Environmental and Economic Scenario Analysis of the Redundant Golf Courses in Japan

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Abstract— Commercial infrastructures intended for use as leisure retreats such as golf and ski resorts have been extensively developed in many rural areas of Japan. However, following the burst of the economic bubble in the 1990s, several existing resorts faced tough management decisions and some were forced to close their business. In this study, six alternative management options for restructuring the existing golf courses (park, cemetery, biofuel production, reforestation, pasturing and abandonment) are examined and their environmental and economic impacts are quantitatively assessed. In addition, restructuring scenarios of these options and an ex-ante assessment model are developed. The scenario analysis by Monte Carlo simulation shows a clear trade-off between GHG savings and benefit/cost (B/C) ratios, of which "Restoring Nature" scenario absorbs the most CO_2 among the four scenarios considered, but its B/C ratio is the lowest. This study can be used to select or examine options and scenarios of golf course management and rural environmental management policies.

Keywords— golf courses, restructuring and management options, scenario analysis, Tokyo Metropolitan Area.

I. Introduction

COMMERCIAL infrastructures intended for use as leisure resorts have been extensively developed in many rural areas of Japan. During Japan's economic bubble from the late 1980s to the early 1990s, resort memberships and real estate speculative deals were popular. As a result, there are over 2,400 golf courses in Japan, occupying 0.6% of the total land cover. Many of them were developed in peri-urban to rural areas relatively close to large cities such as Tokyo, Osaka, Nagoya, and Fukuoka (Fig.1). At present, there are nearly 700 golf courses in the Tokyo Metropolitan Area (Tokyo MA; Fig.2), accounting for 1.6% of the total land cover and 3.7% of the forest cover of Tokyo MA.

In Japan, the development of golf courses is often considered to be one of the major destructive driving forces in rural areas because they are usually developed on rural hills and mountains where local farmers manage an essential part of the traditional agricultural landscape, called Satoyama in Japanese [1]. From the late 1980s to the 1990s, many rural areas experienced protests against landscape destruction resulting from golf course and resort development [2].

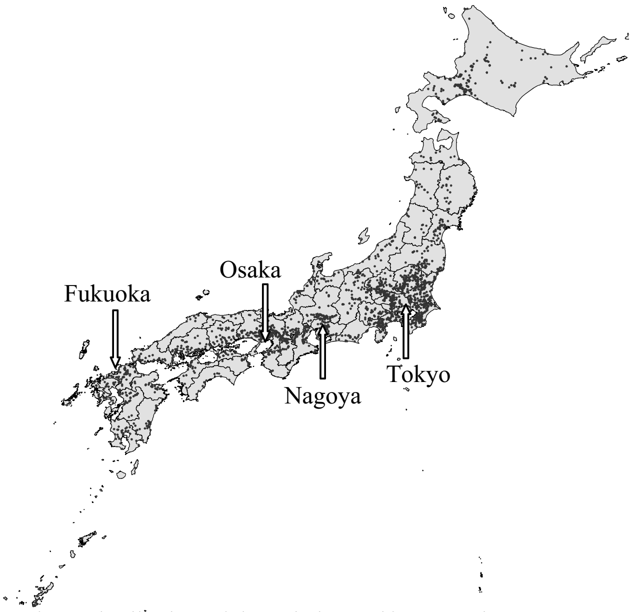

Fig.1 Distribution of the existing golf courses in Japan

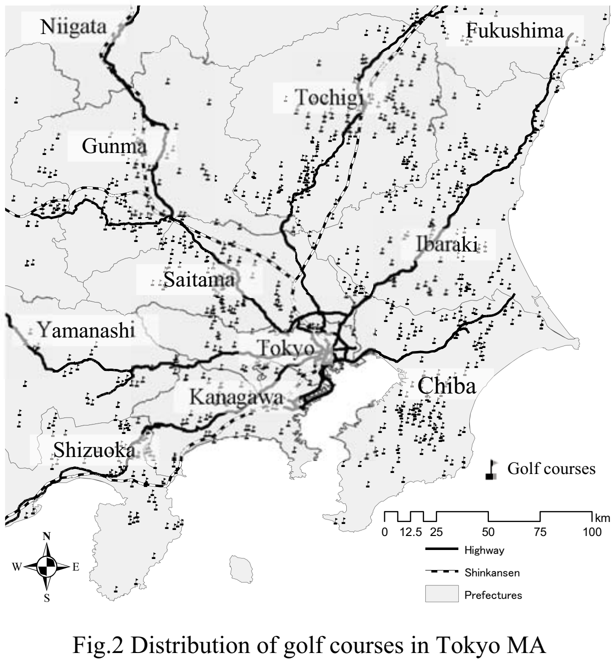

Fig.2 Distribution of golf courses in Tokyo MA

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The number of golfers hit a peak of over 100 million in 1992 and then tended to decrease following the burst of the economic bubble in the 1990s. Several existing courses faced tough management decisions and some were forced to close their business. However, the number of golf courses in Japan increased gradually even during the 1990s because many new constructions planned before the economic bubble burst continued to be developed. The number of bankrupt courses started to increase in the late 1990s and hit a peak of 108 in 2002. The cumulative number of bankruptcies reached over 600 in 2007 [3], accounting for 25% of the existing golf courses. Most of these bankrupt courses have since been acquired by foreign investment groups such as Goldman Sachs Group Inc. and have continued their business by improving operation efficiency. Consequently, the total number of golf courses has been maintained despite the high number of bankruptcies. Today, the Japanese golf industry is in a state of excess supply. With the trend towards diversification of leisure activities and unprecedented depopulation, a significant number of courses are expected to face redundancy or abandonment in near future.

In this context, I previously reviewed the developmental history of golf courses in Japan and estimated that 152 (23%) golf courses will be redundant by the year 2035 in Tokyo MA, and then identified 302 golf courses that are, or will be soon, approaching redundancy through spatial distribution analysis [4]. Although some alternative management options were proposed in the previous study, their economic feasibility and environmental potential were not quantitatively assessed.

The present study aims to (a) examine alternative management options for restructuring of redundant golf courses into a sustainable infrastructure for urban-rural systems in Tokyo MA, and (b) develop scenarios of these options and an ex-ante assessment model for environmental and economic potential in order to support decision-making for golf course management and rural environmental management policies.

II. Materials and Methods

A. Redundant Golf Courses in the Tokyo MA

Tokyo MA consists of Tokyo and six surrounding prefectures (Ibaraki, Tochigi, Gunma, Saitama, Chiba, and Kanagawa). It is one of the largest and densest cities in the world, accounting for 32.5% (41.5 million people) of the Japan's total population in 8.6% of the total land cover of Japan. Its forest cover is 44.1%, whereas the forest cover of Japan as a whole is 66.5%.

In Tokyo MA, there were only 68 courses in 1960, most of them located within 50 km of Tokyo Station, close to the center of Tokyo. From 1960 to 1980, the number of courses increased dramatically, by six-fold (over 400 courses), along expressways and super express train (Shinkansen) networks. By 2000, almost 800 courses had been developed across Tokyo MA, with the exception of some high mountainous areas.

The data for redundant golf courses in Tokyo MA used in this study were obtained from a previous study [4], which estimated that 152 golf courses will be redundant by 2035.

B. Alternative Management Options for Restructuring Redundant Golf Courses

Based on a previous study [4], this study considers six utilization and management options (Table 1). These options are not mutually exclusive; they are complementary. The owner or manager can combine some of them in accordance with the location and condition of each course. With the development of new technology, more options will become available in future; however, considering the cases till date, this study uses six options for scenario analysis.

Table 1 Alternative Management Options for Restructuring Redundant Golf Courses

(a) Multipurpose space (park)	Since footpaths and cart lanes are already built in as a part of the golf course, redundant courses located in urban areas can be converted into multipurpose spaces where citizens will be able to enjoy walking, sports, and other recreational activities [5]. The space can also be utilized as a nature restoration site or even a disaster control center in case of disasters such as a major earthquake.
(b) Cemetery	Because of the rapid population expansion in Tokyo MA, the shortage of cemeteries has become a serious problem [6]. Conversion of redundant courses in suburban areas into cemeteries will address this deficiency.
(c) Biofuel feedstock plantation and storage site for biomass feedstock	Bioenergy feedstock plantation could be an alternative management option for redundant courses in rural areas. Biofuels from grassland perennials, such as switchgrass (*Panicum virgatum*) and little bluestem (*Schizachyrium scoparium*) sequester more atmospheric CO_2 across the full life cycle of biofuel production and combustion during agriculture and transportation [7].
(d) Reforestation	Reforestation of urban courses will contribute to the improvement of the biological diversity of the area, and in rural areas, reforestation would enhance carbon sequestration and water-retaining functions as well as restore rural landscape as a whole.
(e) Pasturing	Converting abandoned agricultural land into cattle pastures is becoming popular in western Japan, since pasturing can deter degradation of the land and other negative impacts caused by abandonment with relatively low cost and labor. Pasturing would allow maintenance of the grassland landscape and livestock production would provide economic benefit [8].
(f) Abandonment	Abandonment might be an alternative because the reversion back to forest (succession) is usually strong in temperate broadleaf forests in the warm and humid climate of Tokyo MA.

C. Scenario analysis

Figure 3 summarizes the process of scenario analysis in the study. For 152 redundant courses in Tokyo MA, six alternative options as well as the possibility of continuing to maintain the land as a golf course are considered under four future scenarios (Fig.4). Alternative scenarios were created by reviewing literature on long-term trends and traditional management of the rural landscape [1],[9], future rural scenarios [10],[11], and ecosystem management as well as biomass production and utilization [12],[13]. "Business as usual" is the scenario in which the golfer population will be maintained and most of the golf courses will manage to continue their business to 2035.

This is a scenario based upon what are considered to be the most likely outcomes under the present trend. Three alternative scenarios are those that would result from a divergence from anticipated trends. In the "Generating Energy" scenario, biomass generated from redundant courses is preferred as an alternative renewable energy source to mitigate emission of green house gases (GHG). In the "Amenity and Comfort" scenario, people favor expanding land use for tourism, retirement-related services, leisure and sports activities, learning, and spiritual satisfaction. Activities such as planting trees and taking care of forests are developed in the "Restoring Nature" scenario.

Management options for the redundant courses were allocated for each scenario and probability distributions were provided to take into account uncertainty in future (Table 2). Monte Carlo simulation using Crystal Ball software (Oracle) was applied to this allocation and assessment process. For example, a probability distribution is given to the options "(M) maintaining as golf courses" (40–80%) and "(f) abandonment" (0–20%) in the S1 scenario (Business as usual) because we can never predict an exact proportion for these options in changing socio-economic conditions. The Monte Carlo simulation was trialed 10,000 times for each scenario.

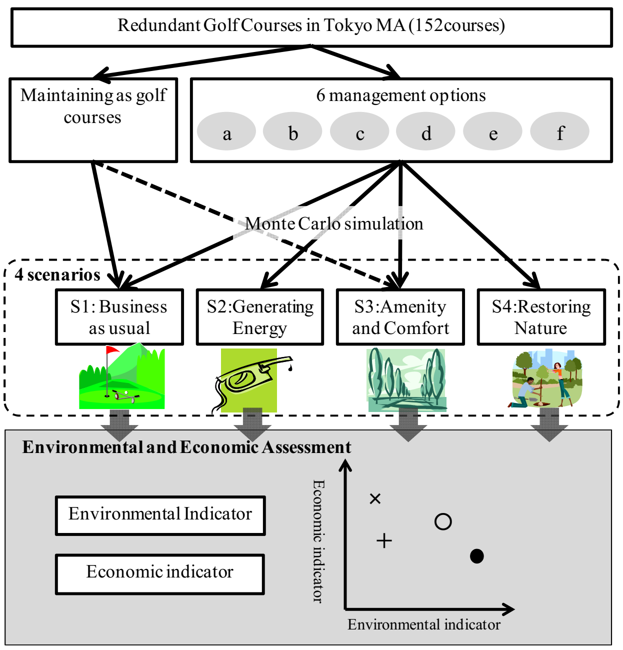

Fig.3 Process of scenario analysis

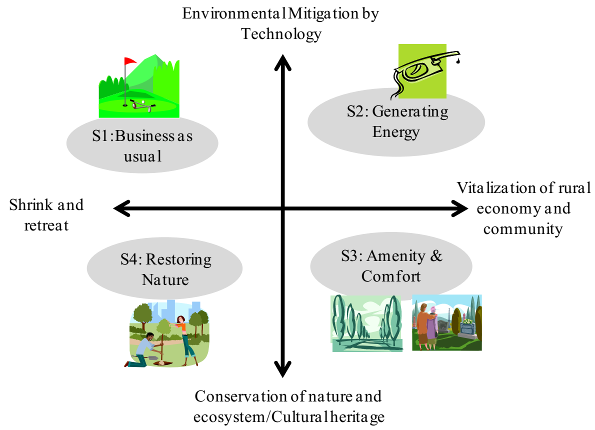

Fig.4 Four future scenarios

Table 2 Allocation assumptions of management options (%)

	Scenarios			
	S1	S2	S3	S4
(M) Maintaining as golf courses	60[1]	10[4]	10[5]	10[6]
(a) Multipurpose space (park)	10[3]	10[4]	30	10[6]
(b) Cemetery	0	0	30	0
(c) Biofuel feedstock plantation and storage site for biomass feedstock	0	60[1]	0	0
(d) Reforestation	10[3]	10[4]	10[5]	60[1]
(e) Pasturing	10[3]	0	10[5]	10[6]
(f) Abandonment	10[2]	10[2]	10[2]	10[2]
Total (%)	100	100	100	100

Figures in shaded cells are distribution assumptions set for Monte Carlo simulation.
[1]Triangle distribution ranging from 40% to 80% with a median of 60%
[2]Triangle distribution ranging from 0% to 20% with a median of 10%
[3](100-M-f)/3
[4](100-c-f)/3
[5](100-a-b-f)/3
[6](100-d-f)/3

D. Assumptions for Environmental and Economic Assessment

The study uses GHG emission and sequestration as environmental indicators, and economic cost and benefit as economic indicators. The formulae and assumptions for accounting GHG are summarized in Table 3, and for accounting cost and benefit in Table 4. Based on the existing statistics, reports, white papers, and scientific articles, the study adopted as many credible national average figures as possible. When those data were not available, estimated figures were used based on interviews with practitioners of each option.

Table 3 Formulae and assumptions for accounting GHGs of the management options

Option	Emission	Sequestration
(M)	*Operation and maintenance of a golf course* = *Energy consumption* (237.4 kl-crude oil equivalent/course[14]) × *Unit calorific value* (38.2 GJ/k litter[15]) × *Carbon emission factor* (0.0187 t-C/GJ[15]) *Transportation by golfers* = *Number of players per course* (40,000 players/course[16]) ÷ *Number of players per vehicle* (1.5 players/vehicle) × *Round-trip distance* (100 km/vehicle) × *Gasoline mileage* (15 km/litter) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15])	*Carbon sequestration* = *Forest area* (50 ha/course) × *Temperate forest net primary production (NPP)* (6.5 t-C/ha·year[17])
(a)	*Construction of a park* = *Developed land area* (50 ha) × *Unit development expense* (200,000 Japanese Yen (JPY)/ ha) × *Carbon emission factor* (3.786 kg-CO_2/1,000 JPY[18]) × *Conversion to carbon* (12/44) ÷ *Period 2010–2035* (25 years) *Operation of a park* = *Floor area of administrative office* (2,500 m^2) × *CO_2 emission factor* (46.8 kg-C/m^2[19]) + *Park maintenance expense* (50 ha × 30.3 JPY/m^2[20] × 2 times/year) × *CO_2 emission facto*r (3.786[5)] kg-CO_2/1,000 JPY[18] × *Conversion to carbon* (12/44) *Transportation by visitors* = *Number of visitors by automobile (*10,000/park·year*)* ÷ *Number of visitors per vehicle* (2 players/vehicle) × *Round-trip distance* (20 km/vehicle) × *Gasoline mileage* (15 km/litter) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15])	*Carbon sequestration* = *Forest area* (50 ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])
(b)	*Construction of a cemetery* = *Number of plots* (8,000 plots/course[21]) × *Unit development expense* (20,000 JPY/plot[22]) × *Carbon emission factor* (3.786 kg-CO_2/1,000 JPY[18]) × *Conversion to carbon* (12/44) ÷ *Period 2010–2035* (25 years) *Operation of a cemetery* = *Floor area of administrative office* (2,500 m^2) × *CO_2 emission factor* (46.8 kg-C/m^2[19]) ＋ *Green space maintenance expense* (20 ha × 30.3 JPY/m^2[20] × 2 times/year) × *CO_2 emission facto*r (3.786 kg-CO_2/1,000 JPY[18]) × *Conversion to carbon* (12/44) *Transportation by visitors* = *Number of visitors by automobile (*20,000/cemetery·year*)* ÷ *Number of visitors per vehicle* (2 players/vehicle) × *Round-trip distance* (20 km/vehicle) × *Gasoline mileage* (15 km/litter) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15])	*Carbon sequestration* = *Forest area* (50 ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])
(c)	*Net GHGs reduction by bioethanol utilization* = [*Forest biomass* yield (6.5 t-C/ha·year [17]× 50 ha) + *Grass land biomass yield* (3.2 t-C/ha·year[17] × 50 ha)] × *Ethanol production yield* (0.342 l/kg[23]) × *Calorific value of Bioethanol* (21.1 MJ/litter) × *Net GHG reduction by bioethanol production and utilization* (12.2 g-CO_2/MJ[24]) × *Conversion to carbon* (12/44)	*Carbon sequestration* = *Forest area* (50 ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])
(d)	*Transportation of forest workers and volunteers* = *Number of workers and volunteers* (1,000 people) ÷ *Number of visitors per vehicle* (2 players/vehicle) × *Round-trip distance* (40 km/vehicle) × *Gasoline mileage* (15 km/litter) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15]) *Forest management* = *Operating hours of weed cutter* (500 hours/year) × *Gasoline consumption* (0.3 litter/hour) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15])	*Carbon sequestration* = *Forest area* (90 ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])
(e)	*Construction of a ranch* = *Developed land area* (50 ha) × *Unit development expense* (20,000 JPY/plot[22]) × *Carbon emission factor* (3.786 kg-CO_2/1,000 JPY[18]) × *Conversion to carbon* (12/44) ÷ *Period 2010–2035* (25 years) *Operation of a ranch* = *Floor area of the administrative office* (2,500 m^2) × *CO_2 emission factor* (46.8 kg-C/m^2[19]) *Methane emission from livestock (enteric fermentation)* = *Ranch area* (grass land area) (60 ha) × *Number of dairy cattle per unit area* (2 cows/ha) × *Methane emission factor* (0.1 t-CH_4/cow[15]) × *Global warming potential of methane* (21) × *Conversion to carbon* (12/44)	*Carbon sequestration* = *Forest area* (40 ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])
(f)	*Monitoring and patrolling* = *Frequency of patrolling* (12 times/year) × *Round-trip distance* (20 km/vehicle) × *Gasoline mileage* (15 km/litter) × *Unit calorific value* (34.6 GJ/k litter[15]) × *Carbon emission factor* (0.0183 t-C/GJ[15])	*Carbon sequestration* = *Forest area* (70ha/course) × *Temperate forest NPP* (6.5 t-C/ha·year[17])

Table 4 Formulae and assumptions for accounting the cost and benefit of the management options

Option	Cost	Benefit
(M)	*Annual operating cost of a golf course* = *Average annual operating cost of 2,026 courses* (459 million JPY[16])	*Annual sales of a golf course* = *Average annual sales of 2,026 courses* (482 million JPY[16])
(a)	*Construction cost of a park* = *Unit development expense* (200,000 JPY/ha) × *Developed land area* (50 ha) ÷ *Period 2010–2035* (25 years) *Operating cost of a park* = *Labor cost of the operating staff* (2.5 million JPY/year) + *equipment and commodities* (500,000 JPY/year) + *Mowing* [*Unit price of mowing per* m^2 (30.3 JPY/m^2[20]) × *grass land area* (50 ha) × *Frequency* (2 times)]	*Admission* = *Unit price of admission* (200 JPY/visitor) × *Number of visitors* (10,000 visitors)
(b)	*Construction cost of a cemetery* = *Number of plots* (8,000 plots/course) × *Unit development expense* (20,000 JPY/plot [22]) ÷ *Period 2010–2035* (25 years) *Operating cost of a cemetery* = *Annual maintenance cost* (5,200 JPY/plot, labor cost for pruning trees, cleaning, waste collection etc.[25]) × *Number of plots* (8,000 plots/course)	*Perpetual usage fee* = *Perpetual usage fee per unit* (690,000 JPY[21] /100 years) × *Number of plots* (8,000 plots) *Maintenance fee* = *Maintenance fee per unit* (6,000 JPY[21]/50 years) × *Number of plots* (8,000 plots)
(c)	*Construction cost of bioethanol plant* (Annual production capacity of 150 k litters, 400 million JPY[26]) ÷ *Period 2010–2035* (25 years) *Feedstock collection and transportation cost* = *Volume of biomass feedstock* (485 dry-tones/year) × *Unit price for biomass collection and transportation* (15,000 JPY/dry-tones[27]) *Conversion cost and taxes* = *Unit production cost of bioethanol* [*Chemicals* (5 JPY/litter[28]) + *Fermentation auxiliary material* (2 JPY/litter[28]) + *Steam and electricity cost* (2.2 JPY/litter[28]) + *Labor cost* (4.5 JPY/litter[28]) + *Road tax* (5.2 JPY/litter) + *Gasoline tax* (48.6 JPY/litter)] × *Annual production volume* (150 kl/year)	*Bioethanol sales amount* = *Annual production volume* (150 k litters/year) × *Unit price of ethanol* (100 JPY/litter)
(d)	*Reforestation cost* = {*Soil coordination* (540,000 JPY/ha) + *Seedlings* (240,000/ha) + *Fencing from animal feeding* (904,700 JPY/ha[29])} × *Reforestation area* (40 ha) ÷ *Period 2010–2035* (25 years) *Forest management* = *Management cost of Japanese cypress* [Weed and shrub cutting (860,000 JPY/ha) + *Monitoring* (200,000 JPY/ha) + *Improvement cutting* (360,000 JPY/ha) + *Thinning* (360,000JPY/ha[29])] × *Correction factor by employing volunteer workers* (1/5) × *Reforestation area* (40 ha)	*Amortization of forest tax* = *Amortization of forest tax* (1,000 JPY/ha) × *Forest area* (90 ha/course)
(e)	*Construction of a ranch* = *Developed land area* (60 ha) × *Unit development expense* (20,000 JPY/plot[29]) ÷ *Period 2010–2035* (25 years) *Purchase of dairy cattle* = *Price of dairy cow* (150,000 JPY/cow) × *Number of cattle* (2 cattle/ha × 60 ha) *Labor cost* = *Annual labor cost* (4 million JPY/worker) × *Number of workers* (2 workers) *Pasture forage and other materials* = {*Purchased pasture forage* (300,000 JPY/cow[30]) + *Fuel* (12,000 JPY/cow[30]) + *Repair cost* (20,000 JPY/cow[30]) + *Consumable materials* (20,000 JPY/cow[30])]}× *Number of cattle* (2 cattle/ha × 60 ha)	Sales from livestock = *Annual sales per delivered cow* (700,000 JPY/ cow[30]) × *Number of cattle* (2 cattle/ha × 60 ha) × *Proportion of delivered cattle* (80%)
(f)	*Monitoring and patrolling* = *Labor cost* (10,000 JPY/person) × *Number of patroller* (2 persons) × *Frequency of patrolling* (12 times/year)	n.q. (not quantified)

III. Results

A. Assessment of Management Options

All options showed positive environmental impact as GHG savings range from 157 to 2,259 tones CO_2 equivalent/course·year (Table 5). As naturally expected, GHG saving of "reforestation (d)" was the highest and that of "maintaining as a golf course (M)" was the lowest among the options. The costs and benefits of operating golf courses are around 10 times higher than those of the other options, but the actual cost-benefit figures of golf courses that may go out of business in near future should be lower than this result. The B/C ratio for the cemetery option is 2.15, the highest among the options. Although this depends on the price fixed for the perpetual usage fee and how many slots can be sold, the study suggests that converting the land into a cemetery is potentially beneficial. The B/C ratios of (a) park, (c) biofuel, and (d) reforestation are less than 0.5, which means that their economic feasibility is very low without subsidies and other economic incentives for their ecosystem services.

Table 5 Assessment results of the management options

Option	GHG savings (t-CO_2 equivalent/ course·y)	Cost (million JPY/ course·y)	Benefit (million JPY/ course·y)	B/C
(M) Golf course	157	459.1	481.7	1.05
(a) Park	631	33.7	2.0	0.06
(b) Cemetery	661	48.0	103.2	2.15
(c) Biofuel	1,234	33.4	15.0	0.45
(d) Reforestation	2,259	16.9	0.1	0.01
(e) Pasturing	270	64.7	67.2	1.04
(f) Abandonment	2,020	0.24	0.0	—

B. *Scenario Analysis*

Using the figures in Table 5 as the unit environmental and economic efficiencies of each option, the aggregated impacts of 152 redundant courses in Tokyo MA were estimated for four scenarios. Figure 5 shows that S4 "Restoring Nature" absorbs the most CO_2, while its B/C ratio is the lowest among the four scenarios. B/C ratios of S1 "Business as Usual" and S2 "Generating Energy" scenarios are higher than 1.0, but their GHG savings are less than half of S4. This result suggests a trade-off relationship between GHG savings and economic viability. The result of the Monte Carlo simulation (Fig.6) clearly indicates this relationship. The GHG saving of S4 ranges from 176 to 330 (1,000 ton-CO_2 equivalent per year), and its B/C ratio varies inversely from 0.94 to 0.28. Connecting simulation results of S1, S2, and S4, we can draw a hypothetical inverse curve. The results of S3 "Amenity & Comfort" did not show such a clear trade-off relationship.

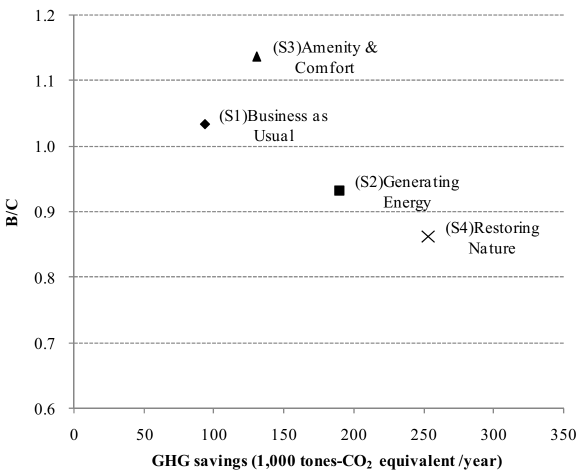

Fig.5 GHG savings and B/C ratios of scenarios

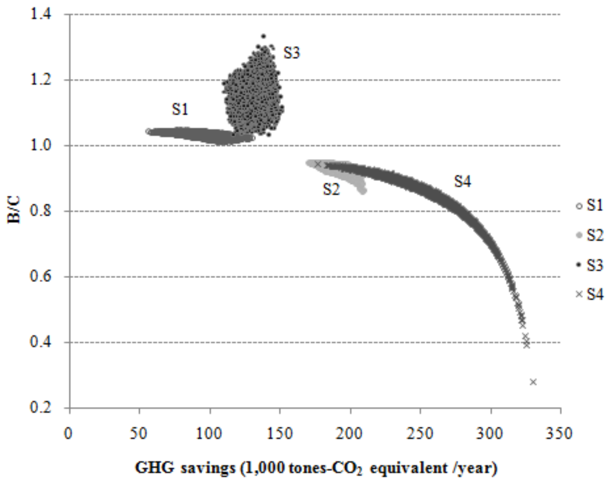

Fig.6 GHG savings and B/C ratios of scenarios by Monte Carlo simulation

IV. Concluding Discussion

This study builds upon an earlier study that estimated the number of golf courses that could potentially become redundant by 2035 in Tokyo MA [4]. Six alternative management options for restructuring the existing golf courses were examined and their environmental and economic impacts were quantitatively assessed in this study. In addition, restructuring scenarios were developed for these options along with an ex-ante assessment model. The following are the major findings:

1) All alternative management options showed positive environmental impact with GHG savings from 157 to 2,259 tones CO_2 equivalent/course·year (Table 5).
2) The result of cost-benefit analyses suggested that converting the golf course to a cemetery or pasture, as well as continuing to maintain it as a golf course, may be economically feasible.
3) Converting to a park, biofuel-producing land, and reforestation were economically difficult options in the absence of subsidies and other economic incentives.
4) The scenario analyses demonstrated that GHG savings of S2 "Generating Energy," S3 "Amenity & Comfort," and S4 "Restoring Nature" are larger than those of S1 "Business as Usual" (Fig.5 and 6).
5) The scenario analysis by Monte Carlo simulation showed a clear trade-off between GHG savings and B/C ratios, of which S4 "Restoring Nature" absorbs the most CO_2 among the four scenarios, but its B/C ratio is the lowest (Fig.6).

Even though many golf course owners, rural developers, and M&A businessmen have recognized this redundancy issue as an avoidable challenge in near future throughout Japan, no scientific study had been conducted before my previous study [4]. Building on that, this study has shown both the environmental and economic potentials of restructuring scenarios. If we leave this issue to market forces, maintaining as golf courses, converting to cemeteries, and pasturing may be the preferred options, but we should design a win-win scenario to maximize environmental, social, and economic benefits. This study can be used to select or examine options and scenarios of golf course management and rural environmental management policies.

Besides, this redundancy problem is not unique to Japan. Other Asian countries such as China and India will face a similar situation as their societies mature in future.

Further research is required to spatially allocate the proposed four scenarios and examine the validity of the allocation assumptions of management options (Table 2). Field surveys of vegetation recovery and environmental changes in abandoned golf courses are also needed to improve the management options and their assessment. Other environmental indicators including biodiversity [31],[32] should also be considered.

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