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Title of Paper: **Restructuring existing rural resorts as a sustainable infrastructure for basin socio-ecological systems in Japan: A case of redundant golf courses in the Tokyo Metropolitan Area**

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Abstract: Commercial infrastructures intended for use as leisure retreats such as golf and ski resorts have been developed extensively 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, resulting in over 2,400 golf courses and 700 skiing sites in Japan. Following the burst of the bubble economy in the 1990s, several existing resorts faced tough management decisions and some were forced to close their businesses. This study estimated that 152 (23%) golf courses will be redundant by 2035 in the Tokyo Metropolitan Area. Based on a spatial distribution analysis of the existing golf courses, the study identified 302 golf courses that are or will be under pressure to become redundant. Finally, the paper discusses alternative management options for restructuring the existing golf courses into a sustainable infrastructure for basin socio-ecological systems.

1. INTRODUCTION

Commercial infrastructures intended for use as leisure resorts have been developed extensively 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 and 700 skiing sites in Japan. These large-scale resorts were usually developed on rural hills and mountains where local farmers managed an essential part of the traditional agricultural system and landscape called *Satoyama* in Japanese (Takeuchi et al., 2002). Thus, from the late 1980s to the 1990s, many rural areas experienced protests against landscape destruction resulting from resort development (Yamada, 1990).

Following the burst of the bubble economy in the 1990s, however, several existing resorts faced tough management decisions and some were forced to close their businesses. It was reported that 49 golf courses went bankrupt in 2007, and the cumulative number had reached approximately 600, 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 businesses by improving operation efficiency. Consequently, the total number of golf courses has been maintained despite innumerable bankruptcies. Today, the Japanese golf industry is in a state of excess supply. With the trend towards diversification of leisure activities and depopulation, a significant number of resorts are expected to face redundancy or abandonment in the near future.

This study aims to (1) estimate the number of rural golf courses that will face redundancy or abandonment by 2035 in Japan and the Tokyo Metropolitan Area (Tokyo MA), (2) identify which golf courses will be potentially redundant in the Tokyo MA and (3) propose alternative management options for restructuring the existing golf courses into a sustainable infrastructure for basin socio-ecological systems.

2. MATERIALS AND METHODS

Based on the government's population projections by 2035 and white papers as well as statistics on leisure and sports, I estimated the number of redundant golf courses in Japan by regression analysis and Monte Carlo simulation using Crystal Ball software (Oracle). For spatial identification of redundant golf courses, I collected basic information on available golf courses in the Tokyo MA from golf course guidebooks and a web database of golf courses, and entered the collected data into a geographic information system (GIS). Alternative scenarios were created by reviewing literature on long-term trends and traditional management of rural landscape (Takeuchi et al., 2002; Saito, 2004b), future rural scenarios (Future Foundation & Newcastle University, 2005; University of Tokyo RCAST & Dentsu Inc., 2007) and ecosystem management as well as biomass production and utilization (Kurita & Yokohari, 2001; Yasuda & Yokohari, 2002; Saito, 2004a).

2.1. Estimation Model of Future Demand for Golf Courses

The number of golf courses (GC) can be estimated by the formula

$$GC = (P \times Rt \times F)/CP,$$

where 'P' is the potential population of golf players, 'Rt' is the participation rate of playing golf in the target population (P), 'F' is the annual frequency of playing golf per player (times player^{-1} year^{-1}) and 'CP' is the annual cumulative number of players per golf course. In this study, P represents the potential population of 20- to 64-year-old players according to the national population projections for 2035 (National Institute of Population and Social Security Research, 2007). For Rt, two potential scenarios were considered. Either Rt will not change until 2035, or it will gradually decrease in the future. For the first case, I used the average participation rate of the last 5 years (11.2% for the Tokyo MA and 10.2% for the rest of Japan). For the second, Rt was calculated by logarithmic regression ($Rt = -2.002\log(x) + 17.52$ for the Tokyo MA, $R^2 = 0.470$; $Rt = -1.417\log(x) + 14.735$ for the rest of Japan, $R^2 = 0.469$; where 'x' is the number of years since 1990) based on the past trends, which show that Rt in both the Tokyo MA and Japan has been decreasing gradually since the last 15 years (JPCSED), 1986–2006). The annual value of F fluctuates significantly, making it difficult to identify any specific trend. Hence, I gave this parameter a logistic distribution (mean: 11.6, scale: 0.6) on the basis of the statistical data (JPCSED, 1986–2006). The official statistics released by the Ministry of Economy, Trade and Industry (1985–2005) was used to define CP (annually, 48,392 players per course in the Tokyo MA and 45,155 players per course in the rest of Japan)

The number of redundant courses (RG) is given by the formula

RG = EG − GC,

where 'EG' is the number of existing golf courses, which is 821 for Tokyo MA and 2,453 for the national total (Nippon Golfjo Jigyo Kyoukai, 2008).

2.2. Spatial Distribution Analysis Model of Redundant Golf Courses

In order to specify the location of potentially redundant golf courses in the Tokyo MA, I developed an analysis model described in Figure 1, in which 'accessibility', 'density' and 'environment' were taken into account. Accessibility was considered as the distance from the centre of Tokyo and the nearest major transportation network. Density was measured by the number of golf courses per municipality and the number of golf courses per unit municipality area (100 km^2). Forest cover and altitude were used as indicators for environment. The data for these indicators were collected directly from golf course guidebooks (Ikki Shuppan, 2007; Golf Digest, 2008), a web database of golf courses (World Konzern, 2008), the Census of Agriculture and Forestry 2005 (MAFF, 2007) and from calculations using GIS functions.

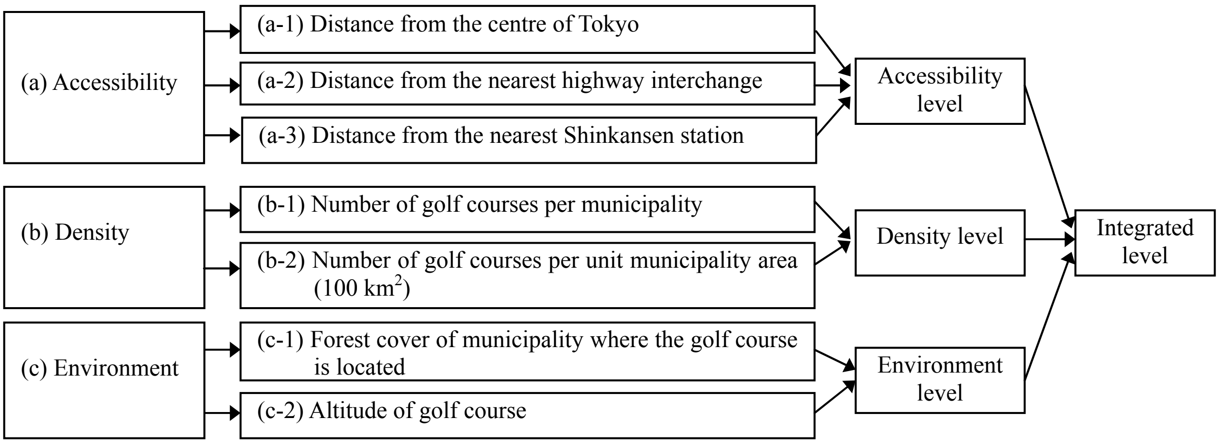


Figure 1 Analysis model for specifying spatial distribution of redundant golf courses

3. RESULTS

3.1. Development History of Golf Courses in Japan

The history of golf courses in Japan dates back to 1901 when the first 4-hole course was developed in Kobe. Until 1960, the total number of golf courses in Japan was less than 200, but it doubled by 1965 and nearly tripled by 1970. Rapid and extensive development of golf courses occurred together with the high-growth period of the Japanese economy during the 1960s and 1970s. More than 100 courses went into

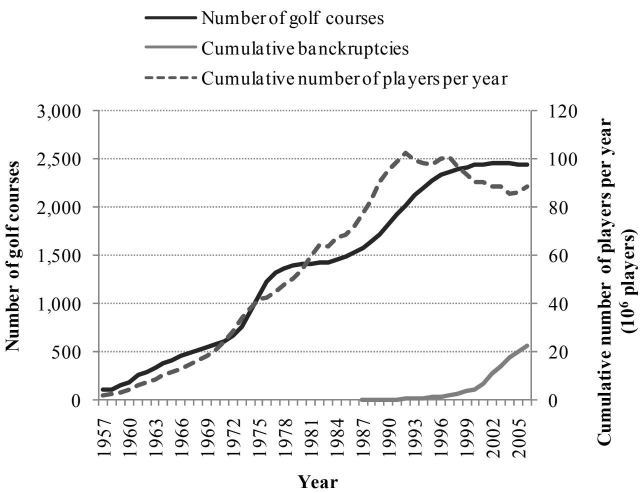


Figure 2 Number of golf courses, cumulative bankruptcies and cumulative number of players per year in Japan

business annually from 1973 to 1976. Most of these golf courses were developed by clearing the *Satoyama* woodland that the local people depended on not only for energy and materials but also for traditional identity and rural beauty. The rate of development stagnated from the late 1970s (after the first oil shock) to the early 1980s, but boomed again from the late 1980s to the early 1990s along with the expansion of the bubble economy in Japan. Because many courses were planned during the bubble economy, they were constructed even after the burst of the bubble economy. The number of courses continued to increase during the 1990s, but since 2003, the numbers have been decreasing slightly. The cumulative number of players hit a peak of over 100 million in 1992 and then tended to decrease. There was nearly a decade of time lag between the construction of golf courses and their use by players. The number of bankrupt courses started to increase in the late 1990s, and it hit a peak of 108 in 2002. The cumulative bankruptcies reached over 600 in 2007 (Teikoku Databank, 2008).

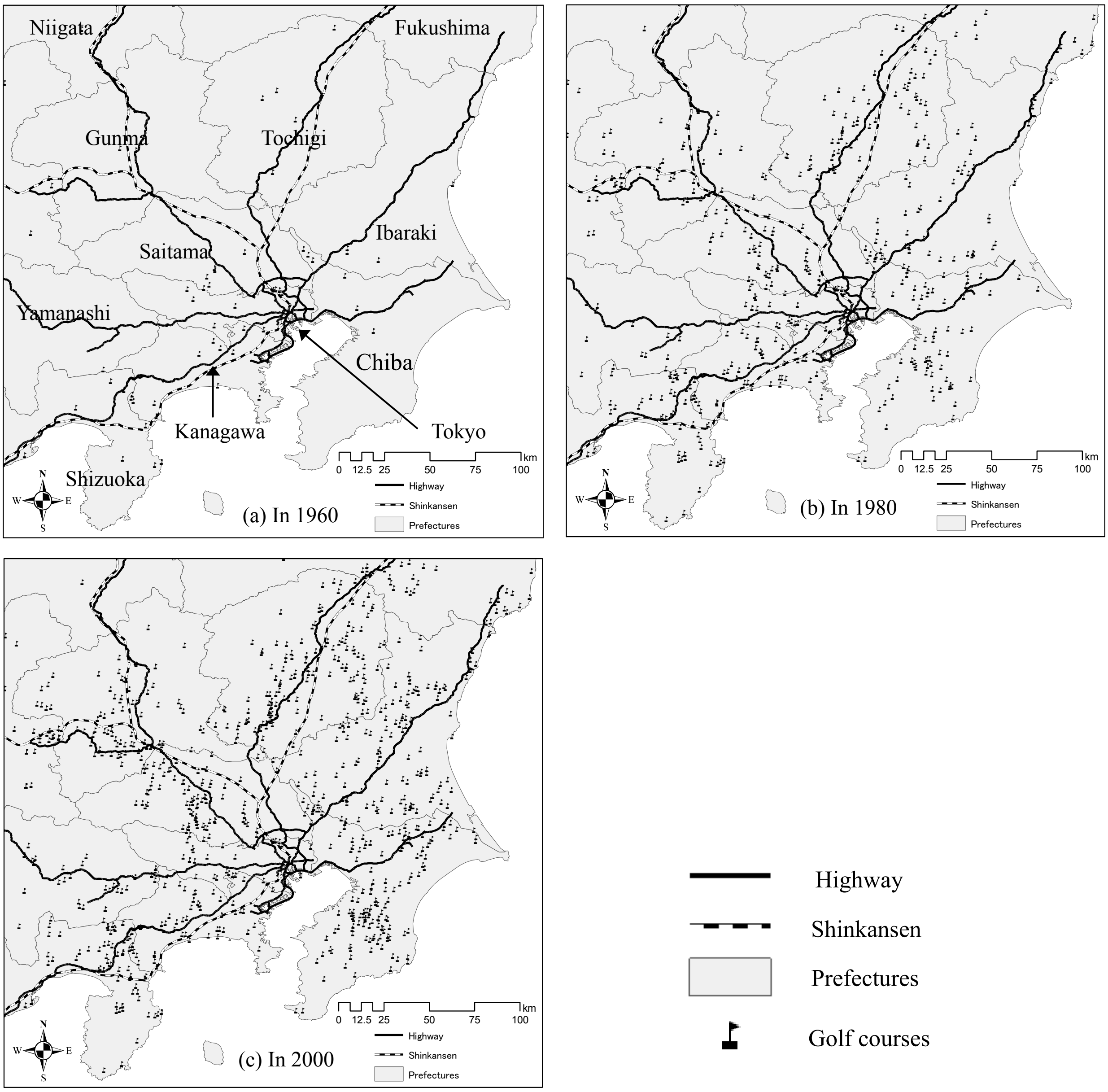


Figure 3 Expansion of golf course construction in the Tokyo MA

In the Tokyo MA, there were only 68 courses in 1960, most of them located within 50 km of the Tokyo Station, close to the centre of Tokyo (Figure 3(a)). From 1960 to 1980, the number of courses increased dramatically by 6 times (over 400 courses) along expressways and super-express train (Shinkansen) networks (Figure 3(b)). By 2000, as many as 800 courses were developed across the Tokyo MA with the exception of some deep mountainous areas (Figure 3(c)). The total land area covered by golf courses exceeded 800 km^2, accounting for 4.7% of the forest cover in the area.

3.2. Redundant Golf Courses by 2035

The results of the estimation model showed that 916 to 1,041 courses will be redundant by 2035, which means that 37% to 42% of the existing courses may face difficulty in continuing their businesses (Figure 4). In the Tokyo MA, redundant courses will be prominent after 2010 and reach 152 by 2035 (Table 1). The redundancy rate (RR) is negative by 2010 in Tokyo MA, which implies the deficiency of golf courses. However, the probability of redundancy in 2005 and 2010 is 17.8% and 18.4%, respectively (Table 1). This suggests that some courses become redundant even before 2010, if playing frequency (F) decreases significantly.

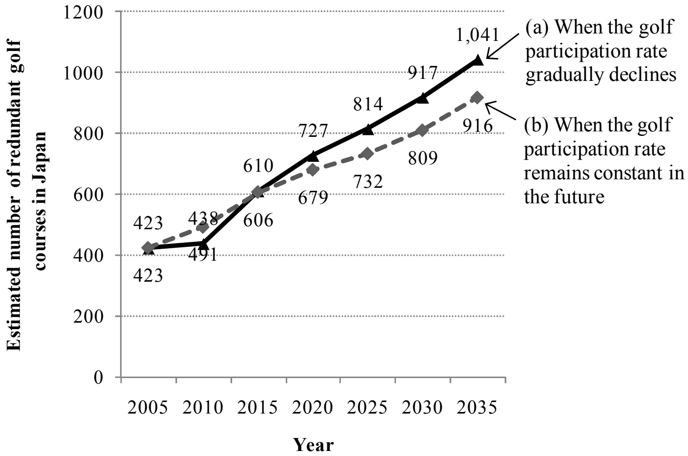


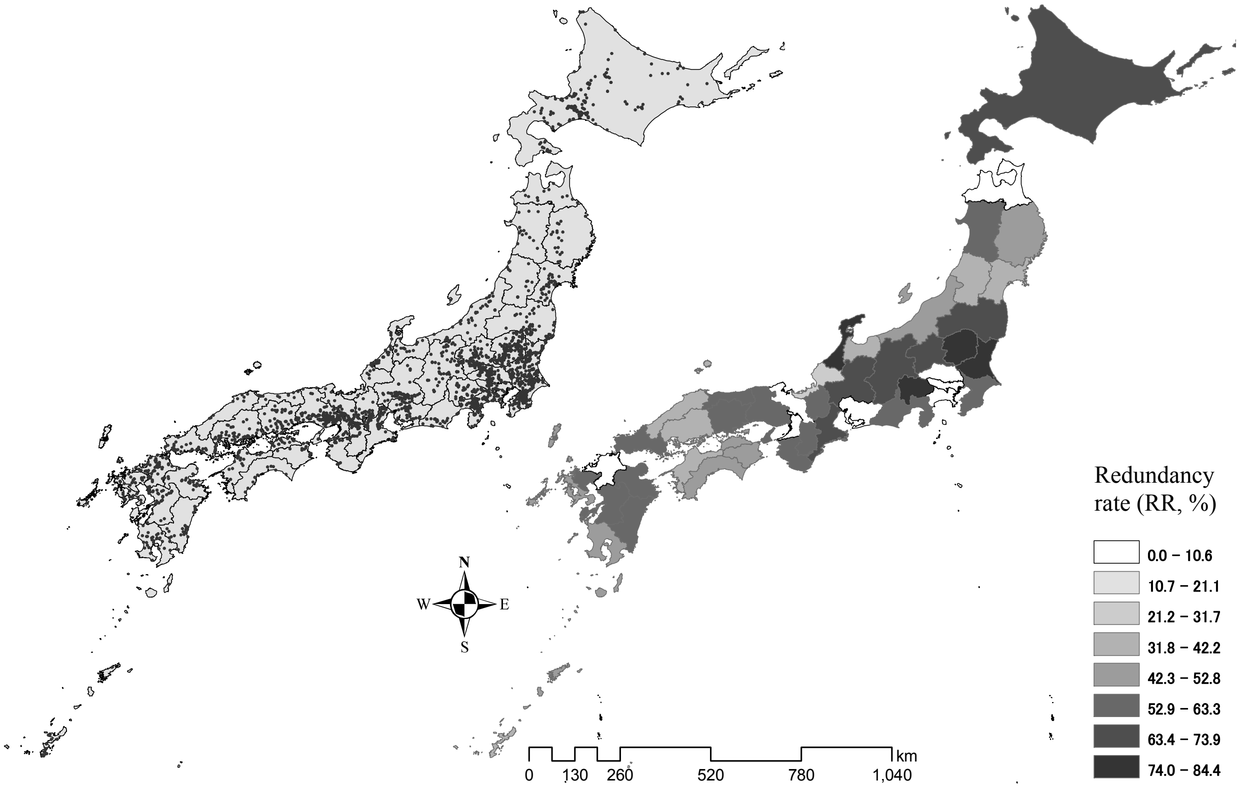
Figure 4 Estimation results of redundant golf courses in Japan

Table 1 Estimated results of the number of redundant golf courses in the Tokyo Metropolitan Area and Japan when the golf participation rate gradually declines

Year	Tokyo Metropolitan Area			National total		
	Number of redundant courses	Redundancy rate (RR) 1)	Probability of redundancy 2)	Number of redundant courses	Redundancy rate 1)	Probability of redundancy 2)
2005	−51	−7.8%	17.8%	423	17.3%	98.8%
2010	−50	−7.6%	18.4%	438	17.8%	99.1%
2015	8	1.2%	54.5%	610	24.9%	99.9%
2020	43	6.5%	80.1%	727	29.6%	100.0%
2025	69	10.5%	91.4%	814	33.2%	100.0%
2030	105	15.9%	98.1%	917	37.4%	100.0%
2035	152	23.1%	99.8%	1,041	42.4%	100.0%

1) Redundancy rate (RR, %) = redundant courses/the total existing courses × 100
2) 'Probability of redundancy (%) is the probability that more than one redundant course will occur among 10,000 trials of Monte Carlo simulation.

Figure 5(b) indicates RR of 47 prefectures in Japan. Darker colours indicate a higher RR for golf courses in 2035. Comparing this with the distribution of the existing golf courses (Figure 5(a)), RRs of prefectures with large cities including Tokyo, Osaka, Nagoya, Kyoto and Hakata are very low (<10%); however, this is compensated for by the surrounding prefectures where their RRs tend to be higher.



(a) Distribution of the existing golf courses in Japan

(b) Redundancy rate by prefectures in 2035

Figure 5 Distribution of the existing golf courses and redundancy rate by prefectures in 2035

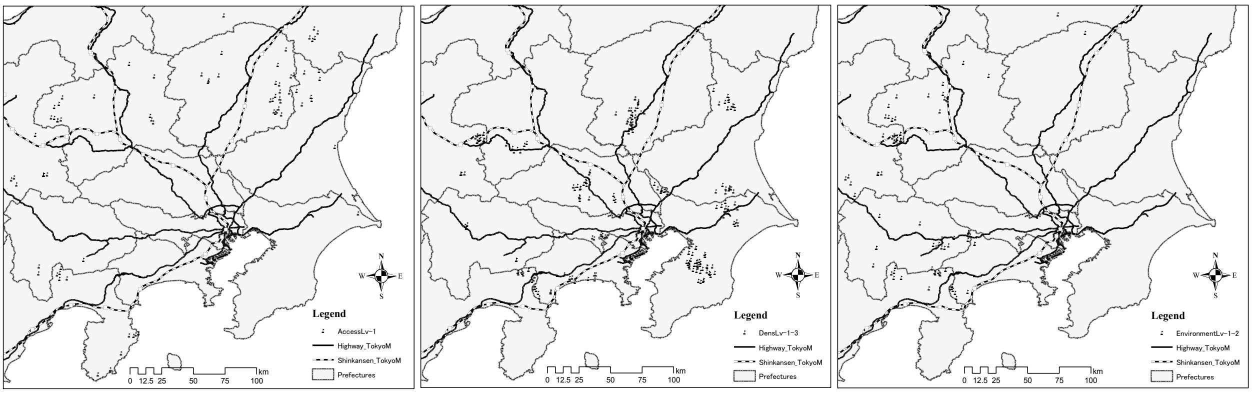
3.3. Spatial Distribution of Redundant Golf Courses

The result of a spatial distribution analysis shows that 58.7% of the golf courses are located within 100 km of Tokyo Station, and 40.9% are located within 10 km of the nearest highway interchange (Appendix). In terms of accessibility level, 79 golf courses are classified as level 1, which is the lowest level of accessibility in this analysis model (Table 2, Figure 6 (a)). The pressure of competition among the courses becomes stronger with the increase in density within one municipality, consequently leading to abandonment of some courses. The analysis identified 205 closely located courses (level 1–3 in Table 2, Figure 6 (b)), including 33 golf courses in Ichihara City, Chiba Prefecture. The forest cover of the municipality in which the golf course is located is related to the natural recovery (succession) potential of the forest when abandoned. Moreover, altitude is known to be one of the most effective indicators for explaining forest vegetation types in the Tokyo MA (Saito, 2004b). Based on the forest cover and altitude, the model identified 85 courses (level 1–2 in Table 2, Figure 6 (c)), where the environment is ecologically important and recovery of the natural forest can be expected. The relationship between the identified golf courses is illustrated in Figure 7, which indicates a total of 302 courses selected, 59 (Integrated level 1) selected by more than two indicators (Figure 8) and 8 selected by all indicators (Figure 7).

Table 2 Summary of spatial distribution analysis

Indicator	Level (Score)	1 (1–2)	2 (3–4)	3 (5–6)	4 (7–8)	5 (9–10)	6 (11–12)
Accessibility level	No. of courses (Percentage)	79 (9.6%)	258 (31.4%)	232 (28.3%)	202 (24.6%)	39 (4.8%)	11 (1.3%)
Density level	No. of courses (Percentage)	0 (0.0%)	84 (10.2%)	121 (14.7%)	319 (38.9%)	250 (30.5%)	47 (5.7%)
Environment level	No. of courses (Percentage)	9 (1.1%)	76 (9.3%)	160 (19.5%)	205 (25.0%)	223 (27.2%)	148 (18.0%)

The shaded portion is plotted in Figure 6 (below). Detailed scores for each indicator are presented in the Appendix.



(a) Accessibility (b) Density (c) Environment

Figure 6 Spatial distribution of redundant golf courses

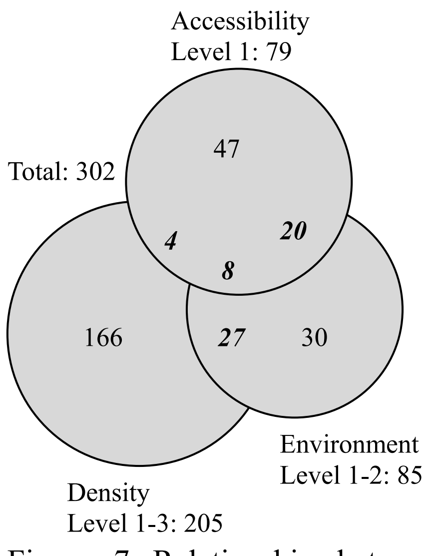


Figure 7 Relationship between the identified golf courses

Integrated level 1: Overlapped parts (bold italic figures, 59 golf courses), level 2: un-overlapped parts (243 courses)

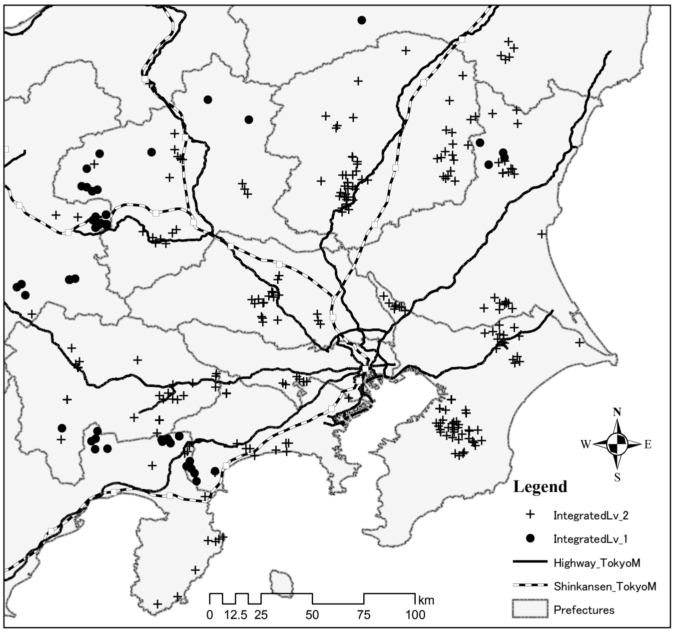


Figure 8 Distribution of potentially redundant golf courses (●: Integrated level 1, +: Level 2)

4. DISCUSSION AND CONCLUSION

4.1. Alternative Management Options for Restructuring Redundant Golf Courses

This study estimated that 152 golf courses will be redundant by 2035 (Table 1), and identified 302 courses (Integrated level 1: 59; level 2: 243) which are potentially redundant with regard to accessibility, density and environment (Figure 8). Although there are some studies that focus on negative environmental impacts of golf course construction and operation (e.g. Yamada, 1990; Shinshu University, 1990), few studies have been conducted in the context of restructuring redundant and abandoned courses. Based on the results of this study and recent issues concerning sustainable land and infrastructure design (Saito, 2006), I propose six utilization and management options as follows.

(1) Multi-purpose space (park): Since footpaths and cart lanes are already built in as part of a golf course, redundant courses located in urban areas can be converted to multi-purpose spaces where general citizens will be able to enjoy walking, sports and other recreational activities (e.g. Adachi City, 2008). The space can be also utilized as a nature restoration site or even a disaster control centre once a disaster like a major earthquake occurs.

(2) Cemetery: Because of the rapid population expansion in Tokyo MA, a deficient cemetery supply has become a serious problem (GIAC, 2004). If redundant courses in suburban areas are converted to cemeteries, they will complement this deficiency. Assuming one compartment of a cemetery is 5 m^2, one golf course can provide about 100,000 compartments. Takarazuka City in Hyogo Prefecture plans to convert a part of the existing golf course (8 holes) into a new public cemetery with 6,500 compartments (GIAC, 2004). This option can avoid or minimize additional forest destruction associated with cemetery development, and utilize existing infrastructure such as driveways and footpaths.

(3) Biofuel feedstock plantation and storage site for biomass feedstock: Bioenergy feedstock production could be a reasonable alternative in redundant courses in rural areas since *Satoyama* used to be an important energy source for firewood and charcoal (Saito, 2004a). It has been reported that biofuels using grassland perennials, such as switchgrass (*Panicum virgatum*) and little bluestem (*Schizachyrium scoparium*) sequestered more atmospheric CO_2 across the full life cycle of biofuel production and combustion during agriculture and transportation, with a net life cycle sequestration of 3.3-4.4 ton $ha^{-1}year^{-1}$ of CO_2 (Tilman et al., 2006). Pereniality eliminates the need for most chemical inputs and tillage and lessens use of nitrogen fertilizer. In addition, redundant courses in rural areas can supply large storage space not only for feedstock of perennials, but also for other cellulosic resources like forest thinning and agricultural residues.

(4) Reforestation: This option should be considered in both urban and rural areas. Reforestation in urban courses will contribute to improving 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.

(5) Pasturing: Converting abandoned agricultural land to cattle pasture 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 labour. For redundant golf courses in rural areas, pasturing would be a reasonable option, since it would allow maintenance of grassland landscape and livestock production would provide economic benefit (Inoue, 2006).

(6) Abandonment: For the redundant courses in deep rural areas, abandonment might be one of the alternatives because the resilience back to forest (succession) is usually strong in temperate broadleaf forests under the warm and humid climate of Tokyo MA. Continuous monitoring of succession and environmental changes is needed in order to accumulate scientific knowledge of such succession, since we have not experienced it in the past. Moreover, since those abandoned courses tend to become the target of illegal dumping of industrial waste (Matsui, 2003), monitoring and patrolling must be carried out regularly.

4.2. Conclusion and Further Research

This paper reviewed developmental history of golf courses in Japan and estimated that 152 (23%) golf courses will be redundant by the year 2035 in Tokyo MA. Then, the spatial distribution analysis identified 302 golf courses that are or will be soon approaching redundancy. Finally, I have described six alternative management options for restructuring the existing golf courses as a sustainable infrastructure. This redundancy is not a problem unique to Japan. Other Asian countries like China and India will face a similar problem, as they turn into a mature and ageing society in future.

Further research is required to spatially allocate the proposed 6 options and assess their benefits and risks, using environmental and social data of each potentially redundant course. Undertaking field surveys of vegetation recovery and environmental changes in abandoned golf courses is also needed to improve the management options and their assessment.

ACKNOWLEDGEMENTS

This study was supported by the program entitled “Promotion of Environmental Improvement for Independence of Young Researchers” under the Special Coordination Funds for Promoting Science and Technology provided by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

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APPENDIX

Results of spatial distribution analysis

(a) Accessibility

(a-1) Distance from the centre of Tokyo

Score	Distance from Tokyo Station	Number of courses	Percentage
6	<25km	10	1.2%
5	25–50km	95	11.6%
4	50–75km	192	23.4%
3	75–100km	185	22.5%
2	100–125km	178	21.7%
1	125–150km	94	11.4%
0	150–175km	67	8.2%

(a-2) Distance from the nearest highway interchange

Score	Distance from highway interchange	Number of courses	Percentage
3	<10km	336	40.9%
2	10–15km	153	18.6%
1	15–20km	93	11.3%
0	>20km	239	29.1%

(a-3) Distance from the nearest Shinkansen station

Score	Distance from Shinkansen Station	Number of courses	Percentage
3	<10km	104	12.7%
2	10–15km	85	10.4%
1	15–20km	106	12.9%
0	>20km	526	64.1%

(b) Density

(b-1) Number of golf courses per municipality

Score	Number of courses per municipality	Number of courses	Percentag e
5	1–3	320	39.0%
4	4–5	159	19.4%
3	6–10	226	27.5%
2	11–20	83	10.1%
1	>21	33	4.0%

(b-2) Number of golf courses per unit municipality area

Score	Number of courses per unit municipality area ($100km^2$)	Number of courses	Percentage
6	<1	68	8.3%
5	1–2.5	183	22.3%
4	2.5–5	305	37.1%
3	5–7.5	106	12.9%
2	7.5–10	115	14.0%
1	>10	44	5.4%

(c) Environment

(c-1) Forest cover of municipality where a golf course is located

Score	Forest cover	Number of courses	Percentage
5	<20%	281	34.2%
4	20–40%	185	22.5%
3	40–60%	136	16.6%
2	60–80%	168	20.5%
1	>80%	51	6.2%

(c-2) Altitude of golf course

Score	Altitude	Number of courses	Percentage
6	<50m	224	27.3%
5	50–100m	138	16.8%
4	100–300m	250	30.5%
3	300–500m	90	11.0%
2	500–100m	91	11.1%
1	>1000m	28	3.4%