Development and Application of IT Platform for Urban Water Circulation System

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Abstract

Today, Development of water circulation that can respond comprehensive to the water environmental problems in urban area is required. Therefore, in this study, to capture visually and quantitatively the urban water circulation system (river, spring water, agricultural water etc.) using the GIS (Geographic Information System), and aim the IT platform development of the water cycle that is a new method for maintenance and management of the integrated manner water cycle.

This study is intended for Hadano City in Kanagawa Prefecture and Tsuru City in Yamanashi Prefecture. In Hadano City, it was performed current situation of groundwater recharge by rainwater use (rainwater seepage pit) of underground water conservation projects. In Tsuru City, since miscellaneous waste water is flowing into the agricultural waterway, water quality is deteriorating. This present condition has been improved, public sewerage and a septic tank were spread, and it is aimed at the city planning by clear stream reproduction.

In this study, to understand the current state of rainwater infiltration Hadano is mainly performed using GIS. In addition, the building has a roof area of more than 500m^2 residential and regional groundwater recharge, ask whether they have the ability to penetrate how if the infiltration pit rainwater for household facilities or rainwater infiltration (hereinafter, infiltration facilities) was introduced into the future going. Moreover, modify the GIS data of the river and agricultural waterway, created the surface water network diagram.

Keywords

GIS (Geographic Information System), water circulation, groundwater cultivation, rainwater infiltration, agricultural waterway

1. Introduction

In recent years, the further progress of urbanization, in urban areas has increased the coated surface of the earth's surface. From the fact that frequent urban flooding is getting worse, it is a need for construction of water circulation that can accommodate these issues comprehensively. On the other hand, farmland is developed into building lots quickly and the situation of using the agricultural waterway as a drainage canal while a sewer and a septic tank for waste water treatment from house are not fixed is seen in the suburbs.

Therefore, in order to build a water cycle that can respond to water environmental problems in urban areas, targeting Hadano City in Kanagawa Prefecture who promote groundwater recharge by rainwater infiltration that target business architecture as underground water conservation, With the aim of creating a potential map using rainwater infiltration GIS (Geographic Information System) in order to understand the current status and future prospects of rainwater infiltration in the city. Moreover, modify the GIS data of the river and agricultural waterway, created the surface water network diagram in Hadano and Tsuru City. In such a form, GIS database creation about the surface water in research is performed. From now on, the data of groundwater in related research is unified and it will aim at creating IT platform that can respond synthetically to various water environmental problems in the area.

2. Water administration of Hadano and Tsuru City

2.1 Conservation of groundwater in Hadano City

Due to the abundance of water resources, Hadano is using ground water or spring water to about 70% of the water supply. However, since the lowering of the groundwater level found in recent years, there is a need for groundwater protection. Order to carry out groundwater recharge in Hadano there, for the building of more than 500 m^2 of construction area of groundwater recharge in the region, which is defined by the ordinance, has mandated the introduction of rainwater infiltration facilities. In addition, we are assisting the amount of one-half of the installation cost when applied to housing in the region for this groundwater recharge, the introduction of household rainwater infiltration pit (Table 1).

Here, in order to distinguish the household rainwater infiltration pit and rainwater infiltration facilities, rainwater infiltration facilities refers to the introduction to the civilian public facilities and mainly, the rainwater infiltration pit refers to the introduction of a house.

Table 1 Matters related to groundwater protection ordinance

Matter of the ordinance	Content
Infiltration of rainwater roof treatment (Town Planning Ordinance Hadano)	Environment for the act of creation is more than 500m² building area of the building, install a rainwater infiltration facilities for groundwater recharge.However, finds that when there is a risk of groundwater contamination, and the mayor does not need the other, this does not apply.
Guidelines established subsidies for household rainwater infiltration pit Hadano	Assist in the amount of one-half of the cost of installing rainwater infiltration pit.However, up to a maximum of 12,500 yen per unit, to a maximum of one to four per house.

2.2 Present condition of the drainage in Tsuru City

Tsuru City is located in the foot in Mt. Fuji. Groundwater and surface water have a rich head. Moreover, there is many agricultural water way which flows through in the city. However, share of population with underground sewers is a low self-governing body also in the whole country, and it will be 26.8% at the present the end of the 2011 fiscal year (the national average is 75.8% at the end of the 2012 fiscal year).

Since there are many buildings in which only the human waste septic tank is installed, waste water from miscellaneous sources is discharged in the state where it is not processed using this agricultural waterway.

3. Research methods

3.1 Current situation and capacity simulation of water infiltration in Hadano City

First, Table 2 shows a summary of the research methods. In this study, to understand the current state of rainwater infiltration Hadano is mainly performed using GIS. In addition, the building has a roof area of more than 500m^2 residential and regional groundwater recharge, ask whether they have the ability to penetrate how if the household rainwater infiltration pit or rainwater infiltration facilities was introduced into the future going.

Table 2 Overview of research methods

Analysis items	content
1. Current situation of rainwater infiltration	Represented on the map by using the GIS, the building has introduced a pit rainwater infiltration and rainwater infiltration facilities from the City Hall Hatano notification data.
2. Rainwater infiltration groundwater recharge capacity in the region	Calculate the total roof area that divides the building of regional groundwater recharge in the mesh of 250m, is included in each mesh to obtain the building coverage.
3. Comparison residential and non-residential building regional groundwater recharge	Use the tools of GIS, to distinguish between residential and non-residential buildings.As a result, we compare the potential of rainwater infiltration pit and rainwater infiltration facilities that can be introduced into public facilities and private facilities and housing.

3.2 GIS database creation of a river and agricultural waterway

In this study, the technique for performing database creation of the river and agricultural waterway which is surface water is developed.

This report shows the procedure which creates a network diagram using GIS. While specifically changing the river channel of an aerial photo into a streamline, about the agricultural waterway which neither an aerial photo nor a map shows, a field survey is performed and GIS database creation is performed for a streamline.

4. Result and discussion

4.1 Current situation of rainwater infiltration in Hadano City

In order to understand the current status of rainwater infiltration, the building where rainwater infiltration facilities those are already introduced was plotted according to the

building use (Figure 1). Furthermore, these facilities were expressed by the shade for every amount of grounedwater infiltration (Figure 2).

In this case, amount of groundwater infiltration have been calculated from the expression-1 and the annual rainfall of Hadano in 2010 (1,941.5 mm), as defined by the ordinance. Figure 3 is the graph which showed the total of the number of cases and roof area which introduced rainwater infiltration facilitiies at a given fiscal year based on the notification in the Hadano city office.

$Q = C \times A$ (expression-1)

Where:

Q : Amount of penetration (m^3/hr)

C : runoff coefficient from the roof (0.95)

A : building area (m^2)

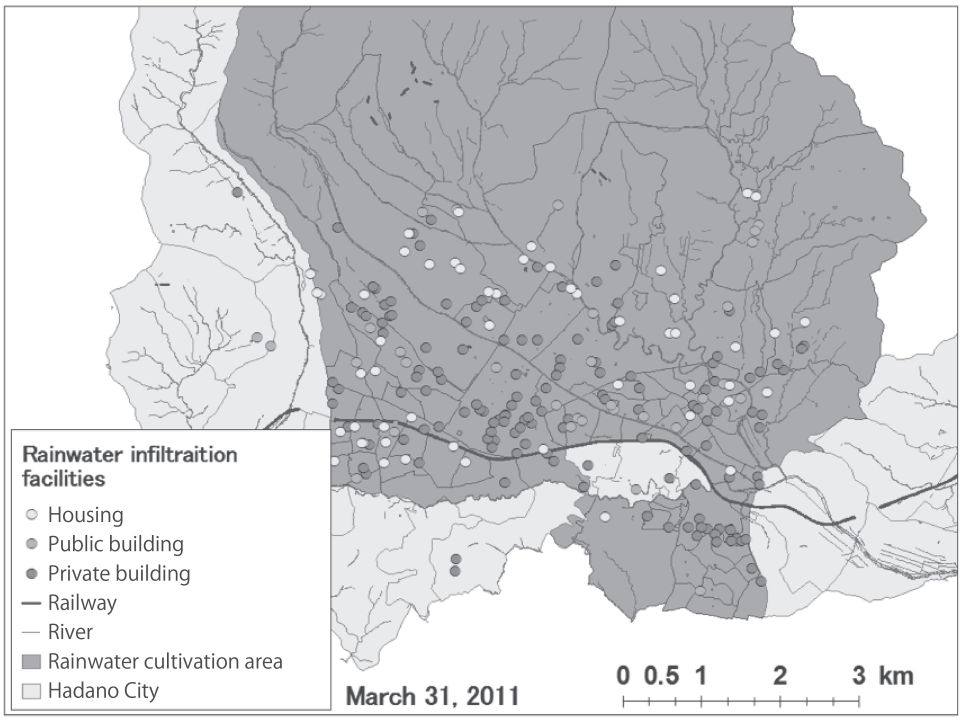

Figure 1 Rainwater infiltration facilities in the groundwater cultivation area

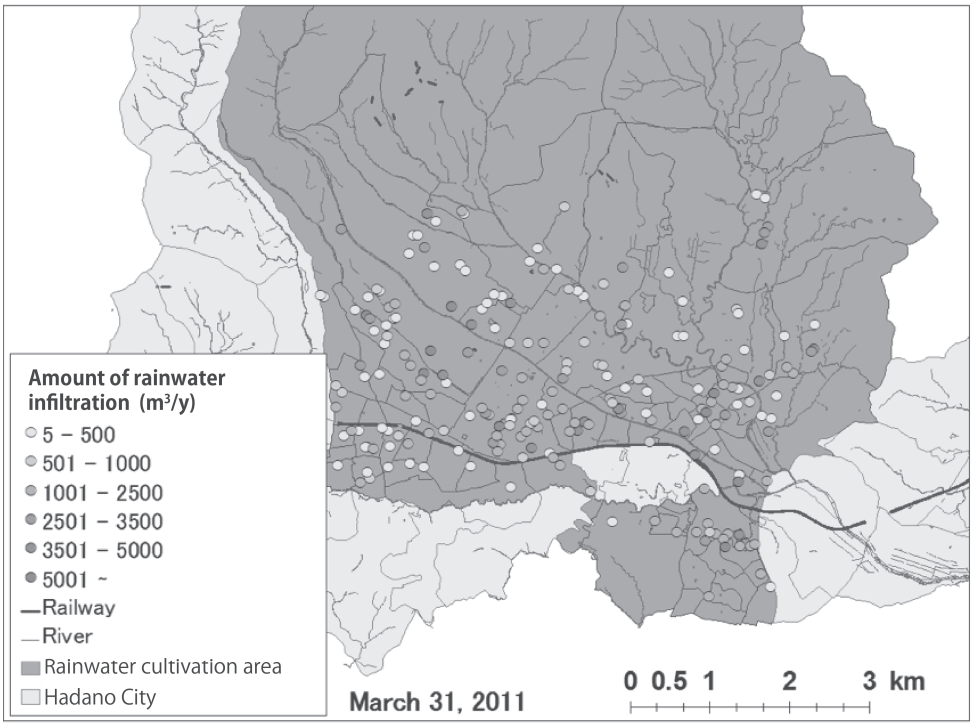

Figure 2 Amount of rainwater infiltration in the groundwater cultivation area

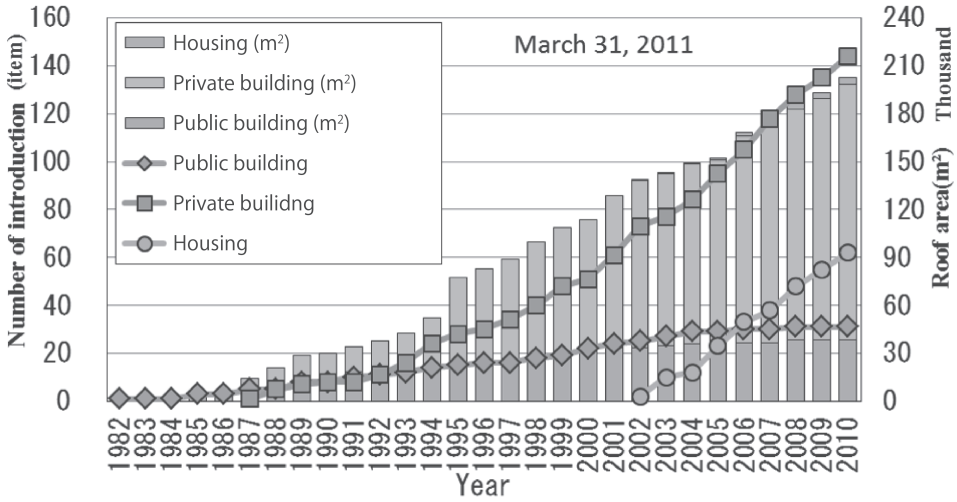

Figure 3 Number and total roof area of rainwater infiltration facilities

4.2 Capability of the rainwater infiltration in the groundwater cultivation area

Groundwater cultivation area is divided in a 250m mesh, and the building coverage of each mesh is shown in figure 4. Moreover, the building coverage only a building of 500 m^2 or more is shown in figure 5. In figure 4, there are large-scale factories and commercial buildings where building coverage is 50% or more of mesh. 30 to 40% of

meshes are narrow quarters of a residence. Also in figure 5, the building coverage of the place with large-scale factories and commercial buildings is high.

4.3 The increase in the amount of infiltration by duty strengthening of rainwater infiltration

Figure 6 totals the number of buildings and area in the groundwater cultivation area from what has a large roof area. This is classified and totaled for the housing and the non-residential use. The housing occupies about 2/3 among all the buildings in Hadano City.

Roof area is very large although the building of a non-residence has few numbers.

This figure serves as a standard for making the infiltration of rain water by an ordinance compulsory.

Current area of roof rainwater infiltration facilities in Hadano City is about 200,000 m^2 (16%) to the total area of about 1,210,000 m^2 (100%) of the building with a roof area of 500m^2 or more. When an infiltration facilitiy is installed to remaining about 84%, groundwater of annual about 2,200,000 m^3 can be infiltrated from the annual precipitation in the 2011 fiscal year (1,941.5 mm/year). Moreover, the sum total roof area (about 3,370,000 m^2) of a housing is also large. Cultivation of groundwater can further expect by promoting installation of household rainwater infiltration pit from now on.

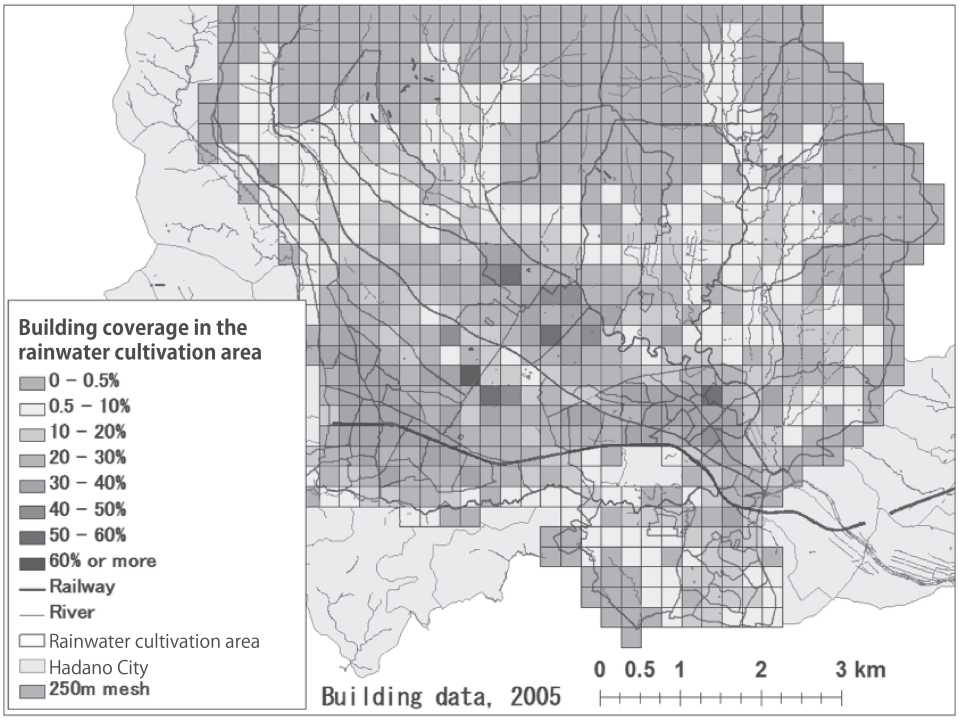

Figure 4 Building coverage of each mesh in the rainwater cultivation area

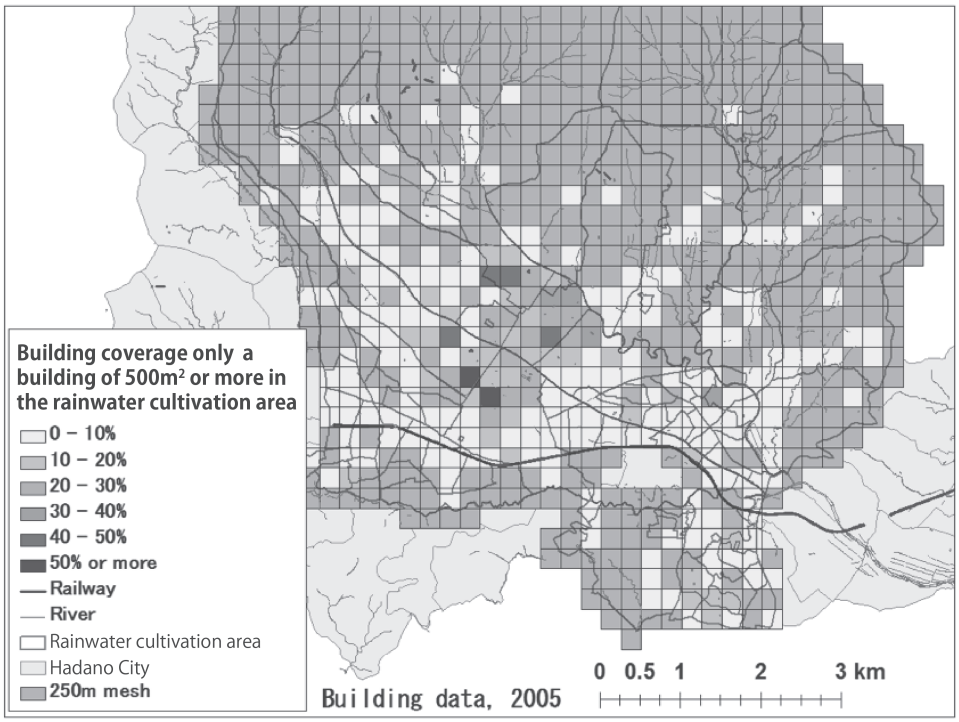

Figure 5 Building coverage only a building of 500m^2 or more of each mesh in the rainwater cultivation area

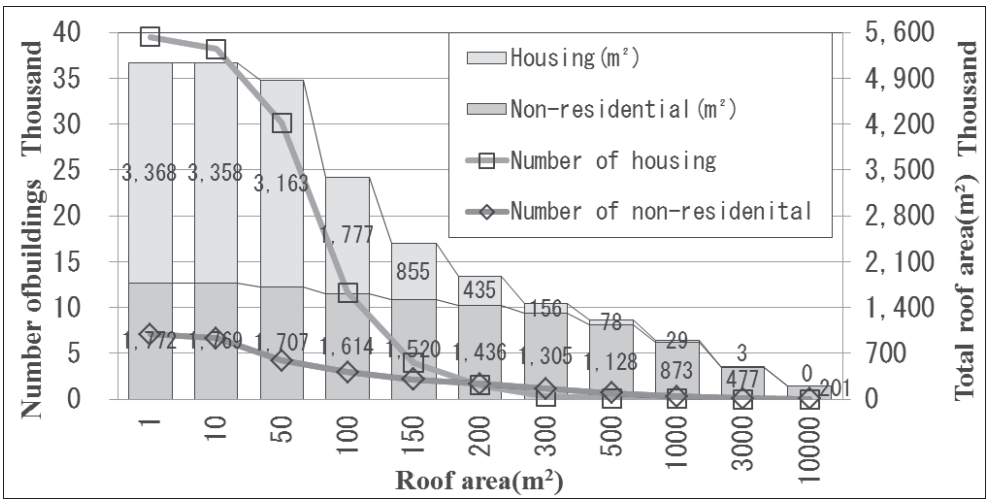

Figure 6 Total of building number and area in the groundwater cultivation area from what has a large roof area

4.4 Technological study about GIS database creation of river, agricultural waterway, etc.

About Hadano City, river data was extracted from the urban planning map of 2005 editions, and this data was corrected to the river channel which can be obtained from the newest 2011 edition aerial photograph (Figure 7). About the agricultural waterway, the channel was checked by the field survey and the streamline was created.

The center line was created in order to collateralize the connectivity and the continuity of data from a river channel. Thereby, extension of river and agricultural waterway can be clarified. Moreover, the point in every 1m was created to the center line with the juncture of a river as the starting point (Figure 8), and the altitude in each point was obtained from 5m mesh DEM (digital elevation model) data (Figure 9).

The data creation in Tsuru City is tackled based on the technological study in Hadano City now, and the site survey about the water quality and flow of river and agricultural-waterway is performed. These data is taken in to GIS.

Furthermore, the data about a sewer pipeline network is also taken in to GIS from now on, and the change factor of the surface water resulting from human activities is clarified.

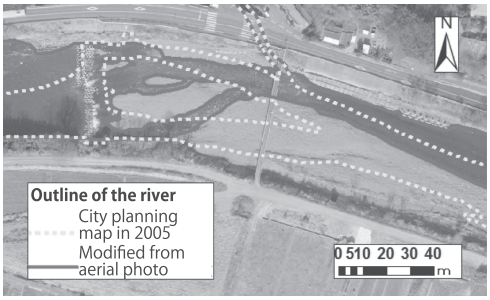

Figure 7 Modifing outline of the river from aerial photo

Figure 8 Center line of the river and the point every 1m

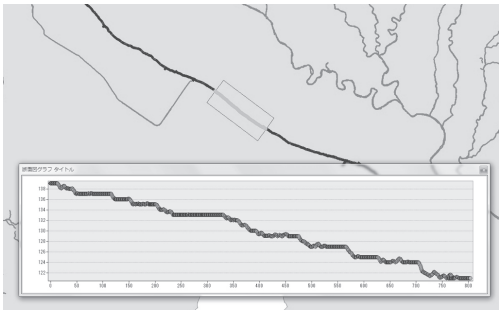

Figure 9 Altitude in every point

Figure 10 Outline of the river and streamline of agricultural waterway with flow rate in Tsuru City

5. Conclusion

This study clarified quantitatively the present condition and the future installation possible quantity of the rainwater infiltration facilities in Hadano City using GIS. Moreover, construction of the GIS database about the river and agricultural waterway was considered technically.

From now on, construction of IT platform that can offer the solution to the water environmental subject of each area is advanced.

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8. Presentation of Authors

Sho Komiyama is a graduate school student of Toyo University from 2012. Main research field is creating IT platform of water environment of area using GIS and the site investigation for it . Is expected in the future, environmental issues related to water and become serious. So, he would like to make a further study.

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