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A practice in valuation of ecosystem services: Inclusion of demand-side factors

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1. Introduction

In recent years, the need for ecosystem conservation has been emphasized, and efforts are underway to assess the benefits that people derive from ecosystems. Researchers expected the valuation of ecosystems and their services to be used in various decision-making processes. However, some studies insist that the valuation results cannot be fully used in the real world. One reason is the lack of locally specific and demand-side information, such as who receives the benefits and to what extent.

This study proposes a new valuation method that includes demand-side factors. Taking the construction case of six solar power plants (SPPs) in the Satetsu-gawa river basin in Ichinoseki, Japan, the study focuses on the headwater conservation service of the forest ecosystem (Figure 1). We estimate multiple indicators to assess the impact of deforestation caused by the construction of plants. The results are compared for each power plant. Finally, we identify the advantages of our valuation method, particularly for local policymakers.

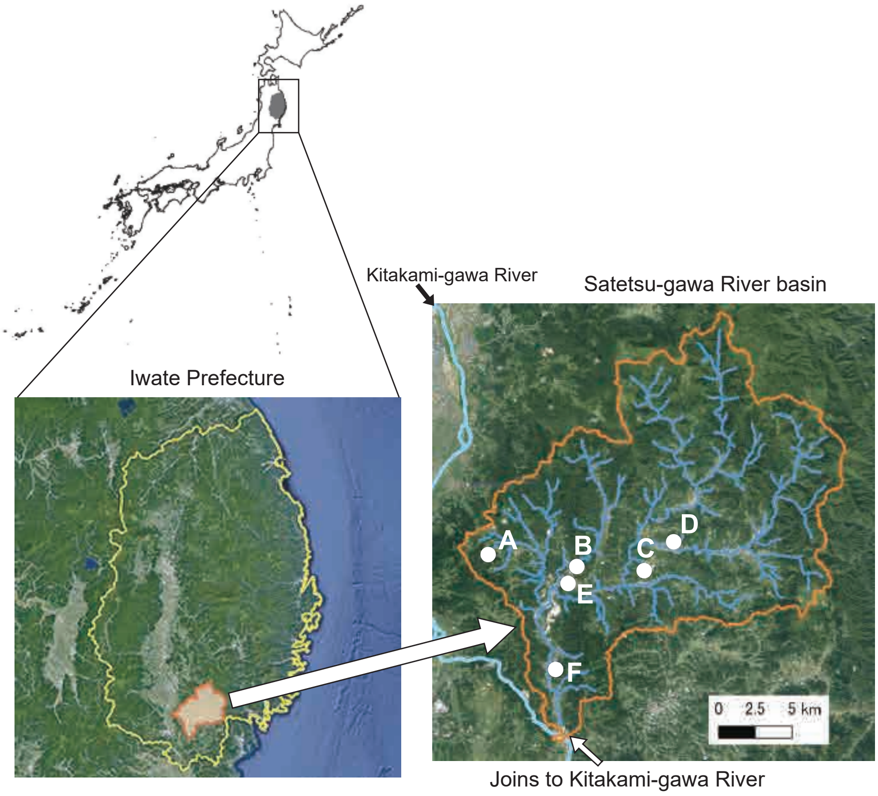

Figure 1. Satetsu-gawa river basin and the locations of solar power plants
Note: A–F indicate the location of each solar power plant.

2. Methods

Through a geographical information analysis, we identify the locations of six SPPs (A–F in Figure 1) and the lower and downstream areas of each plant (hereafter referred to as the affected area). The affected areas are regarded as the areas affected by deforestation owing to the construction of SPPs. Then, we estimate the size of the areas and calculate the number of households in the areas. In addition, based on our previous study (Sato et al., 2019), we calculated the total value of lost ecosystem services owing to the construction of SPPs. Finally, using these estimates, 11 indicators are calculated for all six SPPs, and we compare results by plant.

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3. Results

Table 1 and Figure 2 show the results. From the results of geographical analysis, the total area of the Satetsu-gawa river basin is 37,952 ha, of which 25,239 (66.5%) is forest. Moreover, the number of households in the river basin is 7244, which is 16.8% of households in Ichinoseki (43,046). Table 2 presents the order of performance of SPPs evaluated by each indicator. Plant F performs best in 5 (indicators 2, 5, 6, 7, and 11) of the 11 indicators; these five indicators mainly relate to the lost value and the number of households in the affected area. Plant D performs best in three indicators (indicators 1, 3, and 8) that relate to the deforested area. These results show that Plant F has less influence on residents and that Plant D has less influence on forest ecosystems. However, Plant D performs worst in six indicators—more than half of the total indicators. The performance of Plant D heavily depends on the indicators. Plant A performs best in three indicators (indicators 4, 9, and 10), which mainly relate to the affected area, whereas it performs worst in five indicators (indicators 1, 2, 7, 8, and 11). Conversely, Plants B, C, and E do not perform best in any of the indicators, making them less preferable. However, Plants B and D rank second and fourth in most indicators, implying that these two plants are moderate in terms of the assessment results.

Table1. Results of each solar power plant

Indicator	Unit	Plant					
		A	B	C	D	E	F
1 Deforested area	(ha)	8.2	2.7	1.8	1.0	1.8	1.5
2 Total affected area	(ha)	2,528	2,202	3,007	3,672	1,990	985
3 Share in total forest area	(%)	0.6%	0.2%	0.1%	0.05%	0.2%	0.3%
4 Ratio of deforested are in total affected area	--	309	825	1,661	3,611	1,106	640
5 Number of household in the affected area	(household)	767	938	1,130	1,381	824	328
6 Unit value of lost ecosystem services per hectare	(yen/ha)	409,038	500,232	602,625	736,482	439,436	174,921
7 Total value of lost ecosystem services	(million yen)	3.3	1.3	1.1	0.7	0.8	0.3
8 Deforested area per unit of power generation	(ha/MW)	2.73	1.48	1.21	1.13	1.64	1.40
9 Affeceted area per unit of power generation	(ha/MW)	842.7	1,223.6	2,004.7	4,080.0	1,809.1	895.4
10 No. of h.hold affected per unit of power generation	(household/MW)	255.7	521.1	753.3	1,534.4	749.1	298.2
11 Lost value per unit of power generation	(million yen /MW)	1.12	0.74	0.73	0.83	0.72	0.24

Note: The underlined and red figures are the best results of the six SPPs by each indicator.

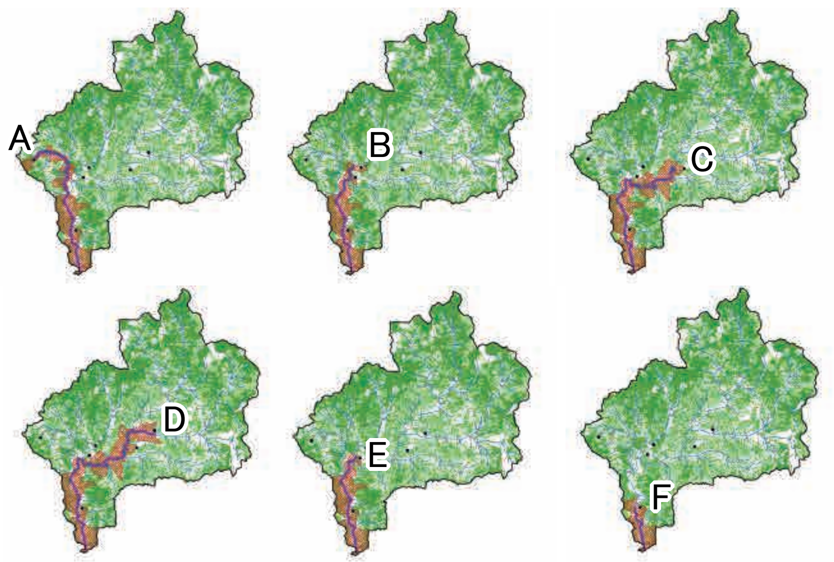

Figure 2. Affected area of each solar power plant

Note: A–F indicate the location of each SSP. Red stripe shows the affected area of each solar power plant. Light green area shows broadleaf forest, and the dark green area shows a coniferous forest.

Table2. Order of performance of solar power plants assessed by each indicator

Indicators	Order of performance					
	1	2	3	4	5	6
	Best ←				→	Worst
1	D	F	E	C	B	A
2	F	E	B	A	C	D
3	D	C	E	B	F	A
4	A	F	B	E	C	D
5	F	A	E	B	C	D
6	F	A	E	B	C	D
7	F	D	E	C	B	A
8	D	C	F	B	E	A
9	A	F	B	E	C	D
10	A	F	B	E	C	D
11	F	E	C	B	D	A

Note: A–F indicate the location of each solar power plant.

4. Characteristics of the assessment method and application to local policymaking

The evaluation presented in this study has the following two characteristics: First, we assessed impacts on areas remote from the ecosystems' location. The effects of ecosystem modification can affect not only nearby areas where ecosystems are located but also remote areas. Local policymakers need to understand the impacts on these distant areas for efficient and effective policy making. In this study, we propose indices for evaluating the impacts on areas far from forest ecosystem locations, such as the affected area and the number of households within the area. These remote impacts have not been explicitly considered in previous ecosystem service assessments.

Second, the evaluation considers the demand-side factors of ecosystem services. Although various international initiatives to evaluate ecosystem services are currently conducted, these valuations mainly focus on the supply-side factors of ecosystem services, such as forest area and land cover. The demand-side factors, such as beneficiaries, are mostly overlooked. Therefore, in recent years, ecosystem service evaluation that considers demand-side factors has drawn much attention. The physical parameters, such as the deforested area, are often used to understand the impact of ecosystem modification. However, the figures vary greatly depending on the demand-side factors of ecosystem services. Therefore, reflecting the impact not only on the supply side but also on the demand side is necessary to properly assess the impact of ecosystem modification. Demand-side information comprises the affected area and the number of households in the affected area in this study. This study presented an evaluation that includes these demand-side factors.

Based on these two characteristics, we could rank the SPPs in the case of the Satetsu-gawa river basin. We believe that such an assessment can provide local policymakers with more helpful information.

5. Conclusions

In this study, we propose an ecosystem service evaluation method that considers demand-side factors. Taking the Satetsu-gawa river basin as a case, we evaluated the headwater conservation service of the forest ecosystem using 11 indicators. We also demonstrated the usefulness of the evaluation method. We believe that these results will be helpful for local residents to consider forest ecosystem conservation as their problem. Furthermore, the results will also be helpful for local policymakers to consider the relationship between climate change countermeasures and forest ecosystem conservation. For details on this research, please refer to the original paper (Hayashi et al., 2021).

[References]

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