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SPECIAL FEATURE: RESEARCH ARTICLE

Interdisciplinarity of Economic Policy Studies

An interdisciplinary approach to environmental conservation policy: a case of Satoyama redevelopment in the peri-urban area

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Abstract

This study proposes a practice and discussion for an interdisciplinary approach to policies for the conservation of suburban and peri-urban ecosystems. We highlight the need for evidence-based assessment of the current quality of the targeted nature from perspectives of natural science and problem formulation, and that causes should be investigated from the combined perspectives of social science, economic evaluation, and policy design and evaluation, with an awareness of the possibility of consensus building. In this study, based on the ongoing international trend of ecosystem conservation, an economic analysis was conducted to examine the direction of Satoyama development as a case study of urban and peri-urban ecosystem conservation. The result identified the preference and needs of citizens with regard to Satoyama ecosystems and discussed the consistency between policy targets and citizens' evaluation.

Keywords Urban ecosystem · Ecosystem services · Economic valuation · Conservation policy · Satoyama

Introduction

The interdisciplinary nature of environmental issues ensures that they always possess a level of complexity. First, it is necessary to understand the current state of the environment from an objective, natural scientific perspective. This is evidenced by the fact that natural science research, such as that performed by the Intergovernmental Panel on Climate Change (IPCC) on global warming, and by

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the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) on biodiversity issues, plays a very important role in discussions on environmental policy by providing quantitative evidence for understanding current status of given environmental issues. Second, when considering the various factors that create these situations, socioeconomic pressures are the central cause in many instances. Further research on the socioeconomic systems that generate such pressures is clearly needed as well. At this stage, a greater volume of work is required on various types of evaluation, such as economic evaluation of the environment, and the cost-effectiveness of measures. There are abundant issues related to the evaluator's ability to value in these instances. This is best characterized by the many existing human scientific issues, such as biases and heuristics. Thus, we need to devise solutions, that is, to formulate better environmental policies, a process for which legal and policy studies are indispensable. A prominent characteristic of environmental problems and policies is that they require collaboration between the natural, human, and social sciences to effectively deal with the same problem.

This study discusses an interdisciplinary approach to urban biodiversity and ecosystem conservation, identifying these issues as the key environmental problems requiring such an interdisciplinary approach. This can be achieved by focusing on economic perspectives, while collaborating with the natural and human scientific research fields concurrently. The situation in cities, which is the subject of this study, has been changing significantly alongside changes in the population structure owing to urbanization. This has been particularly noticeable in Japan.

Japanese cities have been developing in a manner that has expanded residential areas and altered the natural environment as the population has grown. The quality of life of urban residents has been supported by the remaining nature within Japanese cities and the nearby Satoyama[1] ecosystems; however, the process of population growth and accompanying development pressures have often degraded Japan's natural environments. As Japan is now facing a declining population, many areas have begun to worry about the future of their natural environments since cease of management practices will cause ecosystem degradation in city and Satoyama areas. In other words, the context in which sustainable development is changing to sustainability with a declining population [10].

Alongside the decline in Japan's total population, population redistribution is another important consideration, as is the concentration of the population now residing in urban centers, which directly indicates a decline in the overall population. Considering that Japan's natural capital, such as forests including Satoyama and coastal areas, requires a large degree of human care, the decrease in the number of practitioners of natural resource management has important implications. Well-planned management is essential to preserve the remaining Satoyama and coastal ecosystems in Japan's urban and peri-urban areas. Therefore, the government and

[1] The Satoyama Initiative defines that "The Japanese word satoyama refers to a mountain/forest (yama) that is located near an agricultural or mountain village (sato)." (Nature Conservation Bureau, the Ministry of the Environment).
https://www.env.go.jp/nature/satoyama/pamph/en_satoyama_initiative_pamph.pdf

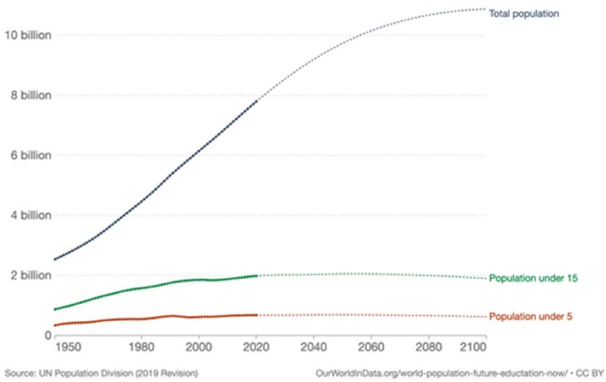

Fig. 1 Growth of the population. Source: Our World in Data based on UN Population Division

local communities must jointly share responsibility for environmental conservation and management. Through this process, the awareness and needs of local residents may change as scientific knowledge permeates the public sphere. Sustainable ecosystem conservation requires continuous communication between the government, citizens, and scientists. One of the objectives of this study was to understand the present needs of local residents regarding Satoyama and its development. We apply the "best–worst scaling" method to analyze residents' preferences for Satoyama use in the suburbs of Kobe, Japan to quantitatively illustrate their expectations for Satoyama redevelopment.

Research background and related literature

Changing population and ecosystem in urban and peri-urban areas

In the 1970s, a seminal report published by the Club of Rome [5] warned that economic growth would in time be limited by resource depletion and environmental pollution. However, this report emerged against the backdrop of explosive population growth (Fig. 1).

Here, the question posed was sustainability under the increasing population. However, this direction has recently changed in some countries, especially Japan, where the decreasing population is one of the most serious problems faced with respect to economic growth and sustainable development. Japan's population has already begun to decrease, and is expected to fall to less than half its current size by the end of the twenty-first century (Fig. 2).

Meanwhile, the population concentration in Japanese megacities, such as Tokyo, is accelerating, which directly implies that many other cities are shrinking and disappearing. This is a serious problem from the perspective of ecosystem conservation. Because nature in Japan requires sustainable maintenance by humans, the population decline causes difficulty to keep the quality of nature by reducing human power and maintenance in Satoyama areas.

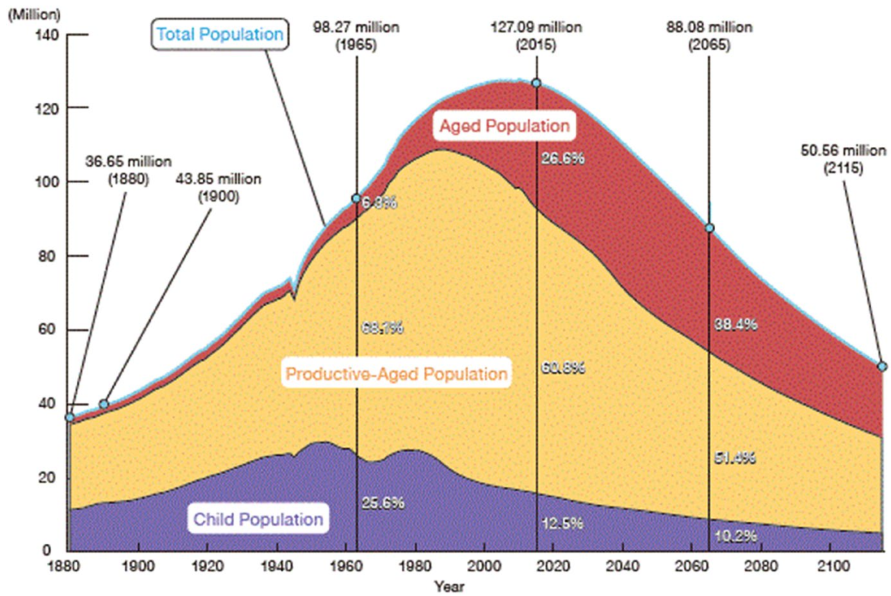

Fig. 2 Population changes in Japan. Source: Population Estimates by the former Statistics Bureau, "Population Census of Japan", "Population Estimates", by Statistics Bureau, Population Projections for Japan: 2017–2065 (Medium Variant)

Simultaneously, an increasing number of people are now living urban lifestyles. A biologist Robert Pyle once warned of the "Extinction of Experience with nature" ([16]). This refers to the idea that an urban lifestyle drives us to lose our experience of nature and our ability to appreciate it. Consequently, many people now neglect the value of nature and forsake it. Urban ecosystems have deteriorated due to large populations and the pressures from modern lifestyles. This results in a loss of native biodiversity and an increase in the number of alien species, leading to ecosystem service loss. Also, this results in the distortion of the natural capital both in Urban and suburban areas.

The trend of related conservation policy

To keep up with the changes in social and ecological situations, a redesign of conservation methods and institutions is needed. This is especially true of the economic valuation of the service provided by ecosystems, with the establishment of a more functional conservation scheme being essential under the new paradigm. The former represents visualization and the latter mainstreaming [18], with this point having been emphasized at COP (Convention on Biological Diversity) 10 in Aichi, Japan. Recently, the international agreement on nature aims to halt and reverse biodiversity loss by 2030 at COP 15 in Montreal Canada. One way to achieve this is the target of the worldwide 30 by 30 initiatives, which plans to conserve 30% of land and sea areas by 2030 through area-based conservation measures. In Japan, it is estimated

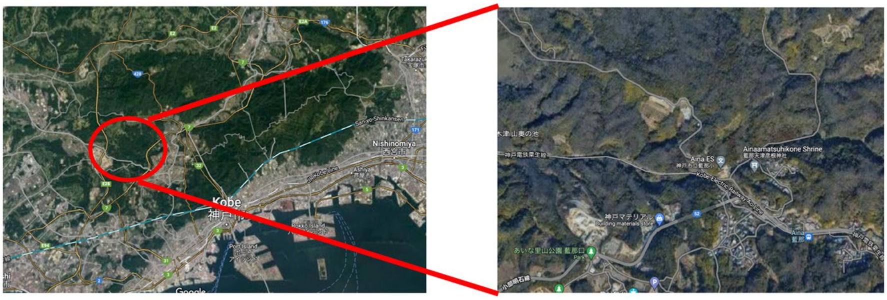

Fig. 3 Location of the target area. Source: Authored by using Google Maps

that approximately 20% of this conservation target will be achieved through already protected areas. To achieve the remaining 10%, other effective area-based conservation measures (OECM) schemes will be established. Officially, OECM is defined as a "geographically defined area other than a Protected Area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in situ conservation of biodiversity, with associated ecosystem functions and services and where applicable, cultural, spiritual, socioeconomic, and other locally relevant values" [6]. These definitely include both urban and peri-urban areas. The point is to find land areas that potentially match these criteria and evaluate them. This is a significant challenge, though Japan remains optimistic and is aiming for more than 100 registrations in these designated areas.[2]

To meet the goal, a list of the valued potential areas is needed. A number of case studies on urban areas have already been carried out (see [3, 8, 9, 11], and [21]). Based on the methodology and practices of the study, the first step in the OECM conservation policy is to empirically identify value, a process in which environmental economic approaches play an important role. This study investigates the case of Satoyama redevelopment in Kobe from the viewpoint of citizens' preferences regarding the management of ecological resources.

The targeted area

In the past, Satoyama areas maintained locally unique and rich ecosystems through human activities, which was widely used by residents and realized coexistence with a wide variety of flora and fauna throughout Japan. However, with the spread of modern urban lifestyles, Satoyama forests are no longer used, resulting in an increase in evergreen trees, a darkening of the forests, and a decline in the diversity of flora and fauna in the western Japan.

The Satoyama area of Kobe targeted in this study (Fig. 3), was once used by people for agriculture and daily life, but with the spread of modern urban life, it is no

[2] Website of the Ministry of the Environment, Japan. https://www.env.go.jp/nature/oecm.html

longer used. However, the redevelopment of this area is now being considered and it became a potential site to be registered as OECM site.

While the "Action Plan for Creating Bright Forests" has been formulated for deciduous broadleaf forests and red pine forests, and the need to maintain and manage these suburban forests has been recognized, the majority are now unmanaged and abandoned, resulting in loss of herb species diversity in the forest floor [22]. However, many herbs including some endangered species (e.g. *Platycodon grandiflorus*), can still frequently be found along the remaining forestry paths, suggesting a positive effect of maintaining sunny conditions on the ground surface by mowing [23]. In addition, through environmental DNA (eDNA) research Minamoto [13] found that species on Rank A of the Red List such as *Ceriagrion nipponicum* (Beniito dragonfly) and Rank B such as *Hynobius setouchi* (Setouchi salamander) can still be found there, suggesting that these areas have the potential to be rich in biodiversity. Furthermore, *Misgurnus anguillicaudatus* (pond loach) and *Ardea cinerea* (grey heron) were also identified, suggesting that these areas serve as a valuable winter-feeding ground for birds.

These ecological studies have shown that the area has the potential to recover biodiversity, but undergo qualitative degradation as soon as human care ceases. Therefore, policy-based restoration and maintenance of Satoyama are essential. The feasibility of implementing such public policies depends on whether they are in line with residents' preferences. To assess if this is the case, we analyzed residents' intentions toward Satoyama redevelopment using best–worst scaling, which is an extension of the stated preference method.

Methodology

Stated preference method and best–worst scaling

In environmental economics, there are revealed preference methods using market data and stated preference methods using questionnaire data. It is important to select an appropriate evaluation method based on the evaluation target. When the target of the evaluation includes the value of biodiversity, the expressed preference method is often applied because there is little or no relevant market data present.

Among the stated preference methods, the Contingent Valuation Method has been the most widely applied since it was used for the economic valuation of ecosystem damage in the United States in the 1990s after the occurrence of the Exxon Valdes oil spill [14]. However, subsequent developments in this area have made it possible to analyze people's preferences in detail through the development of "Choice Modelling" and other methods that deal with the multi-attribute nature of the environment and ecosystems. These developments have been achieved by introducing knowledge from fields such as quantitative psychology and marketing research, which have traditionally focused on analyzing people's preferences, and are now considered one of the leading methods for the economic evaluation of ecosystems.

Based on the accumulation of such studies, we elected to apply the best–worst scaling (BWS) method, which has been attracting much attention in recent years, to analyze the needs of residents with regard to Satoyama in the Kobe City, which is the subject of this study. Studies applying BWS to environmental and natural ecosystem conservation issues are being conducted with increasing frequency in recent years, see Shoji et al. [17], Tsuge et al. [19], and Tyner and Boyer [20].

BWS is characterized by the fact that it obtains information on respondents' preferences even from the least desirable options, whereas conventional evaluation methods take the approach of analyzing respondents' values based on their choice behavior (selection of the most favorable option). By applying this approach to the evaluation of Satoyama, it is possible to understand residents' needs in terms of what is or is not required as a function of Satoyama.

There are three main types of BWS methods [12]. The first is the object type (BWS Case 1), which quantitatively analyzes the importance of the evaluation items. The second is the profile type (BWS Case 2), which evaluates the level of the evaluation items. The third is the multi-profile type (BWS Case 3), in which several profiles are presented, and the most and least desirable profiles are evaluated to analyze the level change. Of these BWS types, this study used BWS Case 1 to analyze the needs of Satoyama. We then applied BWS Case 3 to estimate the economic value of the Satoyama attributes.

Selection of evaluating attributes

In this case, after reviewing the related literature, we chose the attributes summarized in Table 1.

Using the list of items provided in Table 1, BWS case 1 of this study investigated the importance of distance, public transport, parking, exercise, children, barbecue facility, and biodiversity as important factors that Kobe City residents are likely to consider when using Satoyama. For these factors, a choice set was created using balanced incomplete block designs (BIBDs) [12]. Of the BIBDs corresponding to the seven factors identified, this study employed a design consisting of seven choice questions (blocks) with four factors each. Figure 4 is an example.

Respondents were asked to identify the most important (Best) and least important (Worst) factors presented when considering a visit to a Satoyama. The importance assigned by respondents was then quantitatively analyzed using data from responses to similar questions presented in various combinations according to the BIBDs. The maximum-difference (MaxDiff) model was employed for the analysis [7]. The MaxDiff model assumes that utility differences are obtained for all pairs. The pair with the largest utility difference is selected as the Best and Worst, which can be applied to the random utility model represented by the conditional logit model. In this respect, the model is consistent with economic analysis based on microeconomic utility theory.

We assume λ as a parameter representing the weight (importance) of each factor; the probability that respondents choose factor j as Best and factor k as Worst is expressed as in Eq. (1) (see [24]).

Table 1 Target attribute of Satoyama

Satoyama attributes	Keywords
Food supply	Mushrooms, edible wild flowering plants, Matsutake mushrooms, Nuts, Berries, Tsukushi (edible ferns), Wild boar, Deer, (Birds), Terraced rice fields
Resource supply	Timber and compost supply (wood, bamboo, fallen leaves), agricultural land supply (green production land, rental farms)
Purification function	Recharge function, air purification
Maintenance function	Land preservation, disaster prevention, and heat wave mitigation
Tourism and Leisure	Hiking, Barbecue (+ lodging), Cycling, Restaurants (local cuisine), Direct sales, Roadside station, Terraced rice fields, Camping, Glamping, Hot springs, Dog run, Illumination, Autumn leaves, Climbing streams, Playing in rivers, Bamboo forest, Insect collecting, Athletic activities, Craft experience, Experience tour (wild vegetable picking, etc.), Open space, Park, Youth house, Scenery, Scenic overlook, Information center, Round shuttle bus, Parking lot, Marutto Pass (discount pass), Pet hotel, Flower garden, Renting an old house (Airbnb), Camping, Sports (rugby, gateball, frisbee), Orchard (fruit picking), Outdoor concerts (jazz, classical), Work vacation
Education opportunity	Rice terraces, agricultural work experience, creature interaction experience, forest school, student volunteers (high school, university), hub (students, adults, etc.), research base, environmental education, sports education
Habitat	Red frogs, dragonflies
Foreign tourist	Information center, Japanese culture
Employment	Guides, Employees of leisure facilities, Forestry and agriculture workers, Volunteers, Part-time workers, Attracting companies (restaurant industry, hotel chains, IT companies (research))
Access	Direct buses, Shuttle buses, Road maintenance

Most Important		Least Important
[ ]	Distance from home	[ ]
[ ]	Can be reached by public transportation	[ ]
[ ]	Can engage in physical activities	[ ]
[ ]	Many living creatures can be observed, collected and otherwise interacted with in nature	[ ]

Fig. 4 The example of BWS questions

$$P_{jk} = \frac{\exp\left(\lambda_j - \lambda_k\right)}{\sum_{l=1}^{J}\sum_{m=1,l\neq m}^{J}\exp\left(\lambda_l - \lambda_m\right)} \tag{1}$$

Table 2 Social demographic characteristics of the respondents

Age	Total	Male	Female
20–30	215	49	51
30–40	227	49	51
40–50	298	48	52
50–60	295	48	52
60–70	256	49	51
70–80	410	42	58
Over 80	47	47	53
TOTAL	1748	47	53

Total is the number of persons for each age group

The columns of Male and Female represent the percentage breakdown

Note that the error term is assumed to follow a Type I extreme value distribution to derive Eq. (1).

Social survey and analysis

In March 2022, an online-based social survey was conducted among the residents of Kobe. For the BWS questions in this study, survey data collection was conducted by the social research firm Intage, and sampling was conducted so that age and gender were proportional to the actual population. In addition to questions about BWS, the survey examined the respondents' knowledge of terms such as biodiversity and ecosystem services, their actual use of Satoyama ecosystems near Kobe City, and their personal attributes and conditions.

The age and sex distributions of the survey respondents are shown in Table 2. Note that the number of samples was proportional to the population, but that the number of samples was smaller for respondents under 20, who did not have access to the survey request, and for older respondents aged over 80.

Prior to the question on the evaluation of Satoyama ecosystems, respondents were asked if they had ever heard of the terms "Satoyama" and "biodiversity". Table 3 shows the results according to age group.

As for the respondents in the 60 s and older, relatively few of them answered that they had never heard of Satoyama. On the other hand, the term "biodiversity" has a relatively low level of recognition, probably because it is a rather academic term. In Kobe City, people over 60 years of age are familiar with Satoyama as a subject based on their own experiences, whereas the younger generation may have already lost awareness of the concept of Satoyama and the term may be unfamiliar to them.

After providing a basic explanation of the terms Satoyama and biodiversity, we conducted a BWS evaluation of Satoyama in Kobe City using the BWS package of the statistical software R provided by Aizaki and Fogarty [2].

The following index quantifies the importance of the seven factors set forth in the previous section for visiting and using Satoyama, to which BWS Case 1 was applied.

Table 3 Knowledge and recognition of Satoyama

Age	Knowledge of the concept "Satoyama"					Knowledge of the concept "Biodiversity"				
	5 Very well	4	3	2	1 Not at all	5 Very well	4	3	2	1 Not at all
20–30	10.2	14.9	28.4	20.5	26.0	12.6	23.7	21.9	20.5	21.4
30–40	10.6	17.2	22.5	24.7	25.1	8.8	16.3	22.5	21.6	30.8
40–50	6.7	23.2	30.9	16.8	22.5	7.0	15.8	28.2	20.8	28.2
50–60	9.5	18.3	26.8	24.4	21.0	7.8	13.9	23.1	27.1	28.1
60–70	10.5	26.6	29.3	18.4	15.2	6.6	23.8	26.2	18.8	24.6
70–80	14.9	32.2	30.0	11.5	11.5	11.7	25.6	28.0	18.3	16.3
Over 80	6.4	38.3	29.8	10.6	14.9	6.4	36.2	25.5	14.9	17.0
TOTAL	10.6	23.6	28.3	18.4	19.2	9.1	20.5	25.4	20.9	24.1

The values are percentages

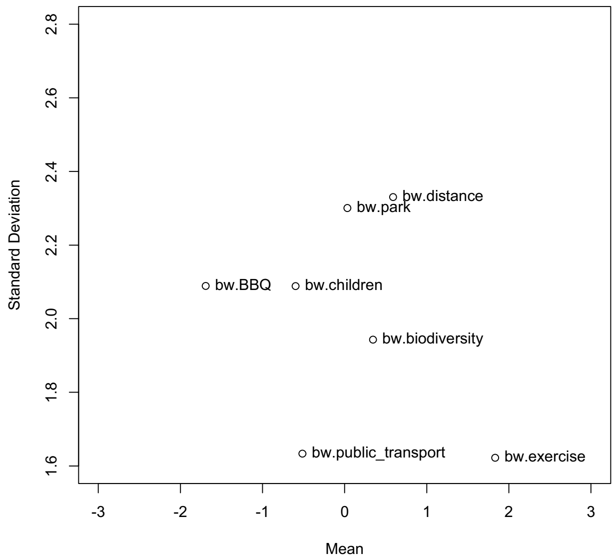

Fig. 5 BWS score of Factors affecting the needs of Satoyama

$$\text{BWS Score}_i = \text{Best}_i - \text{Worst}_i \tag{2}$$

Here, BWS Score$_i$ is the difference between the frequency of the most important (Best$_i$) and least important (Worst$_i$). The BWS scores are plotted in Fig. 5.

Figure 5 shows that the most important factor for visiting Satoyama was the availability for physical activities (Exercise), followed by access to Satoyama (Distance), biodiversity, availability of parking (Park), availability of public transportation (Public_transport), availability of fun for children (Children), and finally, the availability of barbecue availability (BBQ). The importance of biodiversity in Satoyama

Table 4 MaxDiff model estimation results (conditional logit model)

Likelihood maximization of Eq. (1):	Coefficient	Standard error	*t* value
Distance	1.1117***	0.0248	44.75
Park	0.8289***	0.0242	34.27
Public_transport	0.5695***	0.0239	23.82
Exercise	1.7192***	0.0263	65.35
Children	0.5341***	0.0240	22.30
Biodiversity	0.9922***	0.0246	40.36
Likelihood ratio test for all coefficients are zero (H_0)	$p \leq 0$		
Number of observations	146,832		

***Represents 1% significant

use was relatively high, confirming the need for the conservation of biodiversity in Kobe. The vertical axis in Fig. 5 shows the standard deviation of the score, indicating that the higher the factor is located, the more it differs from person to person. In other words, factors such as accessibility, availability of parking, whether barbecue is allowed, and whether children can enjoy themselves may be evaluated differently depending on the attributes of the respondents. If we can identify the distribution of such responses, we can consider the direction of Satoyama development corresponding to future changes in population attributes and user targets.

Based on the BWS scores, Table 4 shows the estimation results from the MaxDiff model, formulated as shown in Eq. (1).

Table 4 shows the relative importance of each of these factors when measured against the factor of barbecue availability (when set to zero). For example, the importance of the availability of physical activities is estimated to be about 1.7 times as important as the distance factor, about twice as important as the parking factor, and about three times as important as the availability of public transportation. Thus, it can be said that a development policy that enables physical activities such as hiking and cycling may be able to overcome to some extent the disadvantages of accessibility conditions such as distance and public transportation. These weights can be applied to the actual Satoyama area to be evaluated and used as a reference for redevelopment policies, such as which factors to focus on.

Economic analysis of the value of Satoyama attribute

In this section, using data collected from the same social survey, an economic evaluation of attributes is performed by BWS Case 3. BWS Case 3 can be considered a developmental model for the choice-type experiment, which has been previously studied as an environmental economic evaluation model. In the choice-type experiment, only the best option was selected, and the choice data were analyzed; however,

Table 5 Attributes and levels in Case3 BWS

Distance	30 min
	60 min
	90 min
Park availability	By no-waiting
	By occasionally waiting
	Not available
Biodiversity	Rich biodiversity
	Commonly seen animals, plants and other living things
	Poor biodiversity
Activity potential	Free open spaces
	Hiking
	Barbecue
	Cycling
Necessary expenses	1000 JPY
	2000 JPY
	3000 JPY

BWS Case 3 also considers information on the least favorable option. This approach has been applied not only to environmental economics, but also to health [4, 15].

In this study, using BWS Case 3, we introduce the cost of visiting Satoyama as a monetary attribute to evaluate the Satoyama attribute economically. We defined the cost of a visit to the Satoyama as the cost required per person, including transportation and parking but excluding the costs of food and beverages. Based on the setting up of BWS Case 1 in the previous section, we set distance, park availability, biodiversity, and activity potential as the attributes to be economically valued. The settings for each attribute are listed in Table 5.

For the attributes and levels listed in Table 5, 32 profiles were generated for the three alternatives, using an orthogonal design. In addition to the three alternatives, a no-choice option was added, meaning four alternatives in total were presented to the respondents for each choice question. Respondents were then asked to provide the most and least desirable options. Considering the respondent load, the number of repeated questions was set to eight. Therefore, there were four versions of the questionnaire, and respondents were randomly assigned to answer an equal number of questions. Figure 6 shows an example of the choice questions presented to respondents. The question for Case 3 BWS were followed by Case 1 BWS questions.

The collected data were analyzed using the MaxDiff model, which assumes a random utility model. First, as a random utility function like Eq. (3)

	Satoyama A	Satoyama B	Satoyama C	
Distance	90 min	30 min	30 min	Cannot choose
Park availability	By no-waiting	By occasionally waiting	Not available	
Biodiversity	Rich biodiversity including rare animals and plants	Commonly seen animals, plants, and other living things	Poor biodiversity	
Activity potential	Free open spaces	Hiking	Free open spaces	
Necessary expenses(per person)	JPY 3,000	JPY 3,000	JPY 1,000	
Most preferred				
Least preferred				

Fig. 6 An example of a choice question

$$\begin{aligned} U = v + \varepsilon = c + \beta_{\text{distance}}\text{Distance} + \beta_{\text{park}}\text{Parkavailability} \\ + \beta_{\text{biodiversity}}\text{Biodiversity} + \beta_{\text{activity}}\text{Activitypotential} \\ + \beta_{\text{expense}}Expense + \varepsilon \end{aligned} \tag{3}$$

where v is the part of the non-stochastic term of the utility function, and each β is the utility parameter for each attribute to be estimated. ε is a probability term that follows a first kind extreme value distribution, which makes the left-hand side U a stochastic utility.

Let UB denote the utility of choosing the most preferable option and UW denote the utility of choosing the least preferable option. If options i and j are answers that yield UB and UW, then the probabilities are

$$\Pr(i,j) = \frac{\exp(v_i - v_j)}{\sum_{p,q \subset S, p \neq q} \exp(v_p - v_q)} \tag{4}$$

where S denotes the set of alternatives. Based on the collected response data, the utility parameter β was estimated by the MaxDiff model,[3] and obtained the results shown in Table 6.

Almost all the coefficients are significant and consistent with expectations. First, the sign of the coefficient of distance is negative, indicating that a closer Satoyama is preferred for visits. Regarding the availability of parking spaces, the estimate

[3] The BWS Case 3 R program provided by Aizaki [1] was used for estimation.

Table 6 Estimation Results of BWS Case 3

Likelihood maximization of Eq. (4):	Coefficient	Standard Error	t value	WTP (JPY)
Distance (continuous variable)	−0.0083***	0.0003	−26.788	−83
Park availability (comparing to not available)				
By no-waiting	0.0219	0.0170	1.286	–
By occasionally waiting	0.2876***	0.0168	17.119	2876
Biodiversity (comparing to poor biodiversity)				
Rich biodiversity	0.2309***	0.0191	12.074	2309
Commonly seen	0.2767***	0.0175	15.811	2767
Activity potential (comparing to cycling)				
Free space	0.0507***	0.0214	2.365	507
Hiking	−0.2151***	0.0220	−9.794	−2151
Barbeque	−0.1003***	0.0210	−4.778	−1003
Expense (continuous variable)	−0.0001***	0.0000	−5.462	Numeraire
No choice (alternative specific constant)	−0.6371***	0.0379	−16.807	
Likelihood ratio test for all coefficients are zero (H_0)	$p \leq 0$			
Number of observations	13,984			

***Represents 1% significant

of being able to park without waiting is not significant and is not considered very important; however, it can be inferred that the need for parking spaces is high. Regarding biodiversity, it can be seen that while the variety of living creatures is in line with people's preferences, the presence of rare and very abundant creatures is not so strongly demanded. It is interesting to note that for citizens, biodiversity in moderation is all that is needed, and very high biodiversity is not desired any more. This implies that policies to conserve very high biodiversity need to be based on other grounds than the needs of citizens. Regarding the possibility of action, it is clear that freely available space is most highly demanded attribute. The coefficient of the expenditure attribute is negative, which is consistent with conventional economic theory.

From the coefficients on the expenditure attributes and their respective coefficients, the willingness to pay can be obtained as follows.

$$\text{WTP for attribute } i = -\frac{\beta_i}{\beta_{\text{expense}}} \tag{5}$$

From Eq. (5), it can be seen that they find an additional value of approximately JPY 507 per person in the Satoyama if they can use the free space in comparison to cycling activity only. On the other hand, the value of preserving biodiversity with a moderate level, i.e., "Commonly seen" in Table 6, is considerably higher at JPY2,767, indicating that citizens very actively support the functioning of Satoyama as a natural habitat for plants and animals in comparison to the situation of poor biodiversity. These results suggest that public spending on Satoyama redevelopment, which prioritizes biodiversity conservation, may be acceptable to citizens.

Conclusion

In this study, we present a schematic diagram of the interdisciplinary approach to environmental issues and conduct an economic analysis to examine the direction of Satoyama development as a case study for ecosystem conservation in urban and suburban areas, in line with the international trend of ecosystem conservation that is currently underway. The results of the case study suggest that the respondents value Satoyama as places for physical refreshment and that such needs can be met even in places with some disadvantages in terms of accessibility. Economic value estimation by attributes shows that conserving biodiversity is valued by citizens. However, for citizens, biodiversity in moderation is all that is needed, and very high biodiversity is not desired anymore and the degree of conservation should be discussed with another approach than citizens' preference. Although citizens' need for accessibility and the possibility of activities were also confirmed, the significance of biodiversity conservation is well recognized, even when compared to these attributes.

However, while the function of physical refreshment is widely demanded by citizens, other factors suggest that their evaluations and needs are divided, and it is necessary to evaluate each target as the next step in the research. The next step should be to evaluate this by targeting the kind of function citizens are looking for. If quantitative trade-offs between each factor, including the function of physical refreshment, are analyzed—for example, to what extent is it acceptable to give up other factors for the sake of physical refreshment—it will be possible to discuss how much weight should be given to biodiversity conservation in Satoyama redevelopment. If we can analyze the degree to which other factors are acceptable to give up, in order to achieve a personal refresh function, we can discuss how much weight should be given to biodiversity conservation in the Satoyama restoration. We hope that these issues will be addressed in future studies.

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Data availability All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. Data are available upon request for reasonable cause.

Declarations

Conflict of interest There are no conflicts of interest to declare.

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