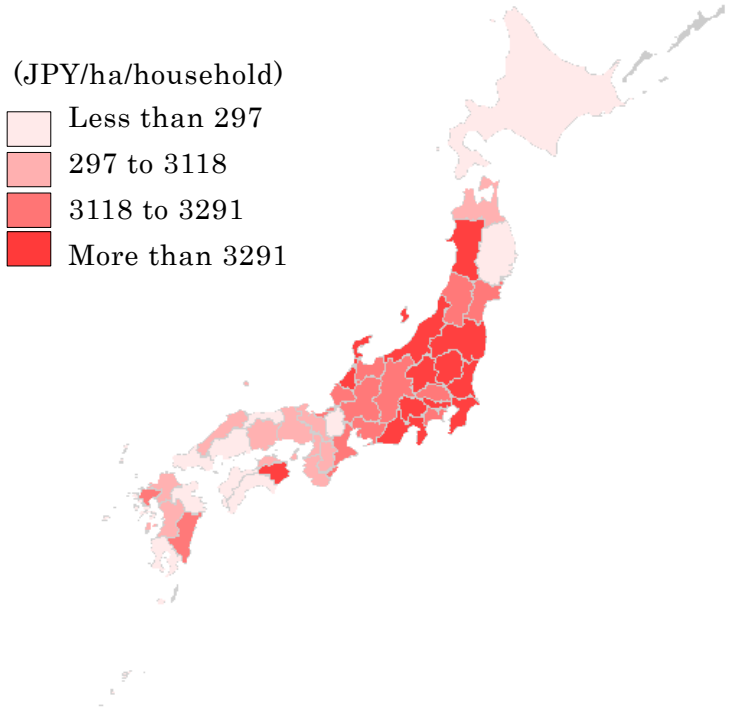


Figure 7. Unit value estimation for wetland

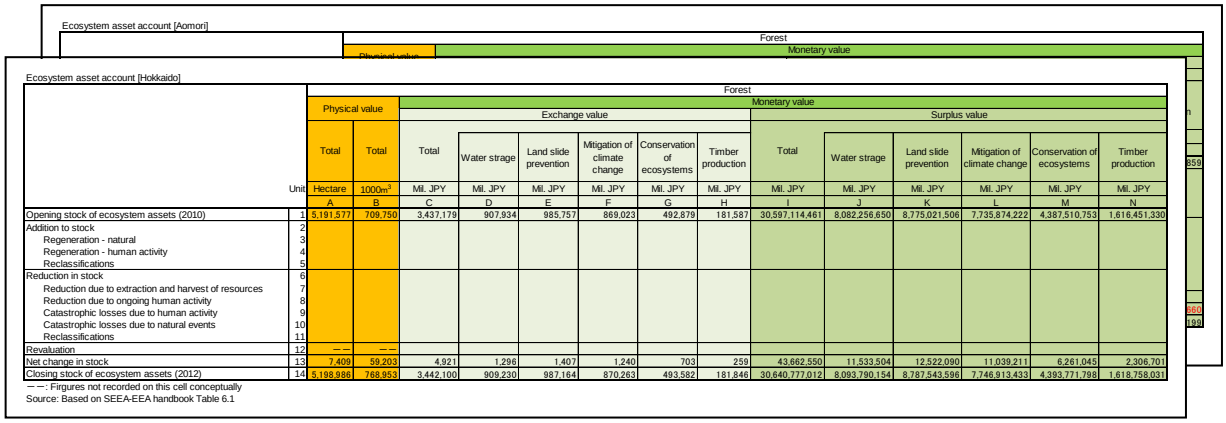
5. Incorporating the value into ecosystem asset accounting

A series of forest asset accounting with some estimates above is illustrated in Figure 8. This accounting contains both physical and monetary estimates, and for monetary estimates, both exchange and surplus value are on the accounts. The accounts record the estimates regarding 2007 and 2012 as opening time and closing time respectively. In upmost row (row 1), the estimates such as forest area and volume at 2007 is recorded, and the estimates at 2012 is recorded in the bottommost (row 14). From the second to thirteenth row, change in stocks (both reduction and addition) is recorded by factor. Note that the estimation of figures in these rows is still underway, so currently they are blank. In Figure 8, the accountings for Hokkaido and Aomori are shown but we compiled that for all other prefectures and the whole national, so the ecosystem asset accounting has 48 accounts in total.

Ecosystem asset accounting enables us to develop a database for the assessment with various indicators which includes change in monetary values as well as physical indicators such as area and volume. Monetary valuation has the advantage that it can reflect local needs and its supply-demand balance (scarcity) of ecosystems. It provides different insights from physical valuation. The ecosystem accounting we have developed can provide useful local information and data which include not only physical value but also monetary one to consider these issues.

The largest characteristic of the accounting developed in this study is that it can record both exchange value and surplus value. These two methodologies can complement each other and gives users more broad information on the value of ecosystem. Users can choose the desirable estimates from the accounting depending on their purposes. This characteristic enables users'

broader usage of the accounting including policy planning for ecosystem conservation and cost benefit analysis of these policies, and CSR activities of enterprises to achieve the visualization and the mainstreaming of ecosystems. In addition researchers can analyze the value and status of ecosystem by prefecture, and it can provide more detailed information on local ecosystems and can reflect local condition of ecosystem to policymaking.



Ecosystem asset account [Aomori]

Forest

Monetary value

Ecosystem asset account [Hokkaido]

		Forest												
		Physical value		Monetary value										
				Exchange value						Surplus value				
		Total	Total	Total	Water strage	Land slide prevention	Mitigation of climate change	Conservation of ecosystems	Timber production	Total	Water strage	Land slide prevention	Mitigation of climate change	Conservation of ecosystems	Timber production
Unit		Hectare	1000m³	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY	Mil. JPY
		A	B	C	D	E	F	G	H	I	J	K	L	M	N
Opening stock of ecosystem assets (2010)	1	5,191,577	709,750	3,437,179	907,934	985,757	869,023	492,879	181,587	30,597,114,461	8,082,256,650	8,775,021,506	7,735,874,222	4,387,510,753	1,616,451,330
Addition to stock	2														
Regeneration - natural	3														
Regeneration - human activity	4														
Reclassifications	5														
Reduction in stock	6														
Reduction due to extraction and harvest of resources	7														
Reduction due to ongoing human activity	8														
Catastrophic losses due to human activity	9														
Catastrophic losses due to natural events	10														
Reclassifications	11														
Revaluation	12	– –	– –												
Net change in stock	13	7,409	59,203	4,921	1,296	1,407	1,240	703	259	43,662,550	11,533,504	12,522,090	11,039,211	6,261,045	2,306,701
Closing stock of ecosystem assets (2012)	14	5,198,986	768,953	3,442,100	909,230	987,164	870,263	493,582	181,846	30,640,777,012	8,093,790,154	8,787,543,596	7,746,913,433	4,393,771,798	1,618,758,031

– –: Firgures not recorded on this cell conceptually

Source: Based on SEEA-EEA handbook Table 6.1

Figure 8. Frameworks of forest asset accounting with some estimates.

The second characteristic is it is compiled not only in the whole nation, but also in each prefecture. Locality of ecosystem is very important factor for land development at national level as well. When we look at forest asset accounting at national level, forest volume and area are quite stable in Japan. For instance, the assessment of degradation of forest is included in Adjusted Net Savings (ANS) of the World Bank and Inclusive Wealth Index (IWI) of the United Nations. In these indicators, the results are null in the whole Japan reflecting the stability of forest area at national level. However, the situation varies depending on the locality. However, when we look at regional level: by prefecture, forest area and volume decline in some prefectures. By using these local data, we can conduct more detailed analysis reflecting these local conditions of forest.

6. Conclusions

In this study, we proposed an ecosystem asset accounting for Japan, which can record the physical data and monetary value of ecosystem: forest and wetland, for each prefecture. For these accountings, we used both an exchange value and a surplus value approach to evaluate monetary values. Depending on the purpose for which the ecosystem asset accounting is being used, either approach can be chosen.

Our ecosystem accounting helps contribute to discussions on current government policy and future challenges in achieving the Aichi Biodiversity Targets. In particular, it offers the basic database for crafting necessary policies to incorporate the value of ecosystems and their services into the SNA, as advocated by the Aichi Biodiversity Targets. The accounting contains a wealth

of information regarding forest, and wetland that are of particular importance to policies on ecosystem and biodiversity conservation in Japan.

We believe that it will stimulate the mainstreaming and visualization of ecosystems and their services. In the conservation of ecosystems, as it is difficult to visualize their benefits and compare them with costs. For this reason, the assessment process involved in policy implementation is often unclear. In such a case, the ability to swiftly create an economic assessment, in both the qualitative and quantitative way, is expected by policymakers to be a useful data source in the process of making comprehensive decisions. At the same time, the visualization of ecosystem stock values is connected to spreading the awareness regarding the natural capital that belongs to the residents and companies of a region. We expect that, for corporates, if the economic value of ecosystems is assessed in a manner that links it to the SNA, it will provide an incentive for voluntary ecosystem conservation by corporates.

Acknowledgements

This work was accomplished under the research project “Evaluation of ecosystem services and the development of ecosystem accounting frameworks” led by Dr. Masayuki Sato, Kobe University, and implemented under the consignment study “Policy Studies on Environmental Economics” of Japan’s Ministry of the Environment. The authors would like to thank the Ministry of the Environment for their financial support.

References

Japanese Academic Council (2001) Multi dimensional value of agriculture and forest related to the global environment and human lives (in Japanese).

van der Ploeg, S., de Groot D., Wang, Y. (2010) *The TEEB Valuation Database: overview of structure, data and results*.