

# An Evaluation of Land Use Control in Hokkaido, Japan

Kayoko Yamamoto

**Abstract**—This study focuses on an evaluation of Hokkaido which is the northernmost and largest prefecture by surface area in Japan and particularly on two points: the rivalry between all kinds of land use such as urban land and agricultural and forestry land in various cities and their surrounding areas and the possibilities for forestry biomass in areas other than those mentioned above and grasps which areas require examination of the nature of land use control and guidance through conducting land use analysis at the district level using GIS (Geographic Information Systems). The results of analysis in this study demonstrated that it is essential to divide the whole of Hokkaido into two areas: those within delineated city planning areas and those outside of delineated city planning areas and to conduct an evaluation of each land use control.

In delineated urban areas, particularly urban areas, it is essential to re-examine land use from the point of view of compact cities or smart cities along with conducting an evaluation of land use control that focuses on issues of rivalry between all kinds of land use such as urban land and agricultural and forestry land. In areas outside of delineated urban areas, it is desirable to aim to build a specific community recycling range based on forest biomass utilization by conducting an evaluation of land use control concerning the possibilities for forest biomass focusing particularly on forests within and outside of city planning areas.

**Keywords**—Land Use Control, Urbanization, Forestry Biomass, Geographic Information Systems (GIS), Hokkaido

## I. INTRODUCTION

ALTHOUGH land prices in Japanese city centers have been in a downward trend in recent years, they are still higher than those in peripheral areas and issues concerning land use such as the difficulty of securing land for offices and housing continue to be pinpointed. On the other hand, there is an increasing trend towards locating offices and housing in the suburbs as land prices are relatively low, and there are many cases of chaotic development of urban areas involving the maintenance of traffic networks as well as cases related to serious land use issues such as the spread of urban areas or urban sprawl. The burden of upgrading urban infrastructure is also increasing and the occurrence of issues such as the time and energy required to move people and materials are increasing as well as there being a decline in maintenance performance. In this way, the underuse of land is being neglected in city centers and (re)location to the city periphery is being permitted and, as a result, there are claims that a radical reform of the land use system is required.

Kayoko Yamamoto is with the Graduate School of Information Systems, National University of Electro-Communications, Tokyo 1-5-1 Chofugaoka, Chofu-shi, Tokyo 182-8585, Japan (Tel & Fax: +81-42-443-5728, e-mail: k-yamamoto@is.uec.ac.jp)

There is also concern that the above land use issues will make the rivalry for all types of land use such as urban areas as well as agricultural or forestry land, that have traditionally been singled out in Japan as land use planning issues, more serious (Land Use Research Group Compilation, 1999) [1]. Furthermore, this is becoming a serious challenge in land use planning as deviations between land use control and the actual use of land, in particular in the periphery of urban areas, are increasing (Mizuguchi, 1997) [2]. In addition, as these kinds of significant changes in land use not only have a serious effect on the local residential environment but also on the wider environment of the entire area, the nature of appropriate urban structure and land use from the point of view of the environment in the future must be questioned. Consequently, due to the deviations between land use control and the actual use of land involved in urbanization particularly in suburban areas, it can be said that one important challenge is the fact that the necessity of an examination of the nature of land use control and guidance is growing stronger. It is for this reason that it becomes indispensable to thoroughly examine land use control in land use master plans by comparing with actual land use.

Studies of land use in Japan with themes as mentioned above include Satake's 1976 study on land use control challenges in areas that overlap [3], Tsukaguchi's 1989 study on land use control in metropolitan urban and agricultural areas that overlap [4], and the Nakamura et al 2001 comparative study of overlapping areas by prefecture [5]. Further, land use studies focusing on areas outside of the three largest metropolitan areas include Yamamoto's 2003 and 2004 studies on an evaluation of land use control in the Lake Biwa basin area [6] [7], Iwamoto's 2009 study on the actual state of and challenges in the land use control of each municipality in the Matsumoto City urban area [8] and Yamamoto's 2011 study on an evaluation of land use control on the main island of Okinawa [9]. In addition, there are many studies on land use in Japan that mainly focus on the three largest metropolitan areas (Tokyo Metropolitan Area, Kyoto-Osaka-Kobe Metropolitan Area and Nagoya Metropolitan Area) which have serious and diverse land use issues but there are almost no evaluations of land use in areas other than the metropolitan areas except for the above-mentioned studies [6] - [9].

Therefore, this study focuses on an evaluation of Hokkaido and particularly on two points: the rivalry between all kinds of land use such as urban land and agricultural and forestry land in various cities and their surrounding areas and the possibilities for forestry biomass that are being proactively implemented in Hokkaido in areas other than those mentioned above. This study also aims to grasp which areas require examination of the nature of land use control and guidance through conducting land use analysis at the district level (by town block or village sector) using highly effective GIS (Geographic Information Systems)<sup>(1)</sup> as a space analysis tool.

In order to do this, Section II discusses the regional characteristics of Hokkaido which is the target for evaluation. In Section III, GIS data for land use control and actual land use is collected and processed to develop a GIS database that is able to be used in this study. Section IV uses the GIS database to evaluate land use control by comparing with actual land use as well as to understand the characteristics of land use control and specifies the orientation of even more detailed analysis. Finally, Section V gives the conclusion to this study and discusses future research challenges.

## II. REGIONAL CHARACTERISTICS OF THE STUDY AREA

Hokkaido is situated at the very northernmost tip of Japan and is the largest of Japan's prefectures with an area of 78,421km<sup>2</sup> and is the fifth largest prefecture in terms of population at approximately 5,520,000. Sapporo City (population: approx. 1,900,000), which is one of the largest cities outside of the three largest metropolitan areas, is located in center of the region but there is also a number of cities with a population of more than 100,000 people such as Asahikawa City (approx.: 350,000), Hakodate City (approx.: 280,000), Kushiro City (approx.: 180,000), Tomakomai City (approx.: 170,000), Obihiro City (approx.: 170,000), Kitami City (approx.: 130,000), Ebetsu City (approx.: 120,000) which are not only located in the vicinity of Sapporo City but which are important cities in each region of Hokkaido<sup>(2)</sup>. In addition, if we focus on land use, in addition to the extensive Sapporo metropolitan area, urban areas such as those mentioned above have developed and are distributed in a concentrated manner. On top of this, in addition to the fact that Hokkaido is the largest agricultural and farming region in Japan, it has a significantly high area of forests.

Due to the fact that Hokkaido has the largest area of all prefectures in Japan, there is great concern that issues of rivalry for all types of land use such as that for urban areas or agriculture or forestry will become more serious and more widespread. However, there are almost no land use studies focusing on Hokkaido and, as mentioned in Section I, the greatest feature of land use studies in Japan up until now has been that they have mostly targeted the three largest metropolitan areas. The reason for this is that because Hokkaido has the largest area as mentioned above, conducting land use analysis itself is extremely difficult and the scope for examination of what kind of spatial scale should be selected for the evaluation of the target region and what kind of analysis methods should be used can be considered to be extremely wide. In other words, it is very difficult to set research tasks and methods as land use analysis methods would be remarkably different due to deviations depending on whether the region to be evaluated is the whole of Hokkaido or is narrowed down to focus on one part of the region.

## III. DEVELOPMENT OF THE GIS DATABASE

This study used Digital National Land Map Land Use Subdivision Mesh Data that is published by the Geographical Survey Institute at the Ministry of Land, Infrastructure, Transport and Tourism as a base map to develop the GIS database. The main reason I selected the above-mentioned GIS data as a base map is because it is GIS data that has been created by dividing the entire country into 3-mesh 1/10 subdivided regions (100 meshes) and, as it is divided into particular district units, data handling is relatively easy. Another reason is because Hokkaido is such a large target region and the above-mentioned GIS data is divided into 40 regions so it is possible to re-integrate GIS data in regions as close as possible to the 14 regions stipulated by the Hokkaido government as shown in TABLE I and Fig.1. Fig. 2 shows an example of the above-mentioned GIS data for land use in Sapporo City and its surrounding area (FY2006) using a visualization system with ArcGIS Ver10.0.

As land use control data for land use master plans, I used the Ministry of Land, Infrastructure, Transport and Tourism Land Use Control Back-up System: Lucky System<sup>(3)</sup> as basic data. As this is in raster format (image format), I first considered compatibility with Digital National Land Map Land Use Subdivision Mesh Data, and I clipped only the Hokkaido portion and converted the file format to a vector format as well as a shape file format. Furthermore, in order to analyze the deviations between land use control and actual land use, I added Digital National Land Map Land Use Subdivision Mesh Data using a GIS overlay function and develop a GIS database with information on land use control and actual land use.

## IV. EVALUATION OF LAND USE CONTROL

### A. Special Characteristics of Land Use Control

#### 1) Special Characteristics in Hokkaido (Overall)

Fig. 3 shows the 5 types of areas in the Hokkaido land use master plan which are: urban, agricultural, forest, natural park and natural conservation areas, and the objectives for land use adjustment for each separate area. In addition, TABLE II shows an analysis of land use control data processed in the previous section and divides the above 5 areas into areas that have no overlap and areas that have overlap by area. From TABLE II, we can see that areas in Hokkaido land use master plans which have not been designated to any of the 5 designated areas amount to only 0.7%.

An important characteristic of Hokkaido land use control is that over 70% of areas have no overlap which is significantly high. I have conducted land use analysis using the same methods as used in this study before in Shiga Prefecture and on the main island of Okinawa but in Shiga Prefecture 34.9% (Yamamoto, 2006) [10] of areas had no overlap and 52.0% (Yamamoto, 2011) [9] of areas on the main island of Okinawa had no overlap. It can also be considered that it is possible to designate many areas with no overlap because Hokkaido has a large area as a reason for this kind of difference with other prefectures.

TABLE I  
 DIVISION OF REGIONS IN HOKKAIDO AND OUTLINE OF EACH REGION

Region	Major City/Town	Number of Cities/Towns/Villages	Population	Area (km <sup>2</sup> )	Population Density (people/km <sup>2</sup> )
Sorachi	Iwamizawa City	10 cities, 14 towns	336,254	5,791.2	58.1
Ishikari	Sapporo City	6 cities, 1 towns, 1 village	2,342,338	3,539.9	661.7
Shiribeshi	Kuchan Town	1 city, 13 towns, 6 villages	232,940	4,305.8	54.1
Iburi	Muroran City	4 cities, 7 towns	416,289	3,698.0	112.6
Hidaka	Urakawa Town	7 towns	75,321	4,812.0	15.7
Oshima	Hakodate City	2 cities, 9 towns	427,807	3,936.5	108.7
Hiyama	Esashi Town	7 towns	42,058	2,630.0	16.0
Kamikawa	Asahikawa City	4 cities, 17 towns, 2 villages	520,365	10,619.2	49.0
Rumoi	Rumoi City	1 city, 6 towns, 1 village	53,105	3,445.8	15.4
Soya	Wakkanai City	1 city, 8 towns, 1 village	73,447	4,625.1	15.9
Abashiri	Abashiri City	3 cities, 14 towns, 1 village	310,009	10,690.6	29.0
Tokachi	Obihiro City	1 city, 16 towns, 2 villages	348,597	10,831.2	32.2
Kushiro	Kushiro City	1 city, 6 towns, 1 village	247,320	5,997.4	41.2
Nemuro	Nemuro City	1 city, 4 towns, (6 villages)	80,569	8,534.2	9.4

Note: Population, area and population density figures are taken from the websites of each town in Hokkaido and are current as of January, 2012. The Nemuro region includes 6 villages in the northern territories in its area and number of cities/towns/villages

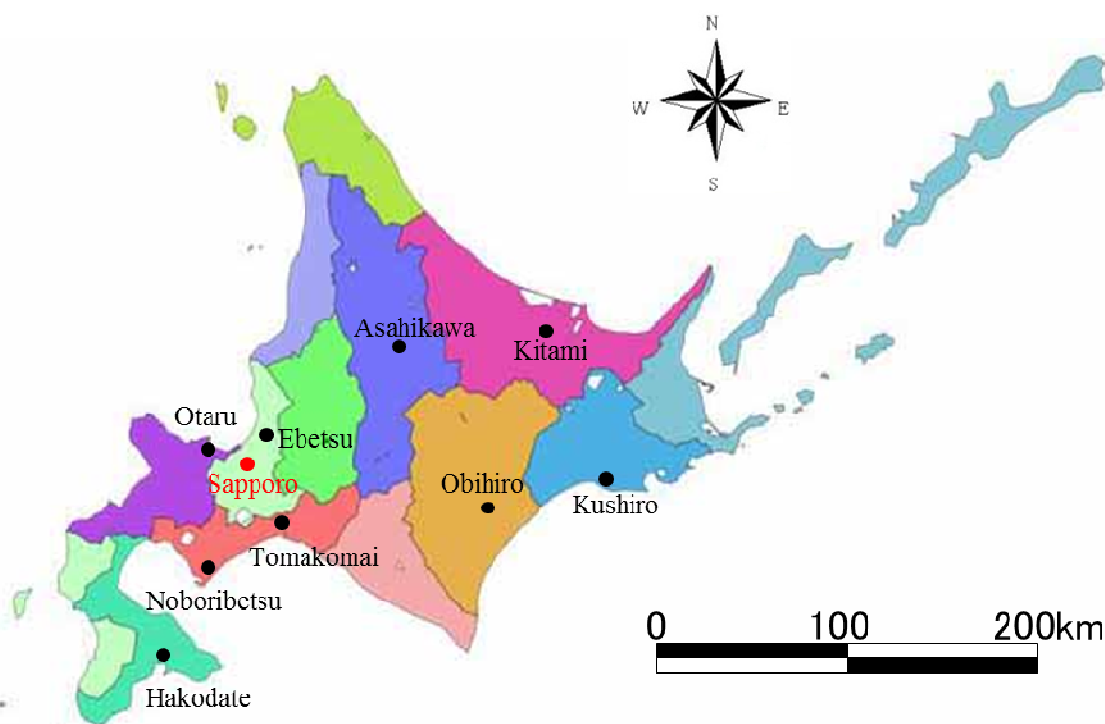


Fig. 1 Map of Regions in Hokkaido

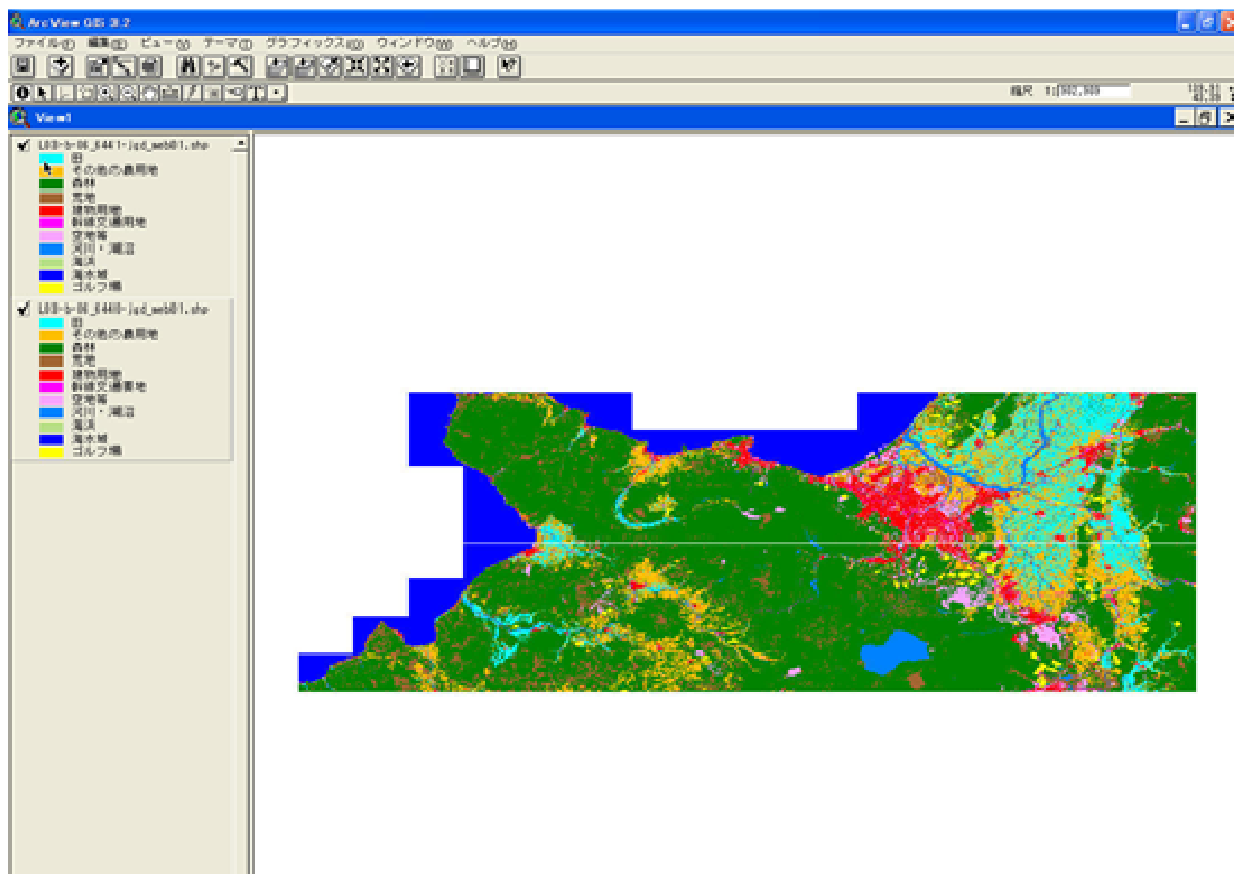


Fig. 2 Example of Land use in Sapporo City and its Suburbs (FY2006)

5 Divisions	5 Divisions		Urban Areas		Agricultural Areas		Forest Areas		Natural Park Areas	
	Subdivision	Subdivision	Urbanization Control Areas	Non-designated Areas	Agricultural Areas	Non-designated Agricultural Areas	Conservation Forests	Forest Areas that are not Conservation Forests	Special Areas	Ordinary Areas
Agricultural Areas	Agricultural Areas		←	←						
	Non-designated Agricultural Areas		1	1						
Forest Areas	Conservation Forests		←	←	×	←				
	Forest Areas that are not Conservation Forests		2	2	4	5				
Natural Park Areas	Special Areas		←	←	←	←	○	○		
	Ordinary Areas		3	3	○	○	○	○		
Natural Conservation Areas	Special Areas		×	←	×	×	○	○	×	×
	Ordinary Areas		×	←	○	○	○	○	×	×

The bold lines denote the target areas for this study.

×: No overlap in system or in reality

←: Takes priority when there is overlap

○: Control both areas in conjunction when there is mutual overlap

1: While paying attention to actual land use in an area, urban use is authorized while adjusting for agricultural use.

2: As a general rule, use as forest is the priority and use as forest and urban use is controlled.

3: Controlled in order to maintain function as a natural park as much as possible.

4: As a general rule, agricultural use is the priority but forest use is authorized while adjusting for agricultural use.

5: Forest use is the priority but agricultural use is authorized while adjusting for forest use.

Fig. 3 Hokkaido Land Use Control Objectives  
 Source: based on Hokkaido (2010a, 2010b) [11] [12]

TABLE II  
RATIO OF AREA BY 5 AREA OVERLAP IN HOKKAIDO LAND USE MASTER PLAN (%)

Division of Areas		Ratio
Areas with No Overlap	Urban Area	2.3
	Agricultural Area	19.1
	Forest Area	48.0
	Natural Park Area	1.3
	Natural Conservation Area	0.0
Total Areas with No Overlap		70.8
Two Overlapping Areas	Urban/Agricultural Areas	3.6
	Urban/Forest Areas	1.2
	Urban/Natural Park Areas	0.0
	Urban/Natural Conservation Areas	-
	Agricultural/Forest Areas	12.8
	Agricultural/Natural Park Areas	0.3
	Agricultural/Natural Conservation Areas	0.0
	Forest/Natural Park Areas	9.2
Three Overlapping Areas	Urban/Agricultural/Forest Areas	1.0
	Urban/Agricultural/Natural Park Areas	0.0
	Urban/Agricultural/Natural Conservation Areas	-
	Urban/Forest/Natural Park Areas	0.1
	Urban/Forest/Natural Conservation Areas	0.1
	Agricultural/Forest/Natural Park Areas	0.2
Four Overlapping Areas	Urban/Agricultural/Forest/Natural Park Areas	0.0
	Urban/Agricultural/Forest/Natural Conservation Areas	-
Total Overlapping Areas		28.5
Non-designated Areas		0.7

TABLE III  
AREA AND POPULATION WITHIN AND OUTSIDE OF HOKKAIDO CITY PLANNING AREAS

Area	Administrative Area		
	City Planning Area	Non-city Planning Area	
Area (Composition Ratio)	8,345,675ha (100.0%)	644,585ha (7.7%)	7,701,090ha (92.3%)
Population (Composition Ratio)	55,209,000 (100.0%)	49,513,000 (89.7%)	5,696,000 (10.3%)

Source: based on Hokkaido (2010a) [11]

TABLE IV  
OUTLINE OF DELINEATED CITY PLANNING AREAS IN HOKKAIDO

City Planning Area	Applicable City/Town
Sapporo City Planning Area	Sapporo City, Part of Otaru City, Ebetsu City, Kita-Hiroshima City, Ishikari City
Otaru City Planning Area	Otaru City
Hakodate City Planning Area	Hakodate City, Hokuto City, Nanae Town
Asahikawa City Planning Area	Asahikawa City, Takasu Town, Higashi-Kagura Town
Muroran City Planning Area	Muroran City, Noboribetsu City, Date City
Kushiro City Planning Area	Kushiro City, Kushiro Town
Obihiro City Planning Area	Obihiro City, Otofuke Town, Memuro Town, Makubetsu Town
Chitose/Eniwa City Planning Area	Chitose City, Eniwa City
Tomakomai City Planning Area	Tomakomai City, Shirao Town, Abira Town, Atsuma Town
Kitami City Planning Area	Kitami City

Source: based on Hokkaido (2010a) [11]

In addition, even in areas that have no overlap, it is clear that forest conservation is very important in Hokkaido land use plans due to the fact that approximately half of these areas (48%) are forest areas. Further, the point that total urban areas only amount to only 7.1% and of these urban areas those with no overlap amount to no more than 2.3% is worthy of mention.

Important characteristics of the designation of these forest and urban areas are not seen in other prefectures and it is estimated that aiming to conserve natural land use such as forests and preventing chaotic spread and sprawl of urban land use such as residential, commercial and industrial areas into the suburbs is strongly intended in land use master plans.

## 2) Details of Special Characteristics in Urban Areas (City planning areas)

Tables III and IV show an outline focusing on urban areas (city planning areas) of the 5 areas of the land use master plan, and Fig. 4 shows the status of designation of delineated city planning areas (city planning areas that have areas designated as urbanization promotion areas and urbanization control areas). First of all, as shown in TABLE III, only 7.7% of the area of Hokkaido is given over to city planning areas but their population is 89.7% of the whole prefecture. Further, Hokkaido has 79 city planning areas set up and, as shown in Table IV and Fig. 4, most of these are designated for each central city in an urban area for each region of Hokkaido, but there are also some which are designated to individual city, town or village units. There are only 10 delineated city planning areas counted in the 79 city planning areas as shown in TABLE IV and these city planning areas, in addition to Sapporo and its surrounding area, are designated as the areas surrounding central cities in each region of Hokkaido. It can also be understood from Table IV that these are distributed with a bias towards the western part of Hokkaido. In contrast to this, there are 69 non-delineated city planning areas and 80 cities, towns and villages that are non-designated city planning areas, and it can be understood that these are distributed mainly in the eastern part of Hokkaido. Therefore, it can be said that there is great regional disparity in Hokkaido with respect to the status of designation of city planning areas.

## B. Evaluation of Land Use Control through Comparison with Actual Land Use

Fig. 5 shows a map of land use in Hokkaido overall (FY2006) and we can observe that urban areas in the various cities around Sapporo City and Asahikawa City, Hakodate City, Kushiro City, Tomakomai City, Obihiro City and Kitami City are expanding and, in particular, the Sapporo greater metropolitan area is expanding considerably and that very high-density urban areas are being formed. Consequently, if land use control and actual land use are compared, in the 10 delineated city planning areas shown in Fig. 4, it can be said that it is essential to conduct an evaluation of land use control, particularly in urban areas in the five areas of land use master plans, focusing on rivalry issues concerning all kinds of land use such as urban, agricultural and forestry areas.

Recently, in Japan, national urban issues such as chaotic suburbanization of cities and the decline of central cities and regional community issues such as depopulation and aging are worsening are driving the introduction of compact city policies. This is based on a concept that aims to restrict suburban development and sprawl, maintain small urban scale and provide a sphere of daily existence within walking distance as well as aiming for community regeneration and town planning that creates places that are easy to live in.

In northern and eastern Japan, which both have particularly high snowfall, one of the aims of introducing the compact city policy is to reduce the costs of snow removal in winter in urban areas in the suburbs that are sparsely populated. The above-mentioned issues also occur in Hokkaido and compact city policies have already been introduced in Sapporo City and Wakkanai City. Further, all over the world, through the efficient use of renewable energy (energy produced by solar or wind power) and using smart grids as core technology, the importance of smart cities as next generation environmental cities that can restrict the environmental burden has come to be widely recognized. Therefore, in the 10 delineated city planning areas shown in Fig. 4, it is essential to introduce urban policies in order to implement compact cities or smart cities and to prevent chaotic spread and sprawl of urban land use into suburban areas as well as aiming for the conservation of natural land use such as forests.

Further, in non-delineated city planning areas, it can be said that it is essential to focus particularly on forests within and outside of city planning areas and to conduct an evaluation of land use control concerning the possibilities for forest biomass. Through this, it is possible to build a specific community recycling range based on forest biomass utilization in Hokkaido overall.

## V. CONCLUSIONS AND FUTURE RESEARCH CHALLENGES

This study focuses on an evaluation of Hokkaido which is the northernmost and largest prefecture by area in Japan and particularly on two points: the rivalry between all kinds of land use such as urban land and agricultural and forestry land in various cities and their surrounding areas and the possibilities for forestry biomass in areas other than those mentioned above and grasps which areas require examination of the nature of land use control and guidance through conducting land use analysis at the district level (by town block or village sector) using GIS. The results of analysis in this study demonstrated that it is essential to divide the whole of Hokkaido into two areas: those within delineated city planning areas and those outside of delineated city planning areas and to conduct an evaluation of each land use control.

In delineated city planning areas, particularly urban areas, it is essential to re-examine land use from the point of view of compact cities or smart cities along with conducting an evaluation of land use control that focuses on issues of rivalry between all kinds of land use such as urban land and agricultural and forestry land. In areas outside of delineated city planning areas, it is desirable to aim to build a specific community recycling range based on forest biomass utilization by conducting an evaluation of land use control concerning the possibilities for forest biomass focusing particularly on forests within and outside of city planning areas.

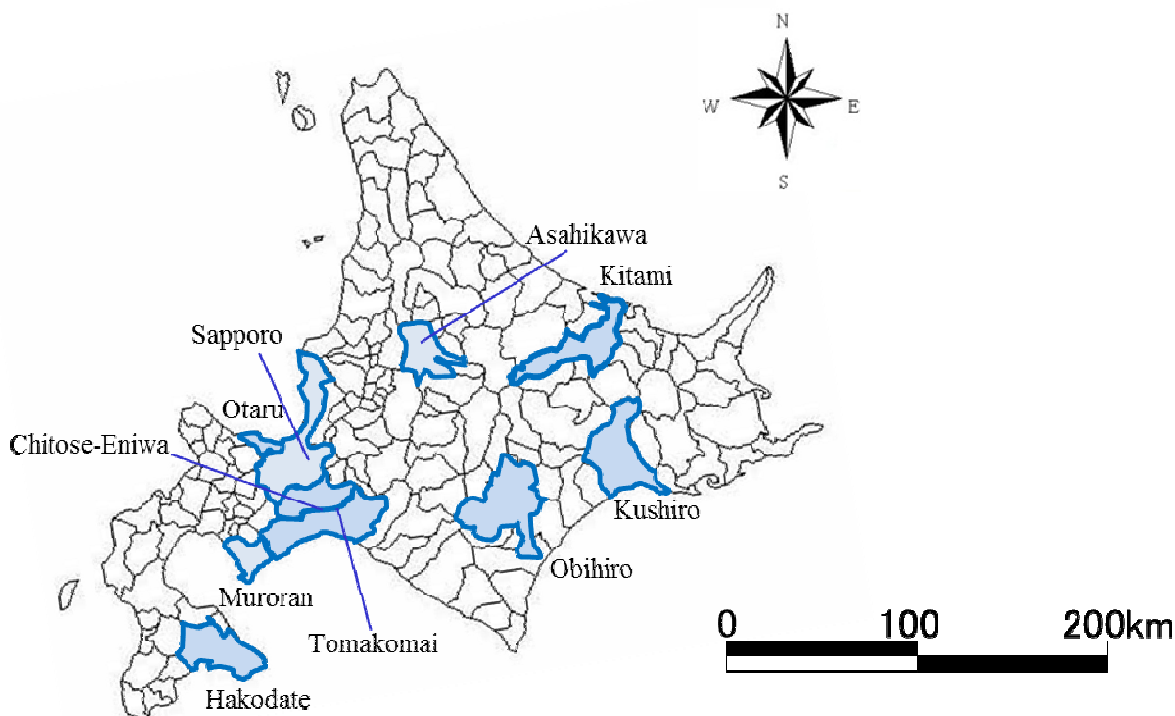


Fig. 4 Designated Delineated City Planning Areas in Hokkaido

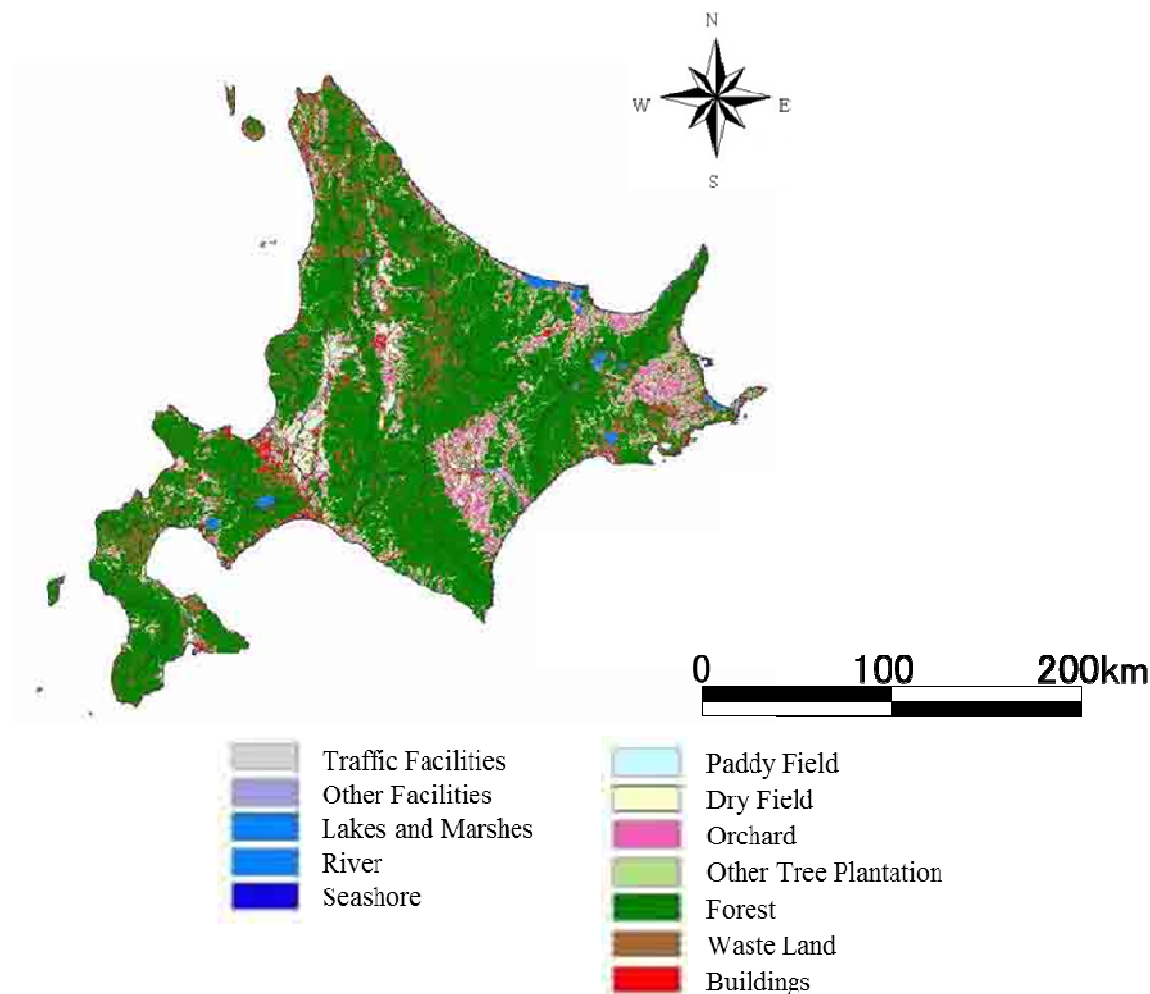


Fig. 5 Hokkaido Land Use Map (FY2006)

Future research challenges are to propose suitable land use control and guidance for Hokkaido by conducting an evaluation of land use control based on the results of this study using the GIS database built in this study, focusing on urban areas within delineated city planning areas and conducting an evaluation of land use control taking the possibilities of biomass into consideration because areas outside of these delineated city planning areas have a lot of forest areas.

One part of this study was conducted with a Grant-in-Aid for Scientific Research on Establishing a Recycling-based Society (representative: Toru Furuichi) entitled Study of Modeling and Diffusion Policy for a Community Recycling Range based on Biomass Utilization.

#### NOTES

- (1) This study mainly used ESRI's ArcGIS Ver10.0 as its GIS application.
- (2) Population figures were sourced from the official websites of each city in Hokkaido and are current as of January, 2012.
- (3) The Ministry of Land, Infrastructure, Transport and Tourism's Land Use Control Back-up System (Lucky System) Website can be found at: <http://lucky.tochi.mlit.go.jp/>

#### REFERENCES

- [1] Land Use Research Group Compilation (1999) Quick Guide to the National Land Use Planning Act, Taisei Publishing, 134p.
- [2] Mizuguchi T.(1997) Land Use Plans and Town Planning – From Control and Guidance to Planning Discussions–, Gakugei Shuppansha, 366p.
- [3] Satake G. (1976) Background to the Establishment of the National Land Use Planning Act and Future Operational Challenges: Focusing on Land Use Master Plans (National Land Use Planning Act), Architecture Yearbook, 1976, pp.655-657.
- [4] Tsukaguchi T.(1989) Study on Change Mechanisms in Land Use Systems Involved in Urbanization and Natural Site Condition and Land Use Control, Journal of the Japanese Institute of Landscape Architecture, Vol. 52, No.3, pp.166-182.
- [5] Nakamura R. and Yoshioka T. (2001) Similarities and Differences between Prefectural Area Divisions through Land Use Master Plans and Individual Control Laws, Papers on City Planning, No.36, pp. 373-385.
- [6] Yamamoto K.(2003) Evaluation of Land Use Control for Land Use Master Plans focusing on the Urbanization of Lake Biwa Basin Area, Journal of the Japanese Institute of Landscape Architecture, Vol.66, No.5, pp. 883-888.
- [7] Yamamoto K. (2004) Evaluation of Land Use Control focusing on Overlap Status between City Planning Areas and Agricultural Promotion Areas in the Lake Biwa Basin Area – An Evaluation considering the Accessibility of Traffic Facilities–, Papers on Environmental Information Science, No.18, pp.183-188.
- [8] Iwamoto Y., Matsukawa T. and Nakaide F.(2009) Study on the Challenges and the Nature of implementing Metropolitan Integrated Land Use Control –Through the Actual Development of Matsumoto

Urban Area and the Initiatives of Each Municipality-, Papers on City Planning, No.41, pp.595-600.

- [9] Yamamoto K.(2011) Evaluation of Land Use Control in Land Use Master Plans focusing on Urban Area Distribution on the Main Island of Okinawa, Journal of the Japanese Institute of Landscape Architecture, Vol.74, No.5, pp.657-662.
- [10] Yamamoto K.(2006) Land Use Analysis for Environmental Conservation using GIS, Kokon Publishing, 162p.
- [11] Hokkaido (2010a) Hokkaido Urban Plan, 133p.
- [12] Hokkaido (2010b) 4th Hokkaido Land Use Master Plan, 20p.



**Kayoko Yamamoto** received the B.H. Degree and M.H. Degree in Geography from Ochanomizu University in 1992 and 1994 respectively, and Ph.D. Degree in Social Engineering from Tokyo Institute of Technology in 1999. She is currently an associate professor in the Graduate School of Information Systems, National University of Electro-Communications, Tokyo, Japan. Her research interests include city planning and regional planning, environmental science and GIS (Geographic Information Systems).