

Development of a land-use map database for urban areas: The case of a fieldwork program at the University of Tsukuba

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Abstract

The purpose of this study is to examine the database-making process for land-use maps and the effectiveness of land-use surveys through the case of a fieldwork program in human and regional geography at the graduate school of the University of Tsukuba. The case illustrates the method of land-use surveying using fieldwork and GIS in urban areas at the micro scale.

First, I examine the importance of performing land-use surveys based on fieldwork to clarify various regional characteristics in detail. We can also analyze land-use patterns through desk work since the infrastructure for spatial information data has been developed in recent years. However, performing land-use surveys based on fieldwork makes it possible to understand the social, economic, historic, and cultural backgrounds of the regions through the actual experience of performing land-use surveys in urban and rural fields. On the other hand, some researchers who study land-use patterns through fieldwork at the micro scale—as with central urban areas—often use the analog method, filling out the usage situations of the land by hand on the base map. Outputs that use handwork are mostly limited to analyzing present land-use patterns. In other words, it is difficult to compare present and future land-use patterns with the handwork method.

To solve this problem, I introduce a case of fieldwork involving graduate students at the University of Tsukuba in an attempt to integrate attribute data gathered from fieldwork with spatial databases edited and processed using the GIS.

Key words: land-use map, land-use survey, Fundamental Geospatial Data, database, central urban area

1. Introduction

This study examines the process of building a database of land-use maps and the effectiveness of land-use surveying using the case of a fieldwork program in regional geography at the graduate school of the University of Tsukuba. This case reflects land-use surveying using fieldwork and GIS in urban areas on a micro scale.

According to Saito (1997), land-use surveys in urban and rural areas not only serve to describe types of cultivated

crops, the uses of buildings, and other characteristics, but can also analyze land-use patterns through desk work since GIS data has become widely used in recent years. However, land-use surveys at the micro scale based on fieldwork make it possible to understand the social, economic, historic, and cultural backgrounds of regions through the actual experience of land-use surveying in urban and rural fields. That is to say, land-use surveys present new possibilities for future studies.

However, some researchers who study land-use patterns through fieldwork at the micro scale, as in central urban areas, use the analog method of filling out land-use characteristics by hand on base maps. There are some questions regarding land-use surveying at the micro level. Land-use maps made using the analog method are sometimes used as only “pictures.” In other words, we cannot extract spatial attribute data from hand-drawn maps. Additionally, some researchers are more likely to establish arbitrary survey areas, blocks, lots, or other survey units. Thus, the outputs unfortunately remain qualitative in their descriptions.

Some researchers have tried to resolve these challenges. Morimoto et al. (2003) offers efficient methods for land-use surveying using GPS and GIS. Tsutsumi (2009) points out that it is important to focus on decision makers for land use to clarify the mechanisms of changing urban land use. My project here, then, was to integrate attribute data gathered from fieldwork with a spatial database edited and processed on the GIS. This task was conducted as a fieldwork assignment for graduate students at the University of Tsukuba.

2. Land-use surveys in urban areas

2.1 Background on land-use surveying in urban areas

Land use in urban areas is closely related to themes of urban geographical studies—such as urban structures, urban functions, and urbanization—and is fundamental to their study. When surveying land-use patterns in urban areas, we must first decide on the spatial scale of the research area. Since many cities are increasing in area through the consolidation of municipalities or suburbanization, it is unrealistic to survey land use in every part of a city at the individual level. I focus, therefore, on land-use survey methods at the micro level, especially in central urban areas.

Geographical land-use surveys in central urban areas

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have been mainly used as tools for understanding commercial structures. Many studies have considered commercial buildings as prime examples of urban functions and have investigated the types of stores and other businesses on central commercial streets. Researchers can link to further field studies through surveys and observations of actual land use from the viewpoint of the type of operation, store format, store continuity, the presence or absence of parking, and the primary customers. Of course, land-use surveying in urban areas is one of the most effective methods for establishing residential and economic functions as well as commercial and other urban functions. Surveying is also a tool for clarifying certain urban characteristics such as the vertical utilization of buildings.

In addition, the emptying of central urban areas and the suburbanization of regional cities has become worrisome in recent years. Hence, it is necessary to analyze the dynamics of land-use patterns in central urban areas. Land-use maps at the micro level are usually drawn by hand by investigators who directly observe and note land usage on city planning maps; most outcomes of these surveys have been limited to analyses of present land-use patterns. In other words, it is difficult to compare present and future, or present and past, land-use patterns using hand-drawn maps. A comparison of land use at several points in time using handwork must rely on investigator's memories.

It is important to set baseline data at the beginning of the survey to easily compare land-use patterns. However, it is important to keep careful records of any research policies such as the storage of hand-drawn maps, classification of land-use patterns, and division of lots. To help solve this problem, I introduce a fieldwork project for graduate students to attempt to integrate attribute data gathered from fieldwork with a spatial database edited and processed on the GIS.

2.2 Case studies

Here, I introduce case studies on the development of land-use map databases in urban areas as examples of fieldwork in regional geography divisions at the graduate school of the University of Tsukuba. The program for graduate students majoring in geosciences is offered each year; the investigation period is one week, and the program averages 20 to 30 students. The program surveys land use in a wide sphere so that many students can join. The program has established several geographic themes, including agriculture, industry, residential organization, tourism, commercial structures, redevelopment of towns, and wild animal damage in specific regions.

Some research groups in the program have surveyed central urban land-use patterns to acquire basic data for their studies. However, hand-drawn land-use survey maps

have proven insufficient for additional studies. In addition, such maps cannot easily be used to calculate quantitative data such as areas, town borders, and census tracts and contours. Accordingly, our program has attempted to build a database of land use in central urban areas to compare present data with past and future data and to overlay electronic data with data from hand-drawn maps. The procedures for surveying land use and building the program's database are described below.

Here, I introduce two examples of fieldwork in which we surveyed land use in the central urban areas of two cities in the Nagano Prefecture (Fig. 1). Case 1 is Suzuka City, which is located in the northern part of Nagano; we surveyed land use there in 2010. Suzuka is a small city with a population of 52,760. The city had prospered as a key junction point during the Edo period. The silk industry developed there after the Meiji period because the central urban area was within the alluvial fan and could utilize a great deal of water wheel power. Because of this economic prosperity, the city had been the commercial core for the surrounding areas, and many traditional storehouses owned by prosperous merchants remain preserved to this day. Two themes were established in the central urban area: historic landscape conservation and the changing of commercial structures (Fukuda et al., 2011; Oishi et al., 2011).

In 2012, we surveyed land use in Iida City (Case 2), which is located in the southern part of Nagano and is the



Fig. 1. Study areas, Suzuka City and Iida City, Nagano Prefecture

core of the south Shinshu region. The city developed as a castle town during the Edo period. The population is 105,335. Because the central urban area is on a river terrace, Iida City is called an “on the hill town.” Two themes were also established in this central urban area: the movement of redevelopment and changing commercial functions (Hashimoto et al., 2013; Fukuda et al., 2013).

To begin these studies, the research groups surveyed land-use patterns in the central areas of both cities.

2.3 Land-use survey procedure

The land-use surveys were conducted in May 2010 in Suzaka and May 2012 in Iida. We prepared city planning maps at 1:2,500 scale as base maps and used residential maps provided by Zenrin Co. We divided the study area into several areas, each surveyed by one member of the group. Using the base maps, each member recorded the land usage for every lot in the field. Each member had the base map and sheets for noting various information, including ID numbers, the number of floors in buildings, store names, land uses, and descriptions or special instructions regarding each lot. When group members could not determine a lot’s land usage, they asked residents.

It is important to record as much primary data as possible. Free descriptions should be recorded in more detail; these can include actual shop names, whether they are chain stores, types of parking, kinds of businesses, and member impressions of land usages. Future investigators will be able to set flexibility land-use classifications based on the records. Since Suzaka maintains many traditional buildings, members who had chosen to focus on historic landscape conservation also surveyed such components as the colors of façades, types of roofs, and types of gratings.

Next, I explain how this study classified land use. After conducting their surveys, the group members discussed how to classify land usages in their study areas and decided on several fundamental land-use classifications. Land use was classified into eight major categories: retail and service,

retail and service with residences, residence, industry and research, public, religious, parking, and park or cultivated site. The major classification of each lot was indicated by color on the maps. The major land-use classifications were subdivided into intermediate classifications. The intermediate classifications under retail and service included supermarket, convenience store, liquor store, pharmacy, bicycle, barber, clinic, dry cleaner, hotel, restaurant, pub, bank, and vacant store, among others. Similarly, the intermediate classifications for residences were single-family house, condominium, apartment house, residence with tenants, and empty house. These intermediate classifications were marked with symbols (A, B, C, etc.) within the major classification’s color pattern. Subsequently, the members completed the land-use maps for their full areas by coloring them in and adding the legends to the maps.

3. Building an electronic database of land-use maps

Here, I explain the process of documenting the land-use data obtained from the fieldwork discussed above. A flowchart of the program’s process is shown in Fig. 2.

The left side of the figure primarily depicts the process of producing the data by hand. After the land-use data were collected, we entered them into a spreadsheet and created an attribute data table. The members discussed the land-use pattern classifications and decided on the legend discussed above. They used colored pencils to draw the legends on the base maps. Based on the drawn maps, the cartographer redrew large-sized maps (A1 size).

We also downloaded the Fundamental Geospatial Data (FGD) for scale 1:2500 to prepare by hand the GIS data from the land-use data. This is depicted on the right side of the figure. FGD is defined as positional information on features, presented in digital form, that provides positional references to geospatial information on a digital/electronic map, including geodetic control points, coastlines, boundaries of public facilities, administrative boundaries, and others listed in the Ministry of Land, Infrastructure and Transport ordinance Basic Act on the Advancement of Utilizing Geospatial Information. FGD is now being compiled all across the country.

Using FGD for basic maps, it is possible to build a cohesive geographic information database. FGD can access data from a variety of cities and has broad utility. It is available free of charge to download from the website of the Geospatial Information Authority of Japan. As for Suzaka and Iida, 1:2,500 data on both cities have already been published, and the data are used for fundamental spatial databases.

The procedure for building a GIS database is described below. The data files of 1:2500 scale FGD-based base maps were converted to shape files for use in ArcGIS. The

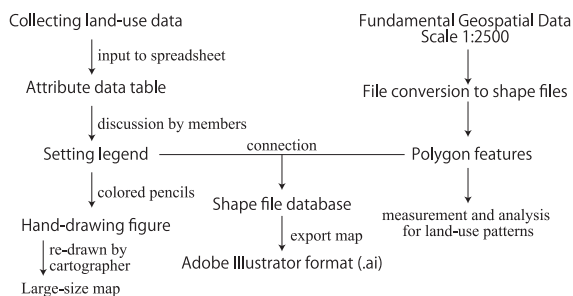


Fig. 2. Flowchart of the program’s process

members made polygon features for each lot surveyed in each area and added ID numbers to each polygon feature in ArcGIS. Next, the ID numbers from the attribute data table created from the field data and the polygon features in GIS were connected. The ID numbers here consisted of eight digits: the first (1) was a dummy value, the second and third were two-digit area numbers, the fourth and fifth were two-digit block numbers, and the sixth to the eighth were three-digit lot numbers (e.g., 1-03-16-017).

Consequently, we were able to assemble a shape file database of land uses that had been surveyed by hand in the central urban areas of both cities and quantitatively analyze land-use patterns from various perspectives. In one simple example, the land-use patterns in both areas—the number and area of surveyed lots—were quantitatively measured. There were 3,261 lots of 147.4 hectares in Suzaka and 3,941 lots of 121.6 hectares in Iida. In addition, GIS maps have the advantage of producing a colored output. Furthermore, the members could make more and clearer maps to show the analysis results by exporting Adobe Illustrator files (.ai) made from shape files (Fig.

3). Here, I wish to emphasize that the database promotes the development of research on land-use surveying in terms of the possibilities for quantitative analyses and the availability of data.

I present two cases that were analyzed using the land-use database. Fig. 4 was created in Adobe Illustrator based on the GIS database. It shows the distribution pattern of roof types on traditional buildings in Suzaka (Fukuda et al., 2011). We can visually identify the remaining buildings with traditional roofs along the historical roads from the figure. Fig. 5 shows the density distribution of service businesses in the central urban area of Iida by the kernel density estimator based on the GIS database (Fukuda et al., 2013). In this way, we are able to create any number of quantitatively analyzed maps to integrate the attribute data gathered from the fieldwork with the spatial database edited and processed on the GIS and thus develop further studies.

4. Future plans

While there is some discussion about the advantages and disadvantages of land-use surveys, questions of use

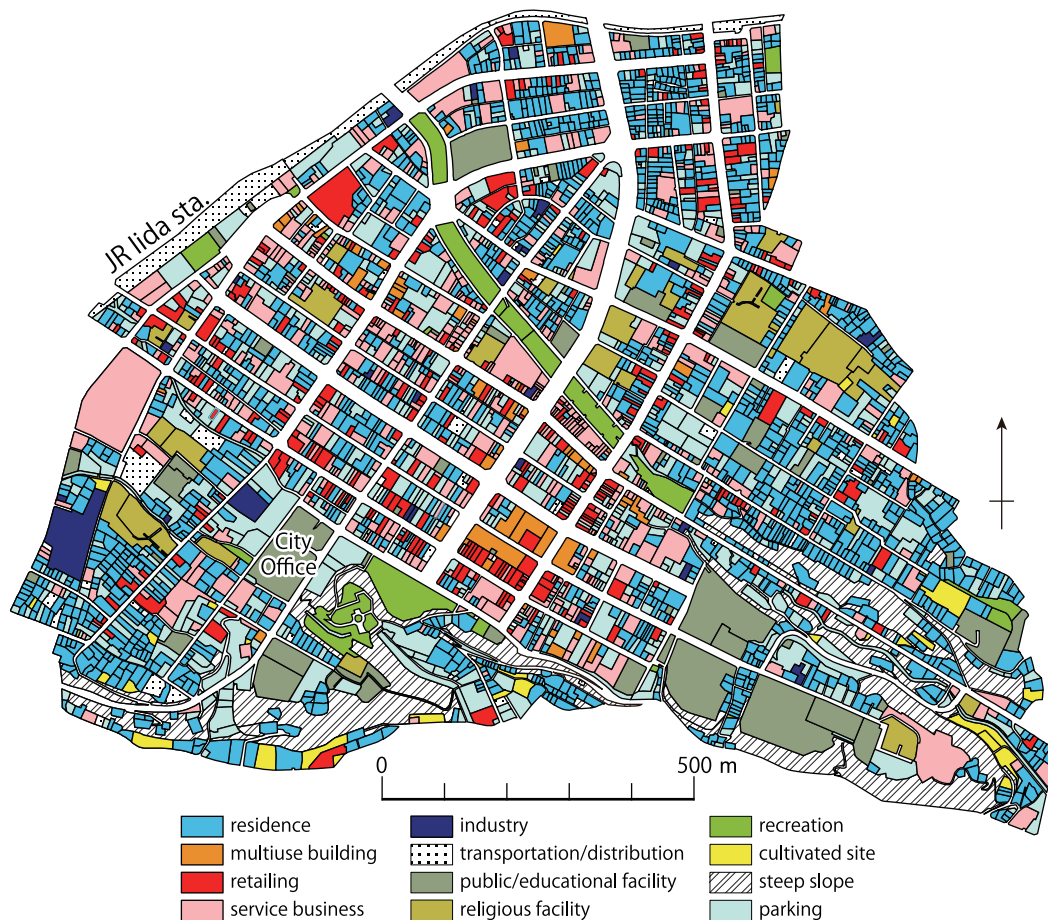


Fig. 3. Land use in central urban area of Iida (2012)

Source : Based on fieldwork in May, 2012 by faculties and graduate students in University of Tsukuba

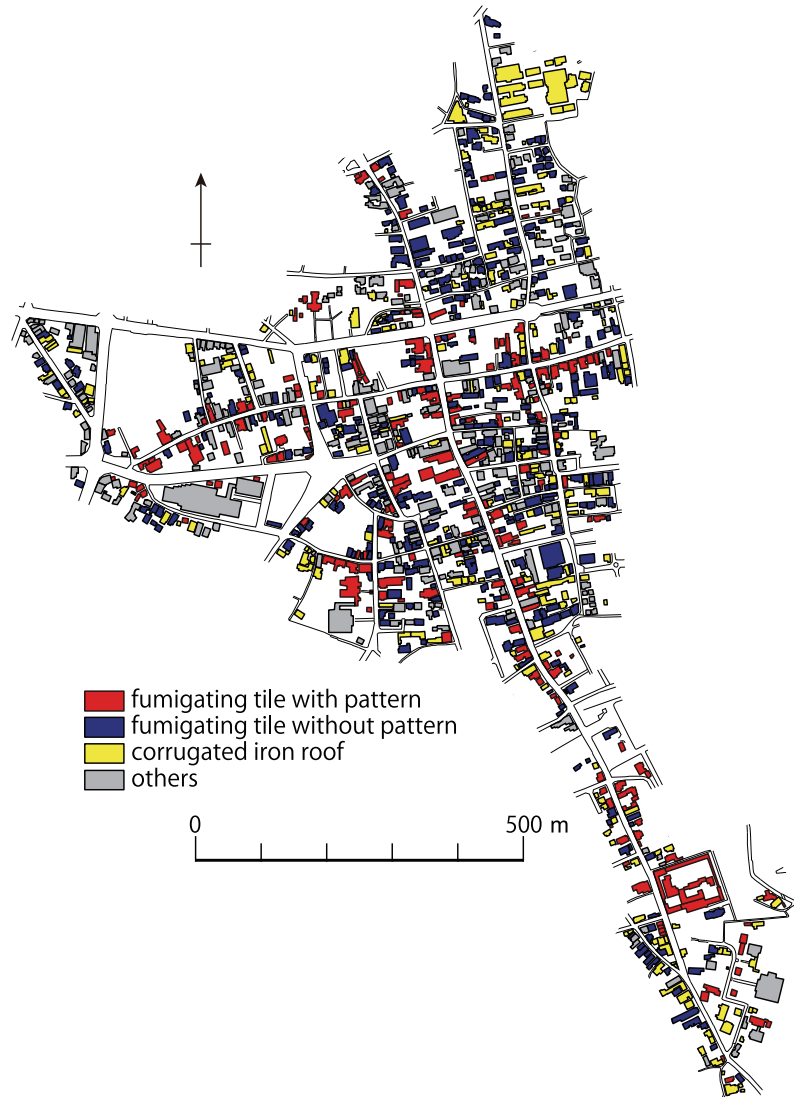


Fig. 4. Roof types of buildings in central urban area in Suzuka (2010)
Source : Fukuda et al. (2011) modified by author

and disuse cannot be discussed without experience surveying in the field. This study's use of GIS to create a database is already a well-known technical method. It is also an efficient approach to understanding the dynamics of land-use patterns in central urban areas that enables comparisons of present, future, and past land-use patterns. This approach also makes it possible to combine qualitative data collected in the field with GIS data for quantitative analysis.

Finally, I would like to suggest several future subjects for the development of land-use map databases in urban areas. First, I would overlay an available public microdatabase—one that contains census data, economic statistics, previous town borders, water areas and contours, and other data—with the land-use database made by our program. By over-

laying a variety of data, we can analyze multilayered regional structures in the study area.

Second, the advantage of converting land-use survey data to GIS format is that the data are easily modified for the database. The database-converted GIS format is easily correctable; additionally, it is easy to add new data, and it is always possible to display full-color outputs.

However, it is difficult to adequately store and utilize the land-use database. Can we use the database at any time? How do we utilize the database and add further data? Does the database vary in response to ordinary users? To address these problems, I would like to develop a study that accumulates land-use surveys in other areas or in the same areas we have already studied.



Fig. 5. The density distribution of service businesses in the central urban area of Iida (2012)
 Source : Fukuda et al. (2013) modified by author

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