A Study on the Location of Castle and Urban Structure of Castle town by Watershed-based Analysis
集水域に着目した城下町の都市構造と城郭位置に関する研究

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This research seeks to identify the urban planning methods for sustainable development by introducing watershed-based analysis. From the viewpoint of the ecological aspects, characteristics of Japanese castle-town, JYOKAMACHI, was dedicated as one of the important urban structure to identify sustainable urban planning methods. Therefore, the location of castle and its urban structure were investigated. In this study, GIS is used to analyze the location of castle and its urban structure by mean of watershed based analysis. Results show that among 86 castle locations, about 44% of castle is located on the catchment edge, 51% is located near by the catchment edge, and 5% is located at the middle of the catchment edge. 80 of the 86 castles was found located at the highest elevation area comparing to its surrounding and within the catchment it's located. It can be said that most of the castle locations tends to be located at the highest elevation area in a unit of catchment. 10 cases of overlaying maps between urban structure of castle-town in Edo period and catchment maps show that urban structure of castle-town has uniform relationship with watershed. The same 10 cases of overlaying maps between the current land use zoning and catchment maps somehow show some land use regulation regarding to the catchments. Therefore, it can be concluded that watershed may be one of the basic factors for urban design, urban planning as well as the landscape planning for JYOKAMACHI.

Keywords: *urban planning methods, sustainable development, watershed-based analysis, and catchment edge*

1. INTRODUCTION

Recent studies show that urbanization is one of the most important human activities that creates enormous impacts on the environment due to the over consumptions of natural resources which results in many environmental issues related to land degradation, forest destruction, river sedimentation, water pollution, air pollution and climate change so forth, which is the cause of some natural disasters such as flood, drought, landslide etc. Surrounding these problems, for example, in Phnom Penh city, the capital of Cambodia, after the year 2000, peace has been regained for this city and investment in infrastructure by foreign company led to the highly increase of land price. From 2003 to 2013, many lakes in the city area had reclaimed due to the highly increased of land price.

The disappearing of the lake and the change at the area surrounding the lake has generated several social and environmental impacts. Facing these current trends, which associated with the natural environment, sustainable development and sustainability, which seek to develop and improve the long-term social and ecological health of cities and towns, have become one of the key elements in the matter of urban planning method over the world especially in Asian developing countries. Therefore, a proper urban planning method respecting to the environmental aspects should be established in order to control and manage the land use, the natural resource and the restoration of natural system efficiency and effectively.

The characteristics of watershed are believed to be able to use as a tool to improve the city planning. Watershed provides water for drinking, irrigation and industry usage. It is a source of food, natural resource, tourism, and transportation of daily life. In general, everyone lives on the watershed, it is a place where we call home, where we work and live, and everyone relies on the water and other resources from water to exist. Besides what we do on the land does impact the quality and quantity of water and natural resources as water flow travels over farmland, forest, city streets, urban areas or it penetrates into the soil and travel as groundwater. High points, such as hills or slope, separate watersheds from each other. Its characteristics can be used for predicting flood patterns, estimating sediment yield, and predicting water availability and quality, which is a key factor for the sustainable development of a city.

Normally, traditional cities such as JYOKAMACHI, Japanese castle-town, a kind of feudal cities, always reflect on the consciousness of the environment and sustainability as its forming and its urban structure had a strong relationship with the topography and water system[1]. Moreover, transportation was mainly by mean of water during Edo period; urban structure of castle-town was considered related to the water system[2) 3)]. Therefore, it was selected in this study to emphasize the relationship between the city planning and watershed.

Based on the above mentioned, the main purpose of this study is to define the relationship between the location of castle and urban structure of castle town in Edo period and current land use zoning of these cities by mean of watershed based analysis.

2. LITERATURE REVIEW

2.1 Previous Research

This research concerns about the urban form and pattern, regional planning and open space planning, the watershed based for sustainable development, topographical and water stream flow network, urban structure and urban design method of JYOKAMACHI

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and watershed analysis method. Several previous related researches are shown as below:

(a) Urban form and pattern

Two types of cities were introduced: planned cities and unplanned cities. Planned city is a designed city with its pattern determined once and for all by some overseeing authority; this pattern is orderly and geometric diagram. Unplanned city is a non geometric, " organic". Its pattern can be underlined as geomorphic[4].

(b) Regional and open space planning

Landscape was composed of many components such as geology, topography, soil condition, vegetation, surface water so on and so forth. From the technique of overlaying the land use, the analysis of variety of landscape elements leading to define the best solution for land use planning[5]. Moreover, restoration of water cycle and ecosystem in the watershed is the key issue in the current greenbelt planning[6].

(c) Watershed based for Sustainable Development

It was found that the land use system of traditional villages is a cultural asset and key elements for sustainable landscape management[7].

(d) Urban structure of JYOKAMACHI

Sorensen, A. describes the urban structure of Japanese castle town in Edo period[8]. Japanese Castle-towns, a kind of feudal cities, showed a concentric-zoning structure in the feudal days[2]. Shigeru S. found that unique spatial structure and landscaping of Japanese Castle-town were grouped in to 5 categories[3]. Tsuyoshi.K, Kyung W. investigated the process of urban modernization, and is believed that the analysis by using Space Syntax could be a powerful methodology to show how the present conditions differ from the historical layout[9].

(e) Urban development based on water path network

6 types of water environment in the urban area were introduced and it contributes to the realization of co-environmental urban planning by giving an urban landscape a rationally designed water environment system[10].

(f) Watershed analysis method

The way of analysis and interpreting the data in watershed analysis process were explained[11) 12)].

2.2 Research Position

In 20th century, starting from the 1970s, the world began to take note of the environmental issues. In the field of urban planning, various movements concerning about the sustainable urban development with long lasting structure, buildings and a great livability for the inhabitants were created. In 21st century, environmental issues became more and more serious, which produces many problems due to the urbanization. Facing these challenges, more and more urban planning methods, which ensure for the sustainable development and sustainability should be identified in order to solve the current environmental impacts and ensure for the future need. Therefore, this study seeks to define the urban planning method respecting to the environment by introducing the watershed-based analysis. Generally, the tradition cities such as JYOKAMACHI always reflect on the consciousness of the environment and sustainability. Hence, JYOKAMACHI, Japanese castle town, in which its forming was found having relationship with topography and water, were selected for defining the relationship between city planning and watershed.

3. RESEARCH METHODOLOGY

3.1 Research framework

This study is composed of seven chapters, and the research framework was shown as **Fig.1**.

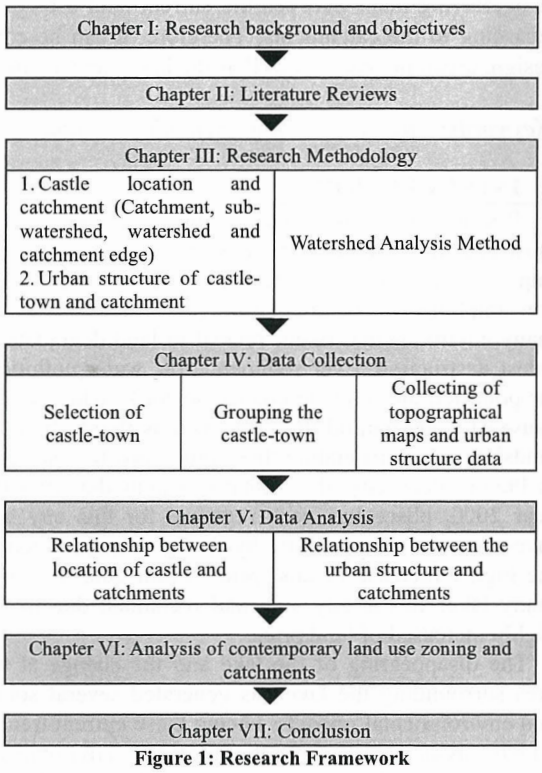

Figure 1: Research Framework

3.2 Research Analysis

3.2.1 Castle location and catchments

(1) Concept of catchment

Catchment is an area that provides water to the point through lateral flow over the surface and underground. Simply, it is the total extent of land where rainfall drains downhill into the river, stream, etc. draining to the location of lower elevation point as shown in **Fig. 2**. Green boundary denotes the watershed boundary while orange boundary color denotes the catchments boundary. The area inside the orange boundary represents catchment. Blue lines denote the natural drainage lines.

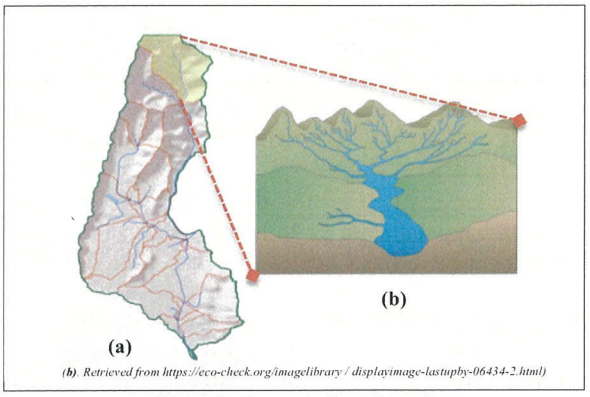

Figure 2: Concept of catchment

(2) Concept of sub-watershed

Sub-watershed is defined as the intersection of flow of two or more catchments into single point of lower elevation. Inside Sub-watershed, there are more than one catchments are defined (**Fig.3a**). Green boundary is the watershed boundary. Blue arrow lines are the flow direction of natural drainage line. Orange color dots represent the lower points of two or more than two intersection catchments. **Fig.3b** shows an example of the sub-watershed, orange boundary is the sub-watershed boundary and area inside this boundary is the sub-watershed.

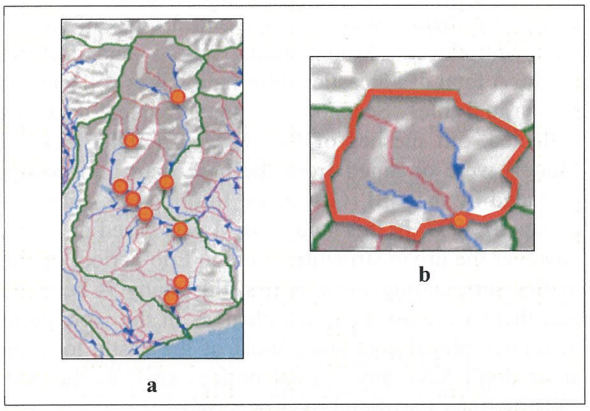

Figure 3: Concept of sub-watershed

(3) Concept of watershed

Watershed is an area of land where surface from rain and melting snow or ice converges to a single point at a lower elevation, usually the exit of the basin, where the water join another water body, such as a river, lake, reservoir, wetland, sea, or ocean (**Fig.4**). Green boundary is the watershed boundary; area inside the green boundary is the watershed containing many catchments represented by red color. Blue arrow lines represent the natural drainage lines. Black dot lines are the limit of the Digital Elevation Model (DEM). This means that the shape of watershed boundary can be varied when the bigger DEM area is analyzed. However, the flow direction must remain the same.

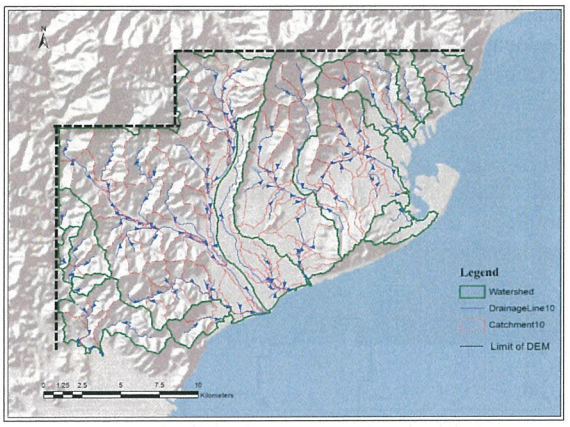

Figure 4: Concept of watershed

(4) Concept of catchment edge

In this study, Catchment Edge refers to the boundary of the catchment, which connects the high points of surrounding areas to form one catchment. In general, catchment edge tends to be located at the higher or highest points comparing to the middle of the catchment. In **Fig.5**, the purple boundary is an example of the catchment edge with the contour line represented by blue contour line, and the number represents the elevation of each contour line.

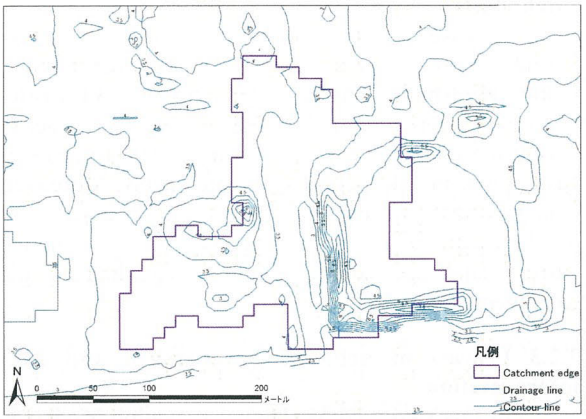

Figure 5: Concept of catchment edge

(5) Identification of castle location and catchments

In order to determine the castle locations precisely, the catchment maps and drainage line were exported to Google earth by KML extension. Importing these extensions to Google earth then key in the name of the castle name, the location of castle was defined. However, some castle location might not be defined clearly as some castle doesn't appear the exact location as they were ruined and some appeared in the wrong location. In the Eric website[13], the castle locations were clearly identified. The location of castle and catchment located the castle having the hydro ID were defined in Google earth, then the location of castle can be found easily in ArcGIS. Three types of castle locations: on the catchment, near by the catchment edge and middle of the catchment edge were discussed. The contour lines were output to show clearly the elevation of each castle

location with its surrounding and within the catchment it's located.

Three types of castle locations were defined as shown in **Fig.6**, Purple boundary is the catchment edge, purple circle is the castle located on the catchment edge, blue triangle is the castle located near by the catchment edge and pink pentagon is the castle located at the middle of the catchment edge; blue line is the natural drainage line.

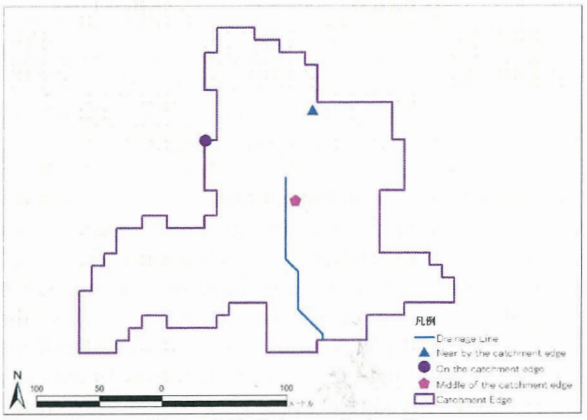

Figure 6: Defining castle location

3.2.2 Urban structure of castle-town and catchments

10 cases of urban structure of castle-town in Edo period: Tottori, Himeji, Kanazawa, Hikone, Sakura, Fukui, Hiroshima, Sunpu, Saga, and Nagoya castle-town were overlaid with the catchment maps in order to define the characteristics of urban spatial structure of castle-town in Edo period with catchments. Moreover, contemporary land use zoning of these 10 cases were overlaid with the catchment maps in order to define the current land use zoning methods regarding to the catchments.

3.2.3 Process of delineating watershed and data interpretation

In this study, DEM (Digital Elevation Model) is the most important source for conducting the analysis of watershed. The threshold for defining the stream definition is vital factor in the analysis process; however, there is no limit for setting the threshold. In this study, threshold 1% is giving a definition of stream after several tries of difference thresholds, for example, 1%, 0.5%, 0.25% and 0.125%. Generally, threshold 1% means that stream definition equals to 1% of the flow accumulation.

- **Process of delineating the watershed**

In **Fig. 7,** left side the process is from the top to bottom, and the right side, the corresponding layers is from the bottom to the top.

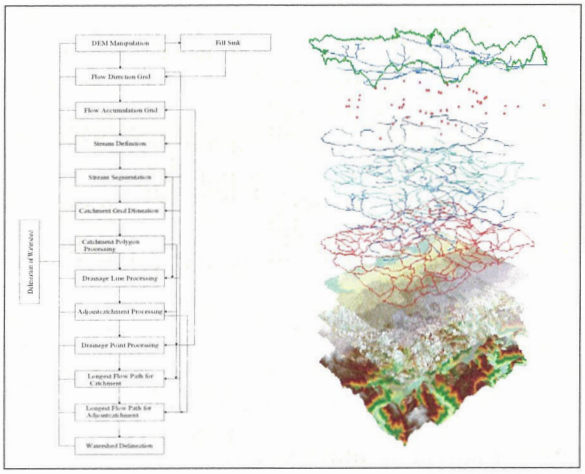

Figure 7: Process of delineating watershed

4. DATA COLLECTION AND COMPUTING SOFTWARE

4.1 Data collection

Selection of the castle town had been carried out on the basic of Eric, O. website. In this website, many information concerning about Japanese castles and castle towns were collected, and it shows the exact location of castle with the historical maps, the condition of the castle such as ruin, became other building, reconstructed so forth. In this study, firstly, Japanese castle information was collected and 3 types of castles were introduced: Mountaintop, hilltop and flatland castle. A total of 86 castles information was collected as shown in Table1. Secondly, the topographical data was collected. 5m meshes of the DEM (Digital Elevation Model) were obtained from the base map information provided by the GSI (Geospatial Information Authority of Japan) 2003, In this study, DEM was based on 2003, however the urban structures were in Edo period, on the matter surrounding these issues, this study is believed that there were not so much changes in the view point of topographical data since most of the castle location areas don't have any special notices such as the new construction of artificial river occurred.

For the analysis of urban structure of castle-town with the catchments, 10 cases of urban structure in Edo were extracted from "An illustrated history of Japanese cities" book, which explains about the urban spatial structure of Japanese castle; Contemporary land use zoning (2011) of these castle towns were obtained from the Ministry of land infrastructure and transportation (MLIT).

4.2 Computing software

Geographic Information System (GIS) is a tool for determination the topography, hydrologic and geomorphologic characteristics of watershed, which is including flow direction, flow accumulation, natural drainage line, catchment, sub-watershed, watershed etc. from the digital elevation model (DEM).

There are many methods for analyzing the watershed. In this study, ESRI's ArcGIS Desktop 10.2

with the extension of Arc Hydro 10.2 was used for analyzing the 86 castle locations. Moreover, the overlaying maps between the urban structures associated with the catchments were conducted both by the ArcMap and AutoCAD.

5. DATA ANALYSIS

In this study, a total of 12 mountaintop castles, 36 hilltop castles and 38 flatland castles were analyzed associated with the catchments.

In this section, two analysis processes were identified: Relationship between the location of castle and catchments and the relationship between the urban structure and catchments, which composes of two time frames: Edo period and current period.

5.1 Relationship between location of castle and catchments

5.1.1Analysis of castle location

Analysis of castle location was conducted in two main steps: castle location and catchments, elevation of castle in a unit of catchment.

(1) Analysis process

Below are the steps of defining the castle location regarding the catchments and elevation of castle in a unit of the catchment:

a) Obtaining the 5m meshes DEM from GSI.
b) Converting the data from GSI to GIS extension by using 基盤地図情報 ビューアー コンバーター version. 3.20.
c) Inserting the shape file (.shp) of Digital Elevation Model into ArcMap.
d) In ArcGIS, from ArcToolbox window [Conversion Tool-point to raster]
e) Using ArcHydro extension for analyzing the watershed.
f) In ArcGIS, from ArcToolbox window [Conversion Tool-To KML-Layer to KML]
g) Importing the KML file to Google earth.
h) Key in the castle name and obtaining the Hydro ID.
i) Defining the castle location elevation in ArcGIS.
j) From ArcToolbox window [Spatial Analyst Tool-Surface-Contour].

(2) Example of castle located on the catchment edge

- **Study area**

Iyo Matsuyama castle is an original castle and also a hilltop castle. To identify the location of this castle, land area of 12,013 ha were used for conducting the analysis of watershed. 5m meshes of DEM obtained from the GSI are converted in ArcGIS as shown in **Fig. 8**, the catchment edge, and the catchments were analyzed, and the area contains a total of 251 catchments as shown in **Fig. 9**.

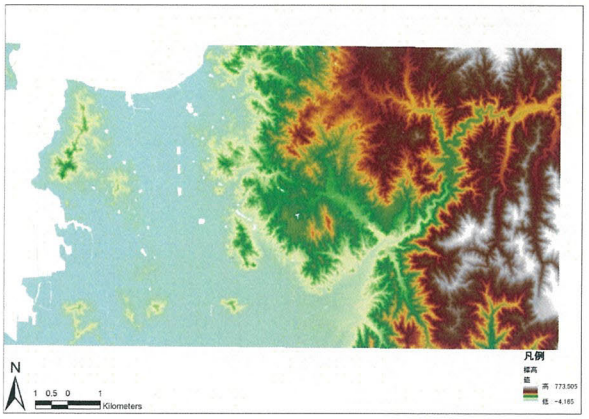

Figure 8: Elevation of study area of Iyo Matsuyama castle

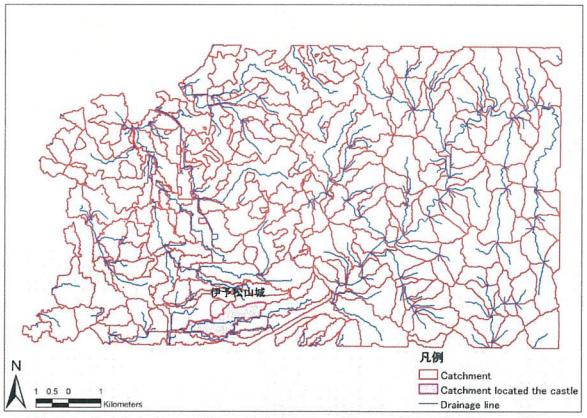

Figure 9: Catchments and drainage lines of study area of Iyo Matsuyama castle

- **Data Analysis**

In **Fig.9**, the red color polygons are the catchment polygons, and the blue lines are the drainage lines. Moreover, highlighted polygon is the catchment located the castle with the total area 119 ha. The contour line is the emphasizing of the elevation of the castle (**Fig.10**), from this figure, the location of castle was found located at the highest elevation area comparing to its surrounding catchments, which were represented by green boundary. Furthermore, from **Fig.11**, it is clearly shown that the location of castle is located on the catchment edge.

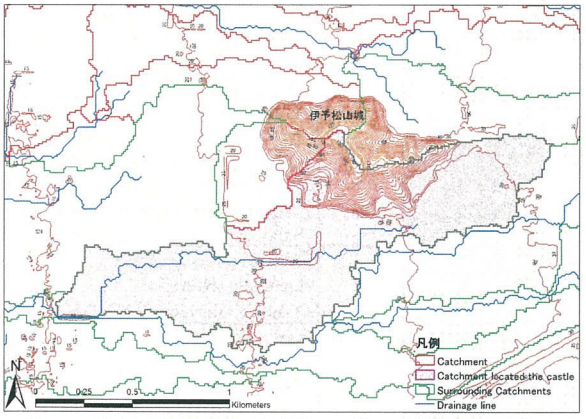

Figure 10: Catchment located the castle and its surrounding catchments

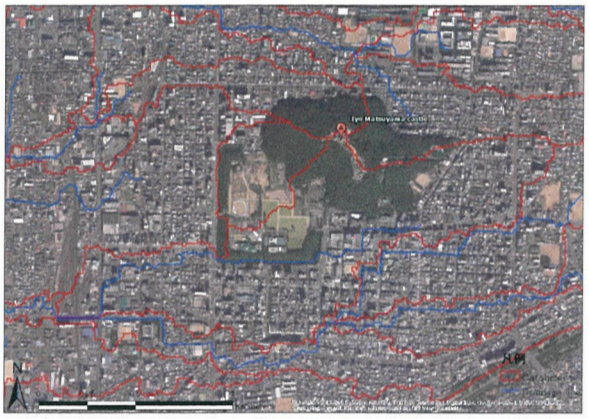

Figure 11: Castle location of Iyo Matsuyama castle regarding to catchments

(2) Example of castle located near by the catchment edge

Fig.12 is an example of castle located near by the catchment edge. In this figure, the area inside the red polygons represents catchments and blue lines are the natural drainage lines.

Figure 12: Castle (Kagoshima castle) located near by the catchment edge

(3) Example of castle located at the middle of the catchment edge

Fig.13 is an example of castle that was found located at the middle of the catchment edge.

Figure 13: Castle (Edo castle) located near by the catchment edge

5.1.2 Results of castle location regarding to catchments

(1) Castle location and catchments

In this study, 86 castles were analyzed. The results of the location regarding to catchments was shown in **Table 1.** Fig. 14 shows the summary of results of castles regarding to catchments.

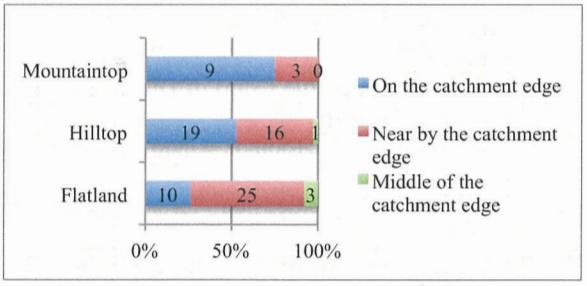

Figure 14: Summary of castle locations regarding to catchments

Table 1: Results of 86 castles regarding to catchments

Castle location / Castle's type	On the catchment edge		Near by the catchment edge		Middle of the catchment edge	
	Total	Castle name	Total	Castle name	Total	Castle name
Mountaintop	9	Hagi, Bitchu Matsuyama Oka, Kururi, kasama Takatori, Nihonmatsu Naegi, Yamato Koriya	3	Sendai, Tatsuno, **Tottori**	-	-
Hilltop	19	Karatsu, Inuyama Iyo Matsuyama, Ozu Fukuchiyama, Morioka Fukuyama, Kochi, Matsusaka Yokote, Odawara, **Kanazawa** Saiki, Fukuoka Wakayama, Kakegawa Uwajima, **Himeji** Tanba Kameyama	16	Mito, Tsuyama, Okayama Shiroishi, Toba, Kaminoyama Hirosaki, Shichinohe, **Sakura** Matsue, Maruoka, Akashi Izushi, Sasayama Aizu Wakamatsu, Hitoyoshi	1	**Hikone**
Flatland	10	**Saga**, Yodo Kawagoe, Oshi Sekiyado, Kokura Utsunomiya, Nishio Tatsuoka, Ueda	25	**Nagoya**, Ogaki, Imabari Niwase, Tanabe, Tatebayashi Yamagata, Minakuchi, Zeze Kagoshima, Takada, **Sunpu** Osaka, Funai, Shimabara Matsumoto, Takaoka, Toyama Ako, Akizuki, **Fukui** **Hiroshima**, Kishiwada Yatsushiro, Tsuchiura	3	Yoshida Edo Nijo

Bold are used for the analysis of urban structure and catchments

▪ **86 castles location in Japan regarding to catchments**

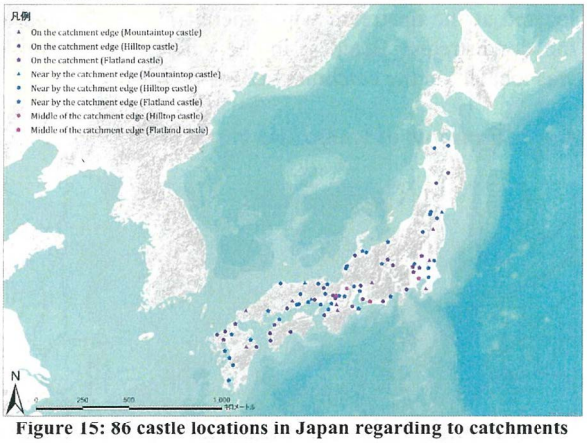

Figure 15: 86 castle locations in Japan regarding to catchments

Fig. 15 shows the 86 castle locations regarding to catchments: On the catchment, near by the catchment edge and at the middle of the catchment edge. Purple color shows the castle located on the catchment edge, blue color shows the castle located near by the catchment edge and pink color shows the castle located at the middle of the catchment edge. Moreover, the triangle symbol denotes the mountaintop castle, circle denotes the hilltop castle, and the pentagonal denotes the flatland castles.

▪ **Conclusion of castle regarding to catchments**

From **Table 1**, within 86 cases of castle location, about 44% is located on the catchment edge, 51% is located near by the catchment edge, and 5% is located at the middle of the catchment edge.

(2) Castle elevation in a unit of catchment

From the analysis of 86 castle locations, the elevation of castle in a unit of catchment was shown in **Table 2**. **Fig.16** shows the summary of results of castle in a unit of catchment.

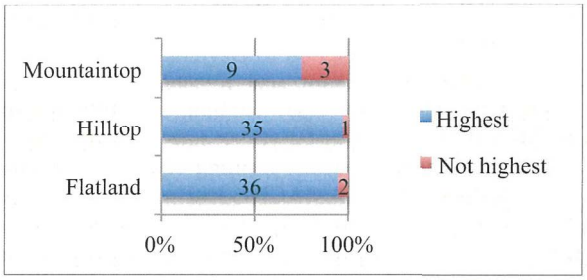

Figure 16: Results of castle elevation in a unit of catchment

▪ **Conclusion of castle elevation in a unit of catchment**

From the **Table 2**, there is a total of 93% of castle is located at the highest elevation comparing to its surrounding and within the catchment it's located. It can be concluded that most of the castle locations tends to be located at the highest elevation area in a unit of catchment.

Table 2: Results of castle elevation in a unit of catchment

Castle's elevation / Castle's type	Highest Elevation		Not Highest Elevation
Mountaintop	Bitchu Matsuyama, Naegi Tottori, Takatori Kururi	Sendai, Oka Yamato Koriya, Nihonmatsu	Hagi Kasama Tatsuno
Hilltop	Karatsu, Inuyama Uwajima, Mito Morioka, Shiroishi Fukuyama, Kochi Hikone, Yokote Shichinohe, Kakegawa Saiki, Matsue Akashi, Himeji Fukuoka, Hitoyoshi	Iyo Matsuyama, Ozu Okayama, Tsuyama Fukuchiyama, Tanba Kameyama Matsusaka, Kaminoyama Odawara, Hirosaki Kanazawa, Sakura Maruoka, Aizu Wakamatsu Sasayama, Wakayama Toba	Izushi
Flatland	Saga, Nagoya Imabari, Niwase Tanabe, Yodo Kawagoe, Oshi Zeze, Kagoshima Sekiyado, Kishiwada Shimabara, Matsumoto Utsunomiya, Takaoka Tsuchiura, Fukui	Nishio, Yoshida Ogaki, Nijo Yatsushiro, Tatebayashi Yamagata, Minakuchi Takada, Sunpu Osaka, Funai Ako, Ueda Toyama, Kokura Hiroshima, Edo	Tatsuoka Akizuki

5.2 Analysis of urban structure and catchments

In this section, the main objective is to investigate the relationship between the urban structure of Edo period, current period and its catchments, which can lead to the defining of the regulation of land use of some important facilities such as the temples, shrines. In this analysis, a total of 10 urban structures of castle-town: Tottori, Himeji, Kanazawa, Hikone Sakura, Fukui, Hiroshima, Sunpu, Saga and Nagoya castle town were extracted from the book "An illustrated history of Japanese cities", and these 10 cases of current land zoning were obtained from MLIT. Overlaying technique with the output catchment maps based on the DEM, 2003 were used.

5.2.1 Characteristics of urban structure of JYOKAMACHI

It was found that the forming of urban structure of castle-town, JYOKAMACHI, had relationship with the topography and water system[2) 3)]. Moreover, from the " An illustrated history of Japanese cities" book at page 17 concerning about the topography and water system of castle town, it stated that castle town always located between the hilly area and riparian area and its topography reflects on the social ranking. The Samurai was located at the highland or upstream while the Chōnin was located at the lowland or downstream.

5.2.2 10 cases of urban structures of castle town in Edo period regarding to catchments

Below are the 2 examples of overlaying maps between Edo urban structures with the catchments. Some characteristics of urban structure of each castle-town related to the catchments were noted as shown in **Fig. 17** and **Fig 18**.

- **Example of Himeji castle town**

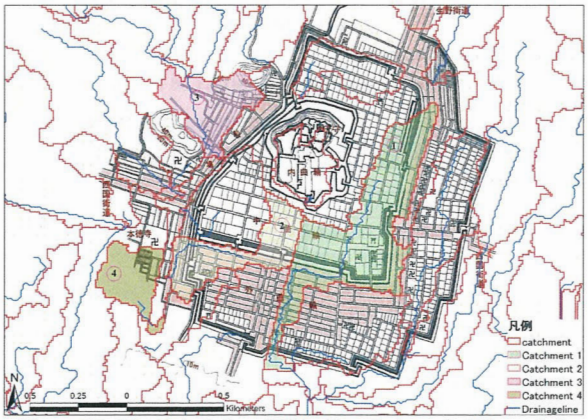

Figure 17: Characteristics of Himeji castle town in Edo period and catchments

Himeji castle refers to hilltop castle. From the overlaying maps of castle town, catchments and drainage lines, it was found that the urban strucutre of Himeji castle town reflects on the land use regulation based on social ranking regarding to the catchments.

From catchment 1, catchment 2 and catchment 3 as shown in **Fig.17**, it was found that samurai was located at the upstream while merchant was located at the downstream. Besides, in the catchment 4, temple was located on the catchment edge.

- **Example of Kanazawa castle town**

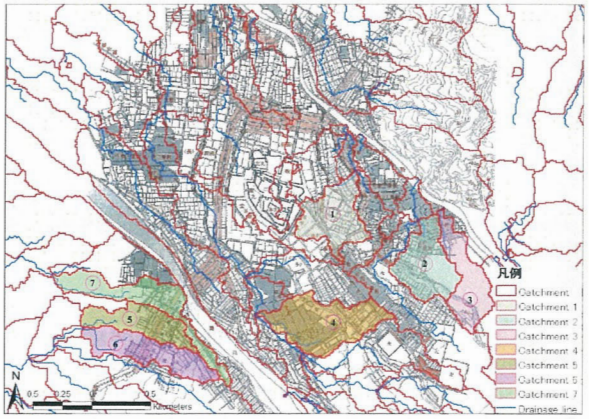

Figure 18: Characteristics of Kanazawa castle town in Edo period and catchments

Kanazawa castle refers to the hilltop castle. From the overlying maps, some characteristics of urban structure regarding to the catchments were defined. In catchment 1, it was found that higher ranking samurai was located at the higher elevation area, and lower ranking samurai was located at the lower elevation area. and in catchment 2 and 3, second home of samurais was located at the downstream. Besides, in catchment 5, 6 and 7, the important facilities, temples, were located on the catchment edge.

6. CURRENT LAND USE PLANNING AND CATCHMENTS

The main purpose of this section is to analyze the urban structure regarding to the catchments of contemporary data of 10 cases urban structure in the previous section. The main data source is contemporary land use zoning (用途地域), which is used for the analysis of current land use zoning methods regarding to the catchments.

6.1 Overlaying maps of contemporary 10 cases urban structures of castle town with catchments

Below are the 2 examples of overlaying maps of current land use planning data with the catchments and drainage lines. Some characteristics of urban structure of each castle town related to the catchments were noted as shown in **Fig. 19** and **Fig 20**.

- Example of Himeji castle-town

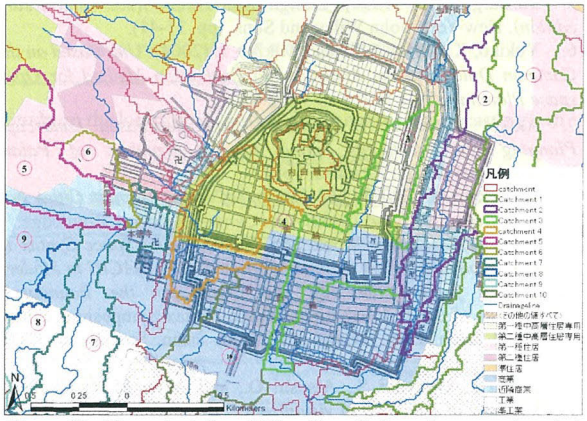

Figure 19: Characteristics of Himeji castle town in current period and catchments

From the overlaying maps, 2 common land use types were defined. Surrounding the castle area, residential area is located at the upstream and commercial area is located at the downstream as shown in catchment 1, 2, 3, 4, 5 and 6. Moreover, from catchment 7, 8, 9 and 10, it was found that the commercial area is located at the upstream while industrial area is located at the downstream.

- Example of Kanazawa castle-town

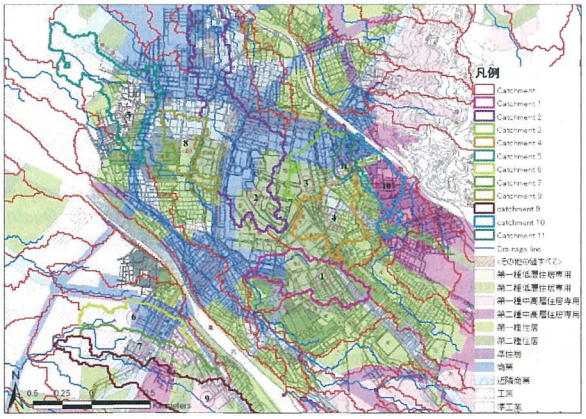

Figure 20: Characteristics of Kanazawa castle town in current period and catchments

From the overlaying maps, some land use regulation regarding to the catchments were defined.

- Mix use of residential area is located at the upstream while commercial area and neighborhood of commercial area are located at the downstream as shown in catchment 1, 2, 3, 8, 10.
- Mix use of residential area is located at the upstream while residential area is located at the downstream as shown in catchment 4.
- Mix use of residential area, residential area and neighborhood of commercial area are located at the upstream comparing to industrial area, which is located at the downstream as shown in catchment 7 and 9.
- Residential area and neighborhood of commercial area is located at the upstream, and the commercial area is located at the downstream as shown in catchment 11.
- Residential area and commercial area are located at the upstream while industrial area is located at the downstream as shown in catchment 6.
- Commercial area and mix use of residential area are located at the upstream while industrial area is located at the downstream as shown in catchment 5.

7. CONCLUSION

7.1 Findings

From the analysis of 86 castle locations regarding to the catchments, it was found that about 44 % is located on the catchment edge, 51% is located near by the catchment, and 5% is located at the middle of the catchment edge. Moreover, 80 of the 86 castles are located at the highest elevation area comparing to its surrounding and within the catchment it's located. It is considered as a factor to the disaster prevention (such as flood risk) and military purpose (such as observing the surrounding area). Moreover, Japanese castle town was found having deep relation with the Topography and water system, in this study, the characteristics of Japanese castle town were demonstrated by the catchments.

From the analysis of urban structure of Edo period and contemporary land use planning regarding to the catchments, some characteristics of the urban structure of these castle towns related to the catchment were identified as below:

From the 10 cases of overlaying maps between the urban structure, catchments and drainage lines show that urban structure in Edo period had a uniform relationship with catchments, sub-watershed and watershed. Within these 10 cases, samurai was always located at the highland or upstream comparing to the merchant in one catchment or one sub-watershed. Moreover, the important facilities such as temples, shrines tended to be located more on and near by the catchment edge in one catchment.

From the overlaying maps of 10 cases of contemporary land use zoning shows some land use regulations such as residential area and mix use of residential area tend to be located at the upstream comparing to commercial area and neighborhood of commercial area, which are located at the downstream. Moreover, the commercial area and neighborhood of commercial area are located at the upstream while industrial area is located at the downstream. It can be said the current land use zoning is sustained from the castle town especially for the area surrounding the castle.

7.2 Significant of the research

Urban planning, Landscape planning are concerning about the regional land use and facilities distribution planning. It is essential to know the way to interpret the region. Moreover, the traditional cities,

such as JYOKAMACHI, normally reflect on the consciousness of the environment and sustainability.

In this research, some characteristics of Edo urban structure of castle town regarding to catchments were identified. The land use based on social ranking and its location have relationship with the catchments, samurai is located at the highland or upstream, merchant is located at the lowland or downstream. Therefore, the characteristics of catchment, sub-watershed, and watershed can be used as the region. In this study, from the above findings, the castle location, which is the most important facility, is located on or near by the catchment edge, and it is also located at the highest elevation comparing to its surrounding in a unit of catchment; moreover, the activities in the upstream always affects on the downstream so that a plan can be established for the regional land use by watershed unit. It means that the most important structure might be located at the upstream, for example, the residential area or commercial area is located at the upstream and industrial area is located at the downstream, which can give worse effect if it is located on the upstream. By doing this, it ensures the water quality, and it also can be used to solve some conflicts regarding to the environment.

7.3 Future Issues

Urbanization is gradually increased. The impacts on the environment is inevitable, however, Sustainable development should be focused to ensure the prevention and management of the land use, natural resource, disaster prevention and the restoration of natural system efficiency and effectively for the future.

Future research will emphasize on defining the method for revealing some essential relationship between the urban structure and watershed by focusing on:

- Analyzing many ancient cities in Asia Countries in order to define urban planning method based on watershed.
- Modern Asian cities will be conducted next for the purpose of comparing between the current and new urban planning method based on watershed.

Finally, an evaluation of the effectiveness of the new method will be established respecting to the watershed.

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