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Measuring the Lifecycle Carbon Footprint of a Golf Course and Greening the Golf Industry in Japan

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1. INTRODUCTION

- Recreation in the countryside has been a cause of land-use changes and a source of controversy over balancing between rural economic development and environmental conservation (Bell, 2000).
- From the late 1980s to 1990s, there were protests in Japan regarding the destruction of the local landscape for the development of resorts, especially golf course development (Yamada, 1990; Matsui, 2003).
- Similar problems caused by golf course development have occurred not only in developed countries (Balogh and Walker, 1992), but also in newly industrialized countries including China (Richards, 2010).
- However, reliable data pertaining to golf course development are scarce at the global level.

1. INTRODUCTION

- On the other hand, as in other industries, greening, i.e. embedding environmental considerations into industrial processes, products and services is considered as an effective management strategy essential for the survival of the tourism industry (Harris et al., 2002).
- It was acknowledged that tourism growth could no longer continue without addressing its major impacts (Berry and Ladkin, 1997).
- In Japan, Greenery by Golfer Group (GGG), whose members are golf club managers, golfers, government agencies and scientists, has been promoting environmental conservation and nature restoration including reforestation.
- However, studies on lifecycle greenhouse gas (GHG) emissions, which would serve as a base for planning effective mitigation measures, have not yet been conducted for a golf course.

Objective

The aim of this paper is to

(i) summarize the recent increase in the number of golf courses at the global scale,

(ii) assess the lifecycle GHG emissions of a golf course as its carbon footprint (CF), and

(iii) identify key factors and measures for more effective environmental management of golf courses.

2. GOLF COURSE GROWTH (1)

How many golf courses have been built in the world?

- There is no official statistics to answer this question. Gange et al. (2003) described that globally there are over 25,000 golf courses, and Golf Research Group (2000) reported a total of 30,730 courses in 119 countries and 57 million golfers.
- The journal of golf management in Japan reported that there are 32,300 courses in 198 countries and regions, based on a survey conducted in cooperation with golf associations in each country and region (Ikki-Shuppan, 2008).
- The WorldGolf website (http://www.worldgolf.com/) provides extensive course guide information for courses in over 100 countries.

2. GOLF COURSE GROWTH (2)

- The author integrated available lists provided by WorldGolf.com and the world list made by Ikki-Shuppan (2008).
- The result indicates that in 2008 there were over 35,100 golf courses globally (Fig. 1).
- The USA accounts for 50% of the global total, and the top five countries (USA, UK, Japan, Canada and Australia) account for 76%.The

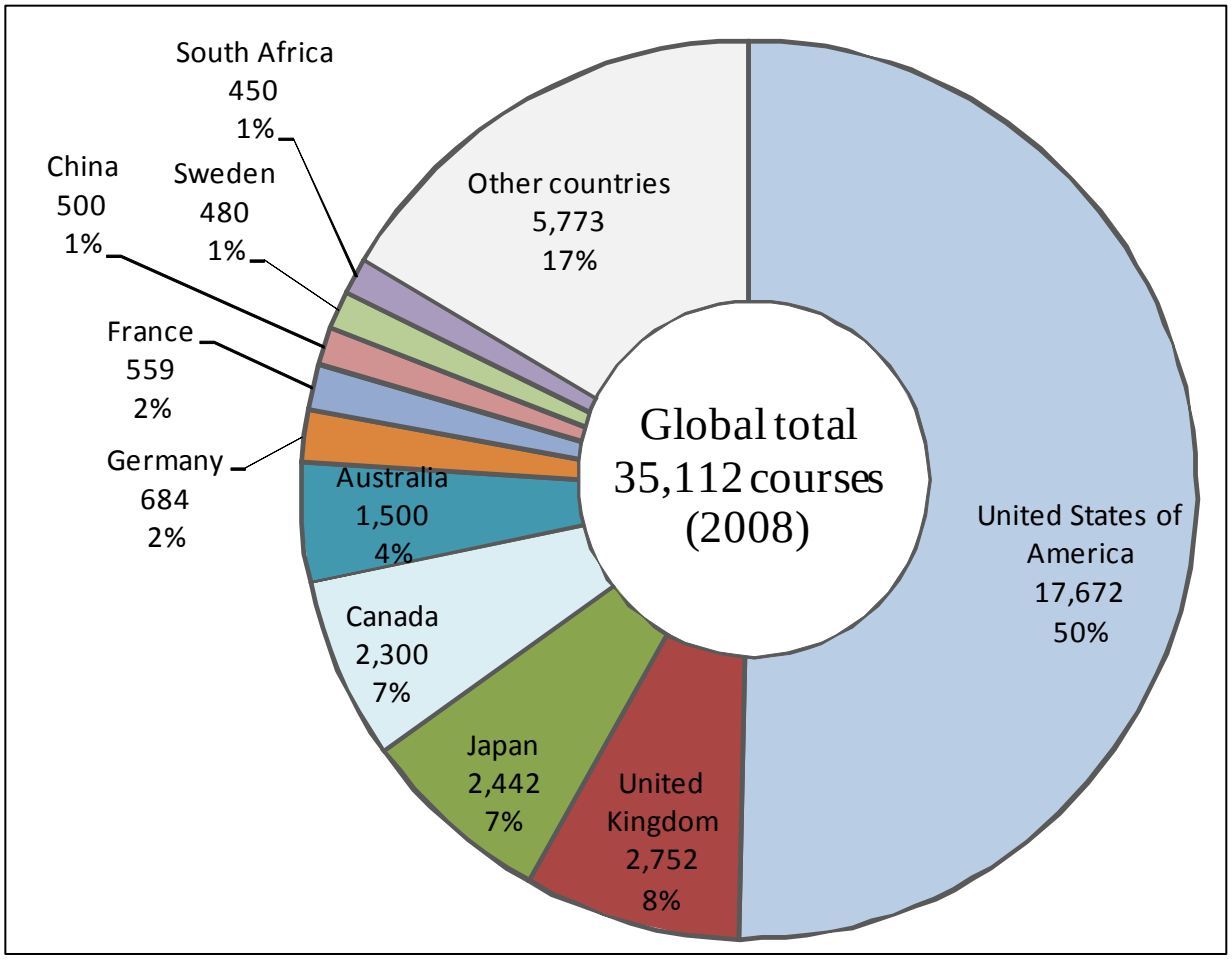
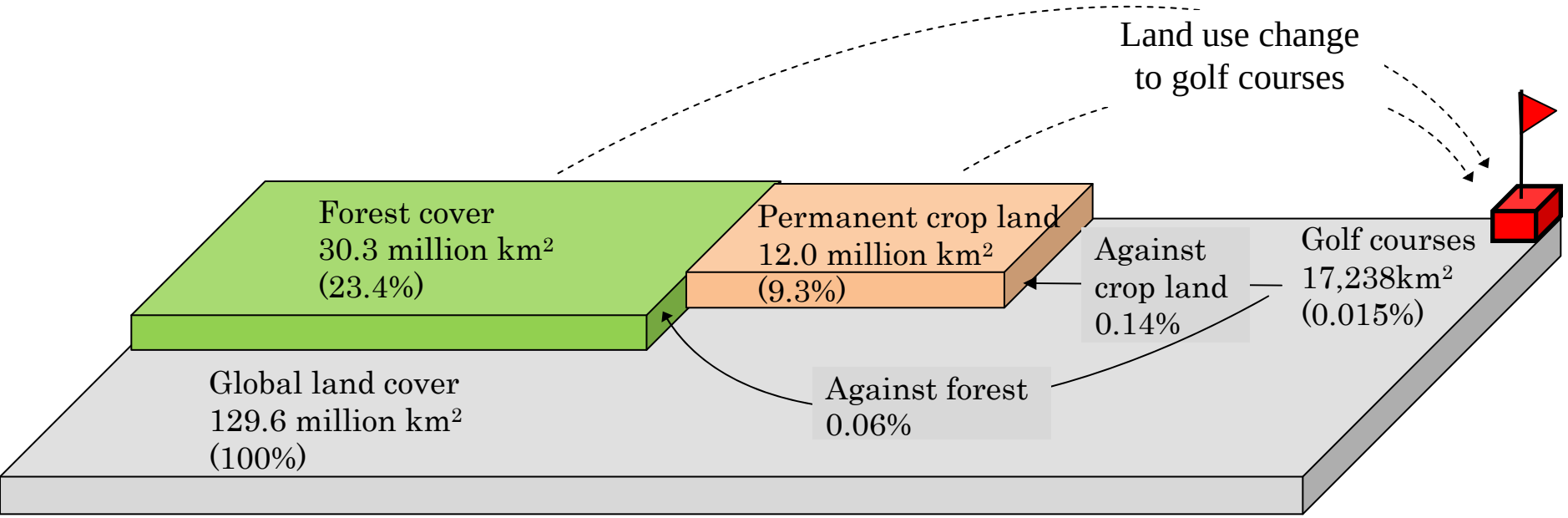


Figure 1. Number of golf courses in the world



- Assuming an average size of 50 ha per 18-hole golf course worldwide, and taking into account the global composition of 6-hole, 9-hole, 18-hole, 27-hole, etc., the golf courses worldwide may cover at least an area of 17,238 km^2, an area equivalent to the size of Kuwait.
- Golf courses cover a mere 0.14% of the global arable land and permanent cropland and 0.06% of the global forest area (The World Bank, 2010).
- However, if golf course development in developing countries continues hand-in-hand with their economic development, golf courses would cover a few percent of the forest and agricultural land, and increasingly compete with those land use types.

3. ASSESSMENT OF THE LIFECYCLE CARBON FOOTPRINT (CF)

3.1. Methodology

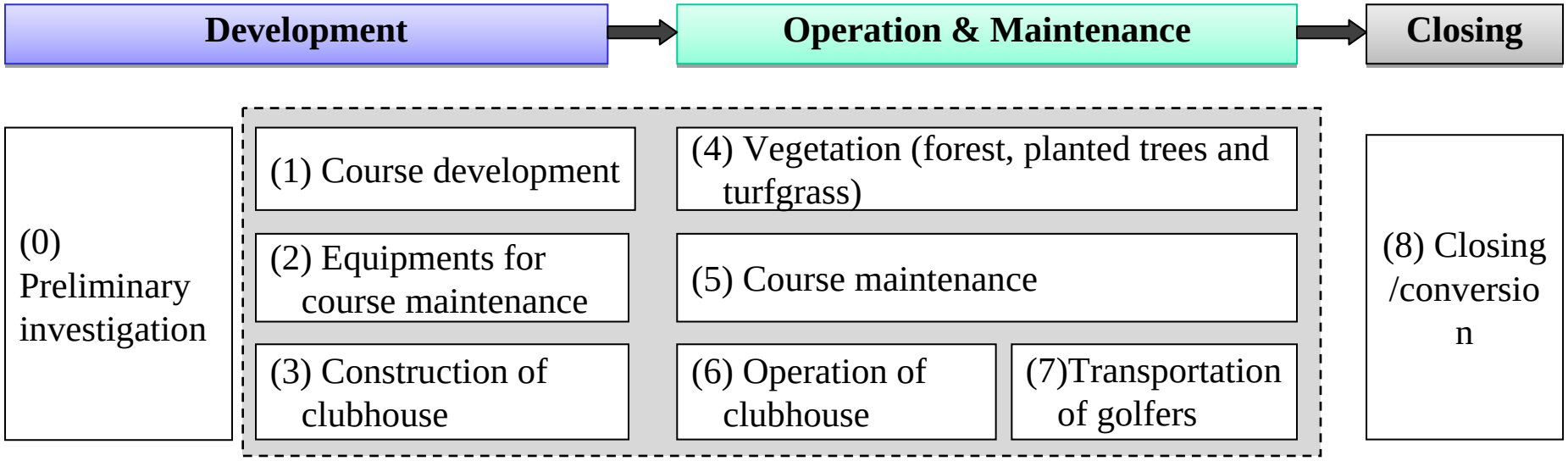


Figure 2. Lifecycle inventory of a golf course

: Inventory items in the grey area with dashed line are measured in this study

- Although there are many golf courses that operate for more than 30 years, this study considers 30 years as the course lifecycle. This duration was chosen because managers who were interviewed indicated that a golf course and clubhouse are often renovated more or less 30 years after they were built.

Table 2. Land use composition of the golf course (18h) for CF assessmen

Phase	Land use types	Area (ha)	Percentage	Note and source
Golf course site	Total land area	86.40	100.0%	Average in Japan (n = 898) Ikki-Shuppan (2010) *The Greenkeeper 2010*.
Prior to the development	Arable land	8.64	10.0%	The planning documents of a new golf course development in Chiba prefecture, Japan
	Forest	77.76	90.0%	
After the development	Tee	1.18	1.4%	Ikki-Shuppan (2010) *The Greenkeeper 2010*.
	Fairway	12.89	14.9%	
	Rough	27.13	31.4%	
	Green	1.53	1.8%	
	Banker	0.60	0.7%	From the interviews with golf course managers and greenkeepers in Tochigi and Chiba prefectures, Japan
	Pond	0.20	0.2%	
	Parking	0.70	0.8%	
	Clubhouse and other buildings	1.30	1.5%	
	Forest	40.87	47.3%	The difference between the total area and the summation of other land use types except forest
Forest loss		36.89	42.7%	77.76(ha) - 40.87(ha)

Lifecycle inventory structure of a golf course and the equations for CF assessment

Lifecycle Inventory	Inventory items	Eq.
1. Course development 	1-1. Land preparation	(1)
	1-2. Stormwater management work	(1)
	1-3. Ground work	(1)
	1-4. Course construction	(1)
	1-5. Placing turf grass	(1)
	1-6. Drainage work	(1)
	1-7. Effluent processing facilities	(1)
	1-8. Maintenance road construction	(1)
	1-9. Access road and parking construction	(1)
	1-10. Water supply facilities	(1)
	1-11. Electric facilities	(1)
	1-12. Planting trees	(1)
	1-13. Ancillary facilities	(1)
	1-14. Turf grass management	(1)
	1-15. Temporal works	(1)
	1-16. Forest loss due to course construction	(1)
	1-17. Carbon stock of planted trees	(1)
2. Equipments for course maintenance	2-1. Equipments for course maintenance	(1)
	2-2. Golf carts	(1)
3. Clubhouse construction	3-1. Clubhouse construction	(1)
4. Vegetation	4-1. Carbon sequestration by forest	(3)
	4-2. Carbon sequestration by planted trees	(3)
5. Course maintenance 	5-1. Mowing (green, tee, fairway and rough)	(2)
	5-2. Spaying herbicide and fertilizer	(1)
	5-3. Supplemental planting	(1)
	5-4. Course renewal	(1)
6. Clubhouse operation 	6-1. Gas	(2)
	6-2. Electricity	(2)
	6-3. Water	(1)
	6-4. Sewage treatment	(1)
	6-5. Waste (food waste, etc)	(1)
7. Transportation of golfers 	7-1. Passenger vehicle use of golfers to access golf course	(2)
	7-2. Use of golf cart	(2)

Price-based carbon footprint (t-CO_2) :

$CF_p = \sum_i (C * EF_p)$, (1)

where C is cost (JPY) of the inventory item, EF_p is price-based CO_2 emissions factor (t-CO_2/million JPY) and i is inventory item.

Energy-based carbon footprint (t-CO_2):

$CF_e = \sum_i (E * GCV * EF_e)$, (2)

where CF_e is E is energy consumption (kg, l, m^3), GCV is higher calorific value (MJ/kg, MJ/l, MJ/m^3) and EF_e is energy-based CO_2 emission factor (t-CO_2/MJ).

Carbon sequestration by forests (t-CO_2):

$CF_{sq} = -\sum_j (A * SQ)*44/12$ (3)

where A is area of forest (ha), SQ is annual carbon sequestration (t-C/yr) and j is forest type.

3.2. Results: Estimated lifecycle CF of the golf course by inventory proportion

- The lifecycle (30 years) emissions of a typical golf course with 18 holes are 39,188 t-CO_2, and carbon sequestration by the forest and planted trees in the course accounts for 16,944 t-CO_2
- Of the total emissions, course development, clubhouse operation and transportation by golfers are the three largest contributors, accounting for 33.4%, 16.5% and 34.9%, respectively (Fig. 3).

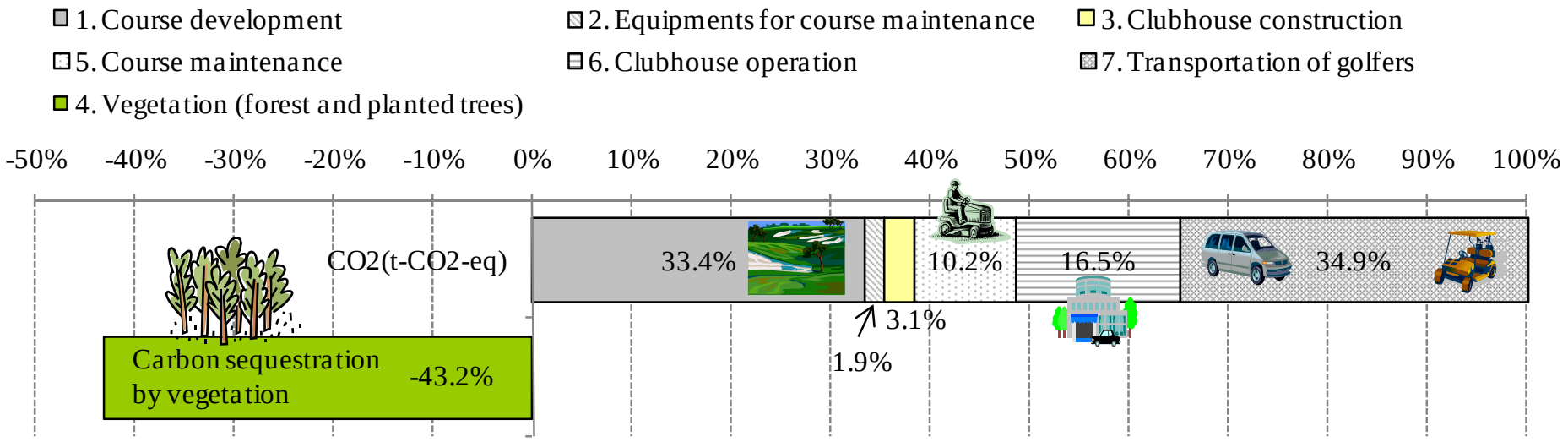


Figure 3. Estimated lifecycle CF of the golf course by inventory proportion

- The breakdown of the CF during the course development phase indicates that CO_2 emissions from forest loss are the largest of the development phase activities (Fig. 4).

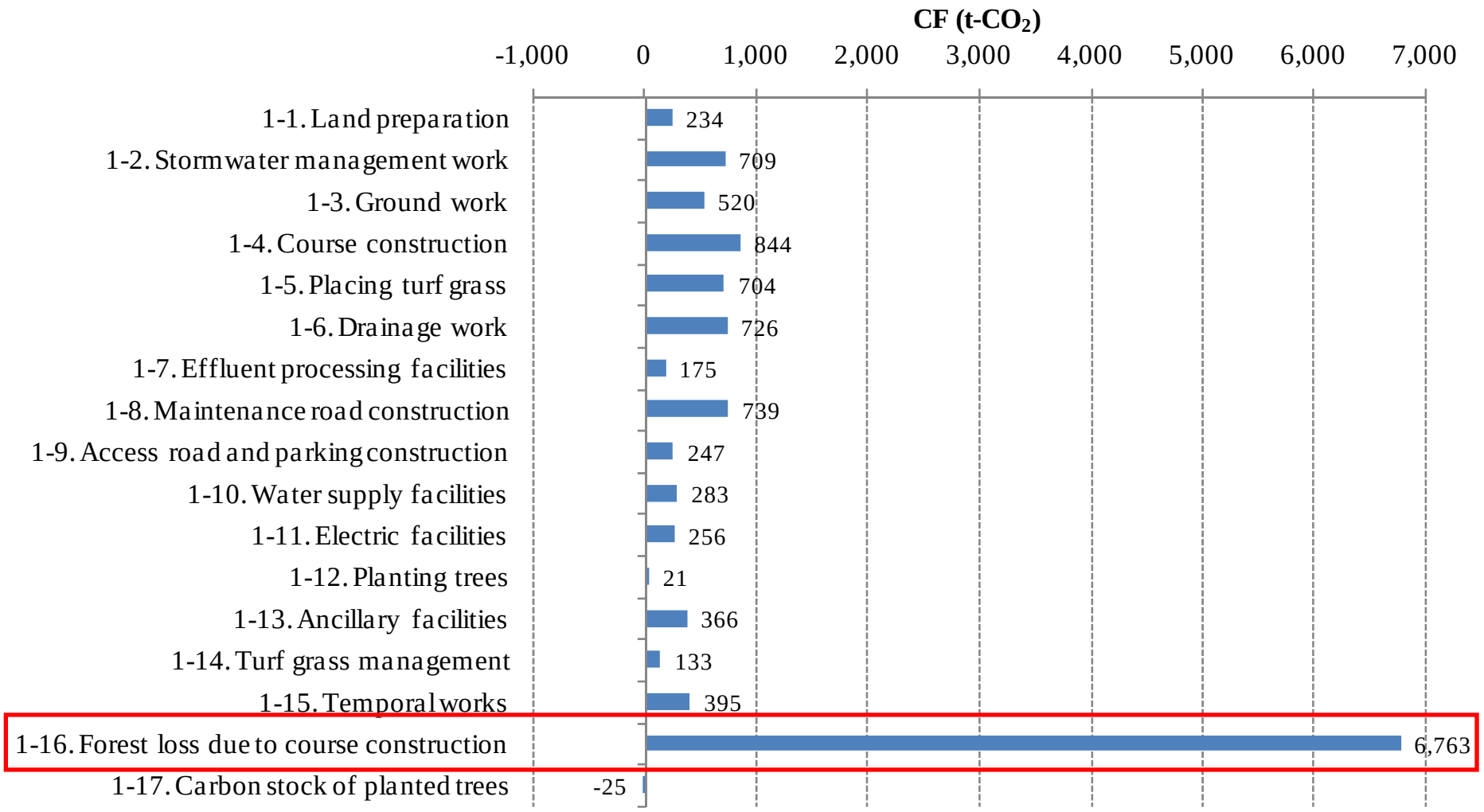


Figure 4. Breakdown of lifecycle CF during course development phase

4. DISCUSSION AND CONCLUSION (1)

- This study estimated that globally around 35,000 golf courses exist currently, of which the top five countries (USA, UK, Japan, Canada and Australia) account for 76%. The study found that these golf courses cover an area of approximately 17,238 km^2, an area equivalent to the size of Kuwait.
- Several developed countries have applied stricter regulations including environmental impact assessments (EIAs) for golf course construction and management. However, in developing countries, where course development is being done under the name of economic development, regulations have been relatively loose, such as in China (Richards, 2010).
- With this trend, the number of golf courses in developing countries will increase over the next decade. Those countries need to introduce not only EIAs and other regulations to protect the local environment, but also assess and manage the CF and carbon offset scheme to reduce the impact on global climate change.
- In addition, for the existing golf courses in both developed and developing countries, assessing their own CF and reducing it would improve management efficiency and increase the success of differentiated marketing.

4. DISCUSSION AND CONCLUSION (2)

- This study developed the inventory and methodology for the lifecycle CF assessment by using sample golf courses in Japan. The results showed not only the total GHG emissions from a golf course but also the carbon sequestration by forests and planted trees within the course. The net CF for a 30-year lifecycle was estimated to be 22,244 t-CO_2.
- The study showed that 43.2% of the emissions may be offset by carbon sequestration by vegetation on the course.
- However, N_2O emissions associated with frequent use of fertilizers may overcompensate for this CO_2 uptake, depending on the quantity and frequency of fertilization (Townsend-Small and Czimczik, 2010).

4. DISCUSSION AND CONCLUSION (3)

Based on the lifecycle CF assessment, following measures should be considered to minimize CO_2 emissions and maximize CO_2 uptake and storage:

(1) The CF resulting from course development can be reduced by minimizing forest loss.

(2) Forest management and tree planting in golf courses can offset carbon loss.

(3) Improving the energy efficiency of equipment used for course maintenance and of the clubhouse facilities can contribute to the reduction in the CF of the operation and the maintenance phase.

(4) Improving gasoline mileage of passenger vehicles and golf carts and promoting ride sharing would contribute to the reduction in golfer's travelling CF.

5. FUTURE TASKS

- This study presented a baseline lifecycle CF of a golf course in Japan. Since a CF labelling scheme has been applied to more and more products and services in Japan (Ministry of Economy, Trade and Industry, 2009), sooner or later the scheme may be applied to the golf industry. At that time, the golf industry should develop a standardized method for the lifecycle CF assessment.
- In addition, each golf course will need to assess their lifecycle CF by a standardized method to establish a baseline, and subsequently establish various operating scenarios.
- Future work includes assessing the golf course CF of other countries, improving the assessment methodology and developing a more tailored approach for managers to propose effective measures of CF reduction.

Thank you for kind attention

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Appendixes

Distribution of the existing golf courses in Japan