Research article

Socio-Economic and Spatial Evaluation of Ecosystem Services in Nagoya, Japan

MAKOTO OOBA*
National Institute for Environmental Studies, Tsukuba, Japan
Email: ooba.makoto@nies.go.jp

HIDEYUKI ITO
Nihon University, Funabashi, Japan

KIICHIRO HAYASHI
Nagoya University, Nagoya, Japan

Received 25 November 2015 Accepted 10 November 2016 (*Corresponding Author)

Abstract In recent years, the value of urban green spaces and parks in Japan has begun to be reevaluated. In particular, attention is being paid to easily accessible and routinely available urban green spaces and parks, where many people benefit from cultural services such as recreation and relaxation. However, these spaces are facing the threat of destruction by urban development. Thus, to assess the recreation function of the small- to medium-scale urban parks and green spaces routinely used by many people, this study aimed to evaluate their economic value using the travel cost method (TCM). To expand the results from the TCM, suggestions were made with regard to prioritizing ecosystems in urban areas for conservation. The potential supply of ecosystem services was estimated using five categorized proxy variables and weighted by the TCM results. This assessment can be applied to any city whose social and natural statistics are not well-managed.

Keywords conservation priorities, land use, travel cost method, urban green space

INTRODUCTION

The Millennium Ecosystem Assessment (MEA) performed the organization of the concept of ecosystem services. These refer to a variety of services, from concrete services that human society receives from ecosystems (carbon storage, soil formation) to related subjective cultural services (landscape, leisure). However, integrated quantitative evaluation tools that would encompass all ecosystem service concepts are still at the research and development stage.

In addition, in recent years, urban green spaces and parks in Japan have been increasing in area, and many people can use such places to engage in recreation and relaxation. However, they are facing the threat of disappearing due to urban development. Therefore, it is important to economically assess their utility values and the values of their ecosystem services.

With regard to the literature on recreation function assessment, Kuriyama (2001) calculated the recreation values of Yakushima Island and Mt. Fuji in Japan by using the travel cost method (TCM) and the contingent valuation method. Maeda (2004) economically assessed the recreation value of Kushiro Marsh and then proposed new environmental conservation measures based on the economic assessment results. Hein et al. (2006) estimated the total economic value of a wetland's ecosystem services based on the assessment results using the TCM. Thus, there are many previous studies assessing recreation functions. However, these studies focused on nationally famous tourist sites and

© ISERD

facilities, and tended to deal less with assessing the economic value of the small- to medium-scale parks and urban green spaces that are used by citizens on a daily basis.

In addition, within a certain management scope, there is also demand to rank ecosystems in order to prioritize their conservation such that important ecosystem services are not lost. There are several conservation planning support softwares that use GIS to conserve certain specified species. Based on certain restrictive conditions (costs, etc.), they obtain the optimum spatial plan, which can be applied to determine conservation priorities in order to maximize ecosystem services.

OBJECTIVE

The study is proposing a method for the integrative evaluation of the supply potential of the various ecosystem services that urban ecosystems provide. This study estimated ecosystem services and biodiversity conservation using the relatively simple method developed by Ooba et al. (2014, 2015), which assumes that land use transforms ecosystem services. The economic values of cultural services in small and medium urban green spaces in Nagoya were assessed through the TCM using an internet survey and estimating the economic value of each ecosystem service. Further, this web questionnaire also asked for the importance of each ecosystem service, and based on the results, weighted and performed integrated evaluations of the ecosystem services that were individually estimated. Finally, conservation software was used to calculate conservation priorities and determine where important urban ecosystems were located.

METHODOLOGY

Study Area

Aichi prefecture in Japan, the venue of the ordinary meeting of the Conference of the Parties (COP10) to the Convention on Biological Diversity in 2010 and a prefecture eager to preserve urban green spaces, was selected for study. The four selected small and medium urban parks and green spaces used on a daily basis by citizens in Aichi pref. are the Idaka green space (60.4 ha), Aioiyama park (84.9 ha), Chayagasaka park (6.18 ha), and Meitoku park (15.4 ha) (Fig. 1).

Estimation of Ecosystem Services

Outline of questionnaire survey: To estimate the economic values of the recreation functions of the urban green spaces and parks, the TCM was adopted based on the travel costs and numbers of visitors for each green space and park obtained through the internet survey (Rakuten Research, Japan). In December of 2014, a screening survey was first conducted with a sample of 20,000 monitor members across Aichi pref. who intended to answer the questionnaire. Then, in consideration of the regional population, age distribution, and sex distribution in the pref., 2,800 samples were collected through pseudo-random sampling in January of 2015. The question items explored the following: whether respondents had visited the selected parks and green spaces within the past five years; the number of visitors in the past five years; the purposes of the visits (multiple choice from 21 items); modes of transportation employed; travel times for each mode of transportation; visit durations; and average number of visitors. Then, the ecosystem services of the general urban green spaces were explained so that respondents could rate the importance of cultural services on a five-point scale. Finally, questions about individual attributes (occupation, annual income, and educational background) were asked.

Analysis by the TCM: Generalized round-trip costs per capita (total cost) were calculated based on required costs such as transportation and facility usage costs (e.g., train fare, cost of gasoline, and admission fee) and the product was found by multiplying required time, i.e., the sum of travel time and

© ISERD

visit duration, by the time value. Following the method of Cesario (1976), the time value was set to 989 yen, which is equivalent to 33% of the average hourly income of 2,967 yen (data from the Ministry of Internal Affairs and Communications in 2012). In addition, demand curves were estimated through regression analyses of the annual average visit times and generalized costs. Then, recreation values were calculated by multiplying the consumer surpluses per visitor by the annual numbers of visitors (Eq. (1)). Finally, the annual recreation values were divided proportionally according to the importance levels of the ecosystem services to determine the economic value of each ecosystem service.

$$RV = (-AT/I) \times AV \quad (1)$$

Where RV is the recreation value, ID is the slope of the demand curve, and AT is the annual average visiting number of a visitor, and AV is annual numbers of visitors.

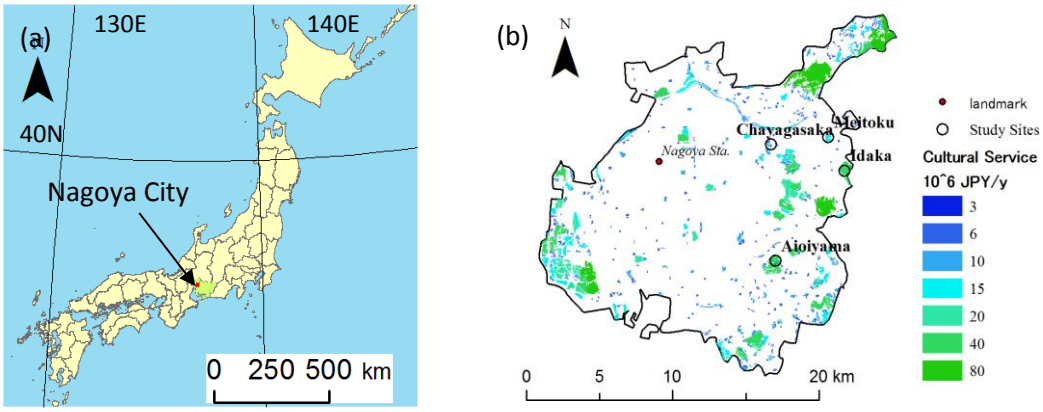

Fig. 1 Location (a) and study sites (b) including economic evaluation for cultural service

Spatial evaluation of ecosystem services: Based on the four MEA categories, ecosystem services were categorized. These services are conceptual, so the carbon storage rate quantified based on proxy variables, food supplies, prevention of soil erosion, recreation, etc., were estimated. Biodiversity was estimated based on habitat continuity (see also Ooba et al., 2015). Detailed Digital Information for Urban Landuse (Geospatial Information Authority and Japan Map Center) was used in relation to land use. The latest version of the product was provided for only map at 1997. Nagoya City has been developed well and then slight change between the current and 1997 was assumed at 1-km grid size. The 17 land use subdivisions were reclassified into five types: water area, cities, roads, agricultural land, and forestland. "Parks" and "green belts" were classified as forestland. This simplification of landuse is aimed to application for developing country where landuse map may be limited and methodology of estimating ecosystem services is also limited. For elevations and slopes, a Digital Elevation Model (DEM) was used provided by the Geospatial Information Authority. For this study, the national third mesh system (approximately 1 km meshes) was used to calculate the total supply of ecosystem services.

Carbon storage and food supply were estimated using agricultural statistics (Table 1). For soil erosion prevention, the USDA's Revised Universal Soil Loss Equation (RUSLE) was employed. The results of the TCM were used to estimate the economic values of cultural services. The economic value V (1 million yen /ha y) per unit of area was estimated as follows.

$$V = aA^b \quad (2)$$

Where A is area (ha) and a and b are parameters obtained by a regression calculation ($b < 1$). For a green space of 1 ha or greater, respective services were evaluated. With regard to habitat continuity, the continuity of green spaces with a radius approximating 2 km was calculated using GIS based on

© ISERD

previous research (Li, 2014). The estimated quantities of services are shown by different unit systems, so for inter-comparison purposes, values were compared after normalization based on the average values and standard differentials through logarithm conversion.

Integrated evaluation of ecosystem services: To perform the integrated evaluation of ecosystem services, Zonation, which calculates conservation priorities (Moilanen et al., 2012), was employed. Zonation divides the region of focus into meshes and identifies the mesh with the greatest overall loss when one mesh is removed (for example, if it is species diversity, then the diversity of species, or if it is ecosystem services, then the value of integrated ecosystem services). Conservation priority is determined by repeatedly removing the mesh that was identified and searching among the remaining meshes for the cell with the maximum loss.

As a calculation method, the Core Area Zonation that minimizes loss by assigning high rank to spatial continuous and high weight ecosystem services was used. This study used the average value of importance obtained through the web questionnaire. The costs were all assumed to equal one. The other Zonation parameters were set to the default values.

Because of technical restrictions on data entered into Zonation, the national 3rd mesh system of Japan was converted into 500 m meshes to calculate conservation priority.

Table 1 Methods used to estimate ecosystem services (see also Ooba et al., 2015)

Service category	Proxy variable	Basic units, method details*	Unit	Reference
Support	Carbon sequestration	3.09(F)	t/y ha	Ogawa et al.(2002)
Provision	Food supply	2.98(A)	t/y ha	Aichi Pref.(2012)
Regulation	Inverse of soil erosion coefficient	$S = 65.41\sin^2\Theta + 4.56\sin\Theta + 0.065$ C = 1 (U), 0.33(A), 0.0085(F)	-	Renard et al. (1997)
Culture	Economic value of green space	Value per unit area as green belt area A(ha) $V = 3.0184A^{-0.437}$	10^6 JPY/y	This study
Habitat	Continuity of green space	ArgGIS tool (Focal statistics) proximity as 2 km radius	-	Li (2014)

** Land-use codes—U: Roads and urban areas, F: Forestland, A: Agricultural land*

RESULTS AND DISCUSSION

Table 2 shows the purposes of visits to the four urban parks/green spaces. Representing about half of responses, the first and second purposes were seeing a landscape and enjoying a walk, respectively. Regarding the characteristics of each park and green space, Meitoku park has a campsite and people who visit this park to use the campsite accounted for 9% of respondents. The Idaka green space has a sports ground and visiting this facility accounted for 7% of responses, whereas seeing the *Hotaria parvula* (species of firefly) in the Aioiyama green space and represented 10% of responses.

Table 2 Purposes of visits (%)

	Chyagasaka	Meitoku	Idaka	Aioiyama
Seeing a landscape	44	26	30	37
Enjoying a walk	19	28	18	12
Light exercise	7	7	7	8
Forest bathing	8	7	13	7
Enjoying playing tool*	5	9	7	10
Other	17	21	25	26

**Firefly viewing only at Meitoku park*

© ISERD

Also shown is the importance of the four types of ecosystem services as estimated on a five-point scale (Table 3). The cultural services obtained high scores for many parks and green spaces, with value of 4.15 on the five-point scale. The supply services obtained low scores, with average value 3.59.

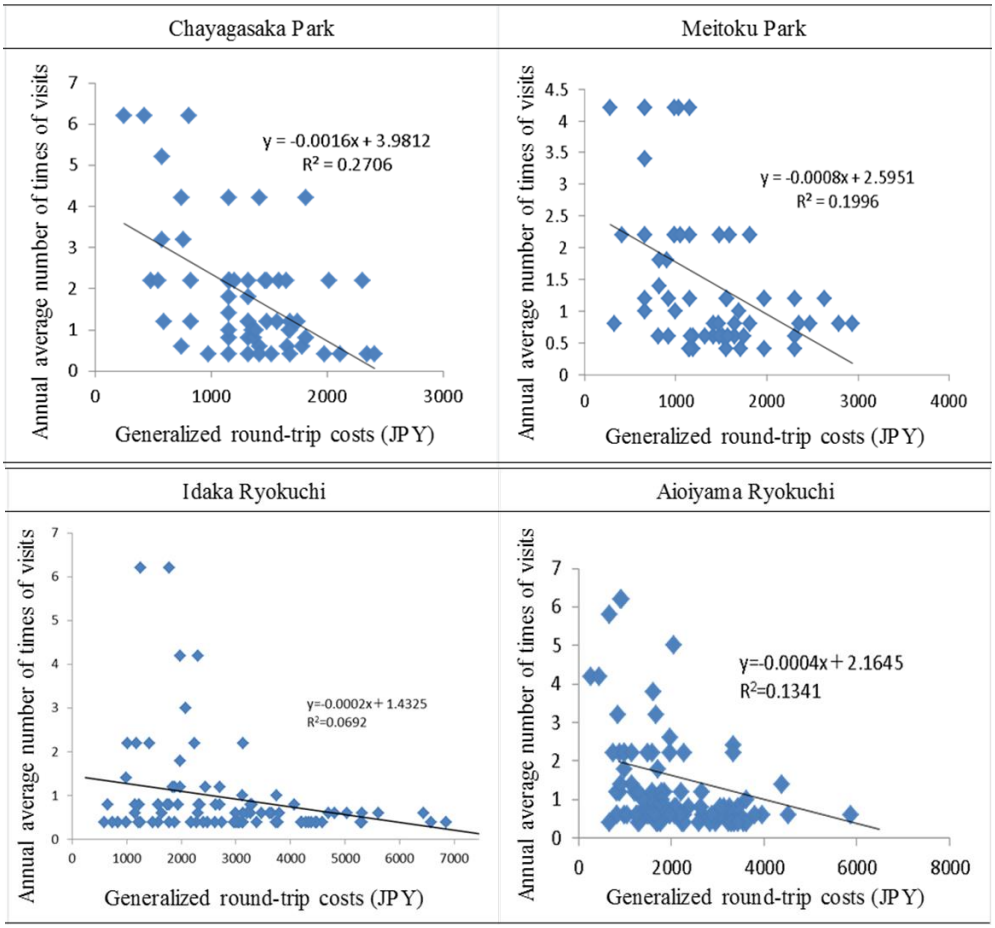

Fig. 2 Estimated demand curves of the parks from TCM

Table 3 Importance level and economic value

		Chyagasaka	Meitoku	Idaka	Aioiyama
Total number of visitor (1/y)		445,569	155,200	571,161	442,646
Number of visit time (1/y)		1.14	0.95	1.05	0.97
Importance level*	Regulating ES	4.15	4.01	4.23	4.13
	Providing ES	3.61	3.51	3.63	3.60
	Cultural ES	4.15	3.97	4.30	4.17
	Supporting ES	3.95	3.89	4.05	4.07
	Biodiversity	4.09	3.88	4.19	4.16
Economic value (Million JPY)	Regulating ES	8.77	11.97	51.84	24.05
	Providing ES	7.63	10.48	44.49	20.96
	Cultural ES	8.77	11.85	52.70	24.28
	Supporting ES	8.35	11.61	49.63	23.70
	Biodiversity	8.64	11.58	51.35	24.22

**Five grade scale*

© ISERD

Figure 2 and Table 3 shows the estimated demand curves and their economic values. The annual average number of visits was about 1.0 for each park and green space, representing a low frequency. The correlation between the generalized costs and the numbers of visits was not very strong. The estimated recreation values correspond to the values of the cultural service, and the economic values vary significantly according to the annual numbers of visitors. In the analysis of importance, all four parks and green spaces exhibited the highest scores for cultural services and the lowest scores for supply services. The reason for this could be that citizens greatly enjoy cultural benefits such as playing and seeing beautiful landscapes but do not care as much about receiving supply services such as food.

Spatial Evaluation of Ecosystem Services

Cultural services were estimated based on the value of four parks by a power function such as Eq. (2), $a = 3.0184$, $b = -0.437$ ($R^2 = 0.63$). If the area increases, the value per unit area decreases, but because this is multiplied by the area, the area and value of the cultural services increases gradually. Figure 1b shows the part of the green space of 1 ha or greater used for this study and the value of the estimated cultural services. Like Itaka and Aioiyama, the values for the Higashiyama and the western part of Nagoya City were high.

The results of the total and converted estimated ecosystem services for each national 3rd mesh are shown in Figs. 3a to e.

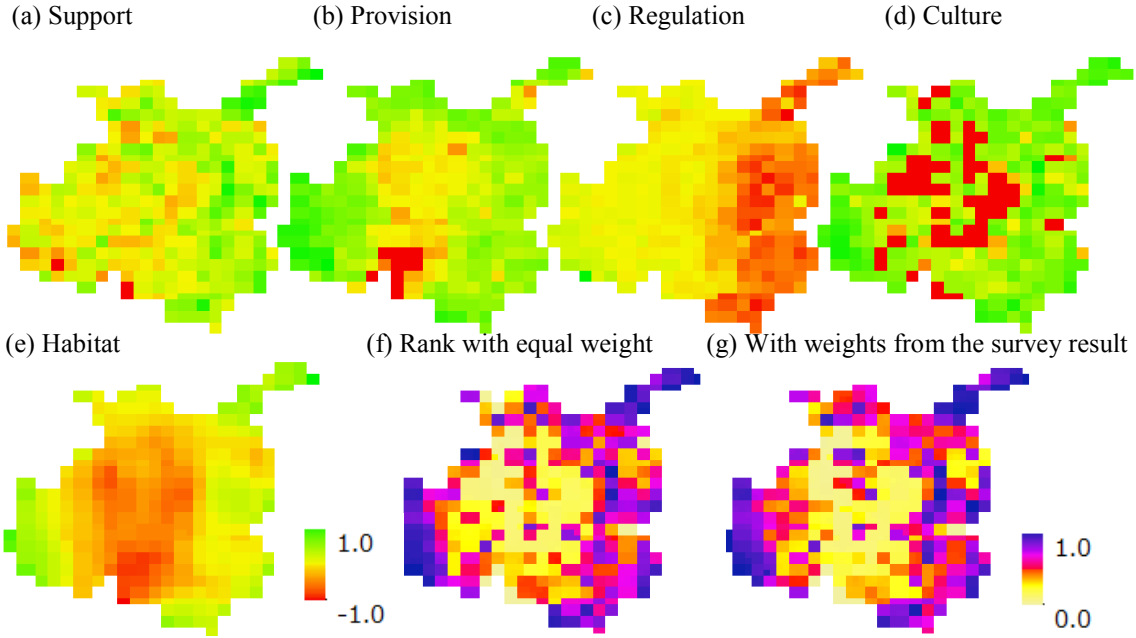

Fig. 3 Distribution of Ecosystem Services (a-e) and Conservation Priority (f and g)

This study performed estimations through a simple method related to land use, so places high in ecosystem service supply were arranged to be relatively easily identifiable. Carbon storage (Fig. 3a) was high in Eastern Nagoya City and Moriyama, where there are many woodland areas. Food production (Fig. 3b) was high in western Nagoya, where there are relatively large areas of paddy and farmland. Cultural services and habitat quality (Figs. 3d and e) tend to be low in the central area but higher in the surrounding areas.

© ISERD

Results that relatively display the conservation priority (where 1 is the top priority) are shown in Figs. 3f and g. Priority tends to be high in the surrounding areas, where individual ecosystem services were high, and in Higashiyama, Moriyama, and western Nagoya City. Atsuta, which is isolated inside the city, and green spaces in the Nagoya region also earned high priority.

The difference between Figs. 3f and g resulted from weighting: equal weights (every weight was assumed to be 1.0) and weighting based on the results of the questionnaire survey. The priority of the east side of Nagoya was lower in the weighted case (Fig. 3g) than the equal weights case (Fig. 3f) due to the low weight of provisioning services. It is assumed that this is because this area has few nearly natural ecosystems.

CONCLUSION

The results show that among urban green spaces and parks, differences are observed in the purposes of use according to the availability of accompanying facilities such as playground equipment as well as urbanization around forest areas. Many visitors simply enjoy the scenery of green spaces, which shows that relaxing by seeing beautiful landscapes and walking in the woods is of great value. Regarding green spaces, the correlation between the generalized cost and the number of visits is not very high. However, the economic value of greenery-related recreation estimated in this survey is shown to be extremely high due to a very large number of visitors per year, despite the small and medium size of the evaluated green spaces and parks.

In the analysis of importance, all four parks and green spaces exhibited the highest scores for cultural services and the lowest scores for supply services. This could be because citizens greatly enjoy cultural services, such as playing in parks and green spaces and seeing beautiful landscapes, whereas they do not care as much about supply services, such as food. However, the respective ecosystem services are not independent, and it is likely that the economic value is overestimated. The authors are reviewing spatial estimation methods about cultural services, and in a future study more reliable methodology can be proposed.

Ecosystem services at the 1 km mesh level were estimated using a simple method related to land use and the survey results. In the area surrounding the city, relatively high services were exhibited due to the presence of agricultural land and green spaces including secondary forests. The conservation rankings also showed the same trend; however, the conservation priority of agricultural land is relatively lower than that of the other green spaces due to the low weight of provision services in the survey results.

The implementation that have been carried out in this study was limited (few landuse types and simple estimation methods). These limitation of landuse are resulted from the aim to application of our framework in developing country where usually data and estimation methods is limited. However these limitation may be easily replaced by more detailed landuse map and complicated methods.

ACKNOWLEDGEMENTS

This study was supported by the funding program for next generation world-leading researchers (MEXT, Japan) and the Environment Research and Technology Development Fund (1-1401, 2-1404, MOE, Japan).

REFERENCES

Aichi Prefecture. 2012. Statistics of agricultural production. http://www.pref.aichi.jp/0000038930.html (in Japanese)

Cesario, F.J. 1976. Value of time in recreation benefit studies. Land Economics, 5 (2), 32-41.

© *ISERD*

Hein, L., van Koppen, K., de Groot, R.S. and van Ierland, E.C. 2006. Spatial scales, stakeholders and the valuation of ecosystem services. Ecol. Econ., 57, 209-228.

Kuriyama, K. 2004. Economic evaluation of green space. Urban Green Tech, 53, 32-35.

Li, R. 2014. The potential distributions of mammalian by Maxent model, Case of Nagoya City. Master Thesis, Graduate School of Environmental Studies, Nagoya University, Japan.

Maeda, Y. 2004. Economic valuation. PREC Study Report, 10, 4-9.

Moilanen, A., Meller, L., Leppanen, J., Pouzols, F.M., Arponen, A. and Kujala, A. 2012. Zonation version 3.1 - user manual. Biodiversity Conservation Informatics Group, Department of Biosciences, University of Helsinki, Finland. http://cbig.it.helsinki.fi/software/zonation/.

Ogawa, K., Miwa, M., Shimada, T. and Ogawa, S. 2002. Air purification function and economic value of green space in Japan. Report of Center for Environmental Science in Saitama, 1, 106-117. (in Japanese)

Ooba, M. and Hayashi, K. 2014. Comparative assessments of ecosystem services between rural and urban areas. Int. J. Environ. Rural Develop., 5 (2), 35-40.

Ooba, M., Hayashi, K., Suzuki, T., Li., R. 2015. Analysis of urban ecosystem services considering conservation priority. Int. J. Environ. Rural Develop., 6 (2), 66-72.

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K., Yoder, D.C. and coordinators. 1997. Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE) (Agricultural Handbook 703). Washington, D.C., USA.

© *ISERD*