

A Study on the Location of Castle and Urban Structure of Castle-town by Watershed Based Analysis

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This research seeks to identify the urban planning methods for sustainable development by introducing watershed based analysis. From the view point of the ecological aspects, characteristics of Japanese castle-town, JYOKAMACHI, was dedicated as one of important factors to identify urban planning methods. Therefore, the location of castle and its urban structure were investigated. GIS is used to analyze the location of castle and its urban structure by mean of watershed based analysis. Results showed that among 86 castle locations, about 34% of castle locations of Hilltop, Mountaintop and Flatland is located on the catchment edge, 60% is located near by the catchment edge and 6% is located in the middle of the catchment edge. 88% of most of the castle locations 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 as a unit of watershed. 10 cases of overlaying maps between urban structure of castle-town in edo period and catchment maps showed that urban structure of castle-town had strong relationship with watershed. Therefore, it can be concluded that watershed is one of the basic factors for urban design, urban planning as well as the landscape planning for JYOKAMACHI.

Key Words : *urban planning methods, sustainable development, watershed based analysis, catchment edge.*

1. INTRODUCTION

Recent studies show that urbanization is one the most important human activities that creates enormous impacts on the environmental problems related to land degradation, destruction of forest, sediment of river, water pollution and climate change, which generates some natural disasters such as flood, drought, landslide etc. 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 issues in the matter of urban planning method especially in Asian developing country. Therefore, a proper urban planning method respecting the environmental aspects should be established in order to prevent and manage the land use, the natural resource and the restoration of natural system efficiency and effectively.

The watershed based analysis has been advocated as an useful method of analysis for urban planning and natural resources management. In general, everyone

lives on the watershed 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. Characteristics of watershed can be used as a tool to improve the city planning which can lead to the sustainable development.

JYOKAMACHI, Japanese castle-town, a kind of feudal cities, was selected in this study to emphasize the relationship between the city planning and watershed. It had been found that JYOKAMACHI's forming and its urban structure had a strong relationship with the topography and water system. As transportation was mainly by mean of water during edo period; urban structure of castle-town was considered related to the water system¹⁾²⁾. It can be said that the location of castle and its urban structure were some how also based on natural environment, especially the water system. It is believed that the watershed analysis method acts as a very important role to clarify the topography and water system in castle-town which seeks to identify the urban planning methods for sustainable development in the future.

Based on these reasons, the main purpose of this study is to define the relationship between the location of castle and urban structure of castle town by mean of watershed based analysis.

2. EXISTING RESEARCH

Some previous research concerning about the watershed and JYOKAMACHI have been done as below:

1) Watershed based for Sustainable Development

Akiko.I⁴⁾ “A study on watershed based landscape planning on Babeldaob Island in the republic of Palau”, found that the land use system of traditional villages is a cultural asset and key element for sustainable landscape management. Whereas Yukiko. K, Hideya.Y, Mikiko.I.,⁵⁾ believe that the restoration of water cycle and ecosystem in the watershed is the key issue in the current greenbelt planning and gave the comprehensive view of open space planning and facilities the understanding of characteristics of urban fringe areas where the urban development and natural conservation exists.

2) Urban structure of JYOKAMACHI

On the matter concerning about the JYOKAMACHI, the Japanese Castle-towns, a kind of feudal cities, showed a concentric-zoning structure in the feudal days¹⁾. Shigeru S. found out that unique spatial structure and landscaping of Japanese Castle-town were grouped in to 5 categories²⁾. 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 layout³⁾.

3) Research Position

This study seeks to define the urban planning methods respecting to the environmental by introducing the watershed based analysis. Analysis methods is conducted differencely from the above mentioned researches, in this study, watershed was conducted by using difference extension. Arc Hydro was applied in this study while a) used the Spatial Analyst-Hydro Modeling. JYOKAMACHI was selected for defining the relationship between the city planning and watershed.

3. METHOD

(1)The ideas of Catchment, Sub-watershed and Watershed

a. Catchment

Catchment refers to any points in the landscape which is an area that provides water to the point through lateral flow over the surface and underground. Normally, the catchment is usually delineated on the basis of the watersheds determined from surface topography (Fig.1).

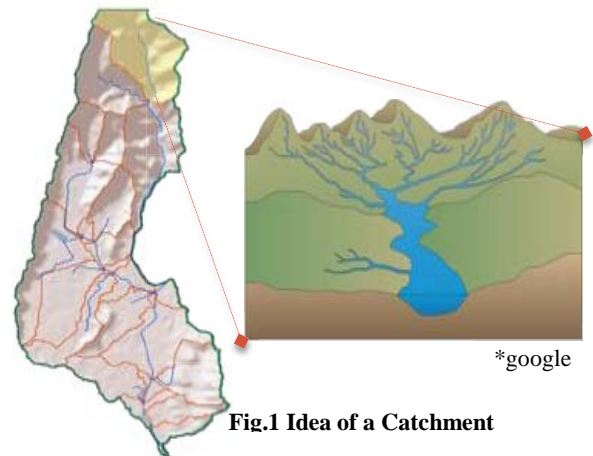


Fig.1 Idea of a Catchment

b. Sub-watershed

Sub-watershed is defined as the intersection of flow of two or more catchments into single point of lower elevation. In Sub-watershed, there are more than one catchments are defined (Fig.2). Sub-watershed is represented by the Orange dot in the left side, purple dot in the right side of Fig.2, and watershed is represented by green boundary. Red dot is the exit of

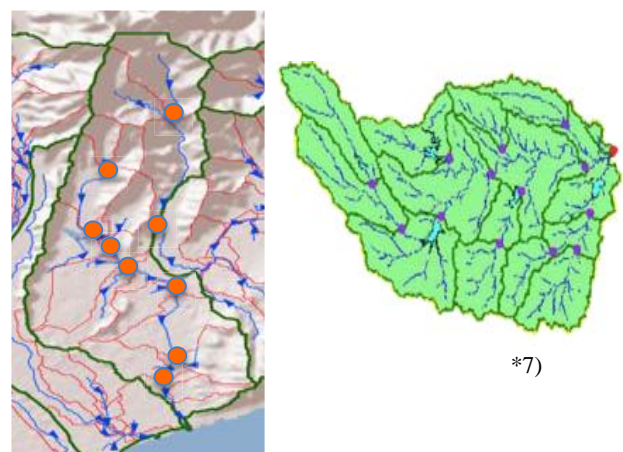


Fig.2 Idea of Sub-Watersheds

the watershed.

c. Watershed

Watershed is defined as the synthesis of all the edge catchments draining into particular hydro junction in the network. It is an extent or 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.3).

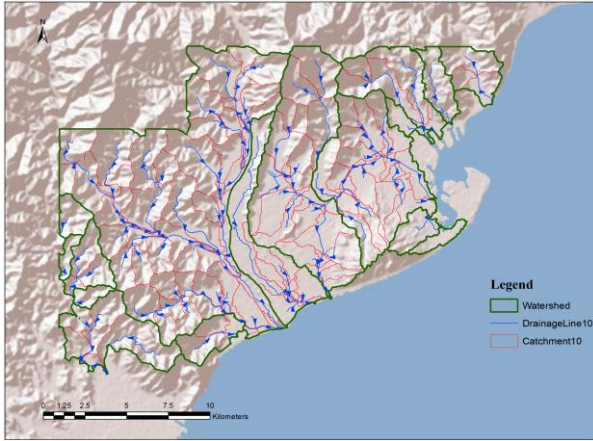


Fig.3 Analyze of Watershed in Shizuoka City

d. The procedures of delineating the watershed

The procedures of delineating the watershed was shown as **Fig.4**. In **Fig.4** (left side), the procedures start from top to bottom, and **Fig.4** (right side) corresponding layers start from bottom to top.

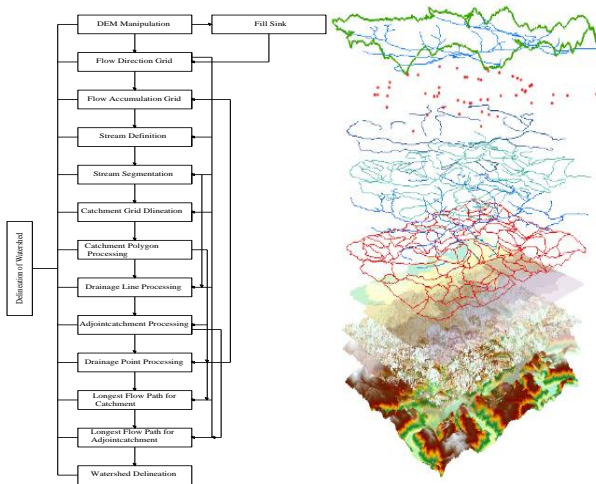


Fig.4 Process of delineating the watershed

e. 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 middle of the catchment. In one catchment, elevation of each catchment edge is difference.

(2) Research Methodology

In this study, firstly, the list of castles shown on the website by Eric.O⁶⁾ was used. In this website, Japanese castle information were collected and 3 types of castles were introduced: Mountaintop, Hilltop and Flatland. Secondly, the topographical data was collected from GSI. Thirdly, Identification of watershed was conducted. Then location of castle was defined. Finally, the maps between the urban structure of Edo period and catchment maps out put from the GIS were overlaid.

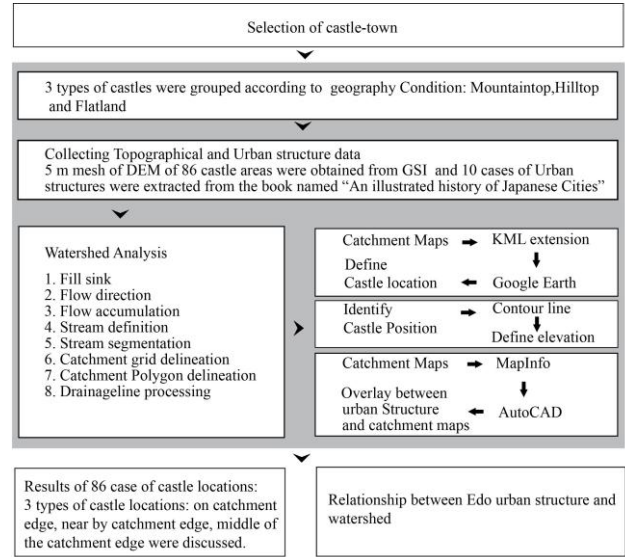


Fig.5 Framework of Research Methodology

(3) Analysis Method

a. Data and Computing software

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. Urban structure maps were extracted from the book “An illustrated history of Japanese Cities” with the exact scale⁸⁾. 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 built points 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.

Geographic Information System (GIS) is a tool for determinating the topography, hydrologic and geomorphologic characteristics of watershed including flow direction, flow accumulation, natural drainage line, sub-watershed from the digital elevation model (DEM). ESRI’s ArcGIS Desktop 10.2 with the extension of ArcHydro 10.2 was used for analyzing the 86 castle locations and their urban structures associated with the watershed.

b. Identification of watershed

Watershed shape, size vary according to difference topography and characteristics of each city. In this study, threshold of 1% gave a definition of stream. It means that stream definition equals to 1% of the flow accumulation which is the accumulation of flow direction. Flow direction was obtained on the basis of the slope. Slope was calculated based on the 8-direction pour point model. Finally, the areas of stream having the value less than the definition is not considered as the stream so that the catchment is not established.

c. Analysis of castle location

In order to determine the castle locations more precisely, the catchment maps and drainage line were exported to google earth by KML extension. Importing these extension to google earth then key in the name of the castle name, the location of castle was defined. The location of castle and catchment located the castle showing the Hydro ID were defined in Google Earth, then the location of castle can be found easily in ArcGIS. 3 types of castle locations: on the catchment, near by the catchment edge and middle of the catchment edge were discussed. The contour lines were out put to show clearly the elevation of each castle location with its surrounding and within the catchment it's located.

(4) Example of Analysis

In order to clarify the process of analysis clearly, In this study, Iyo Matsuyama castle, an original castle, an hilltop castle, was selected as the example.

a. Study area

12,013 ha of castle location areas were used for conducting the analysis of watershed. It contains a total of 251 catchments as shown in Fig.6a. The total area of the catchment located the castle is 119 ha.

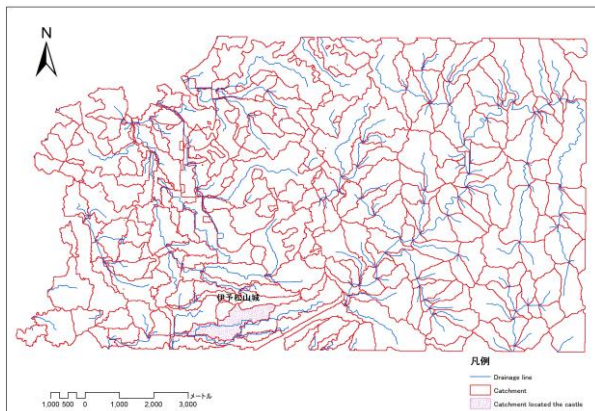


Fig 6a. Catchment and Drainage line of study area of Iyo Matsuyama castle

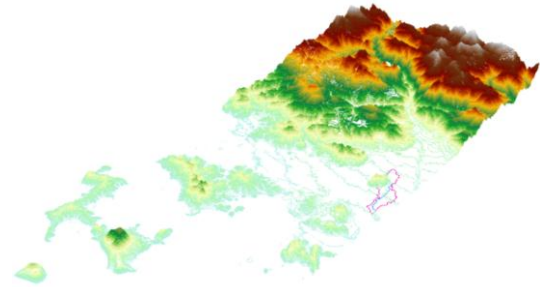


Fig. 6b Contour line of study area of Iyo Matsuyama castle in 3D

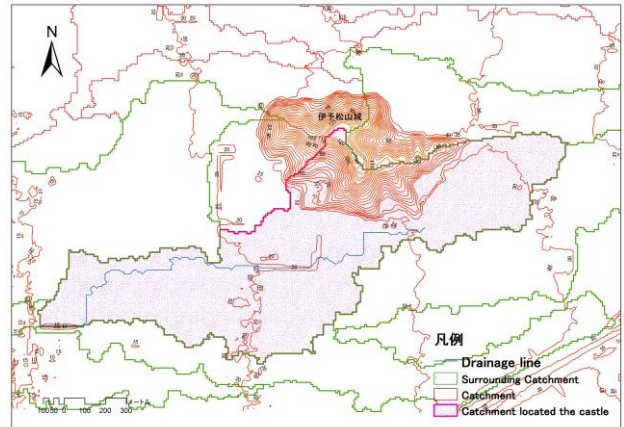


Fig.6c Catchment located the castle and its surrounding catchment

b. Data Analysis

In Fig.6c, pink color denotes the catchment located the castle with the castle location, green denotes the surrounding catchments, natural drainage line was represented by blue line color. These data were out put from the ArcGIS. From this figure, the castle location is located on the catchment edge and at the highest elevation area within the catchment its located. Moreover, it was also found as the highest elevation comparing to its surrounding.

4. RELATIONSHIP BETWEEN LOCATION OF CASTLE AND CATCHMENT

1) Three types of castle

In this study, the data was categorized according to the geography condition of castle locations: Mountaintop, Hilltop and Flatland. Within 138 castles, 13/18 of Mountaintop, 36/62 of Hilltop, and 37/58 of Flatland castle locations were analyzed. Within one catchment, the location of Mountaintop and Hilltop tend to be located more on the catchment edge and near by the catchment edge position, however, in the case of the Flatland, there is not so much difference between located near by the catchment edge or on the catchment edge.

2) Results of the relationship between the castle locations and catchment

Table 1: Summary of results of castle location and catchment

Castles>Type	Catchment Edge			Elevation		Total
	On	Near	Middle	Highest	Not Highest	
Mountaintop	5 (38%)	5(38%)	3(24%)	9 (69%)	4 (31%)	13
Hilltop	18(50%)	18(50%)	0	33(92%)	3(8%)	36
Flatland	6(16%)	29(78%)	2(6%)	34 (92%)	3(8%)	37
Total	29(34%)	52(60%)	5(6%)	76(88%)	10(12%)	86

Table 2: List of castle according to location type

Castle's type	On the catchment edge		Near by the catchment edge		Middle of the catchment edge	
	Total	Name of castle	Total	Name of castle	Total	Name of castle
Mountaintop	5	Hagi, Bitchu Matsuyama Naegi,Oka Takatori	5	Iwakuni, Yamato Koriya Nihonmatsu,Tatsuno Nihonmatsu	3	Kururi Tottori Tsuwano
Hilltop	18	Karatsu,Inuyama Iyo Matsuyama,Ozu Uwajima,Fukuchiyama Tanba Kameyama,Hitoyoshi Fukuyama,Kochi Matsusaka,Yokote Odawara,Kanazawa Saiki,Fukuoka Himeji,Wakayama	18	Mito,Okayama Tsuyama,Morioka Shiroishi,Toba Kaminoyama,Hikone Hirosaki,Shichinohe Kakegawa,Sakura Matsue,Maruoka Aizu Wakamatsu ,Akashi Izushi ,Sasayama	0	No
Flatland	6	Saga,Yodo Kawagoe,Oshi Sekiyado ,Kokura	29	Nagoya,Nishio,Ogaki,Nijo Imabari,Niwase, Tanabe, Tatebayahsi Yamagata,Minakuchi,Zeze,Kagoshima Takada,Sunpu,Kishiwada,Osaka Funai,Shimabara,Matsumoto,Tatsuoka Ueda,Edo,Utsunomiya,Takaoka Toyama Castle Toyooka Jinya Ako,Akizuki,Fukui,Hiroshima	2	Yoshida Yatsushiro

From **Table.1** and **Table.2** show that about 34% of total castle location was found located on the catchment edge, 60% located near by the catchment edge and about 6% located in the middle of the catchment. 88% of most of the castle locations was found located at the highest elevation area 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 as a unit of watershed.

5. URBAN STRUCTURE OF CASTLE – TOWN AND CATCHMENT

(1) Study example

In this section, the main objective is to investigate the relationship between the urban structure of edo period and catchment which can lead to find the regulation of land use and some important facilities such as the temples, shrines so that 10 cases of urban structures of castle-town: Kanazawa, Fukui, Hiroshima, Sunpu, Nagoya, Himeji, Sakura, Hikone

Saga and Tottori castle town, which were extracted from the book “An illustrated history of Japanese cities” were overlaid with the out put catchment maps based on the DEM, 2003.

2) Urban structure of castle-town and catchment

From the 10 case studies found out that the social ranking during edo period might have some relation with the watershed. For example, in the case of kanazawa castle town (**Fig.7a**), samurais are always located on the catchment edge. Temple areas mostly located on the catchment edge and at the highest elevation areas within the catchment it's located. From **Fig.7b**, Himeji castle-town, shows that the urban structure according to social ranking. Upstream is located the samurai area, and downstream is located the Chonin machi.

It seems to be easy to have some regulations just visually see its relationship through the overlaying maps, but quantitative data was difficult to be realized. Therefore, the quantitative data will be defined in the future study.

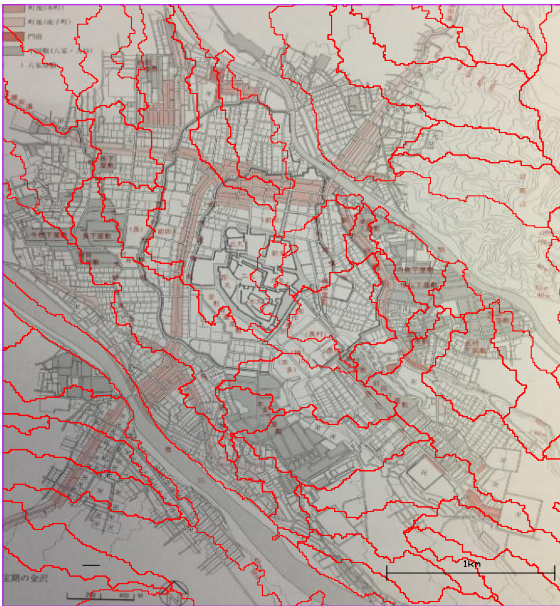


Fig.7a Kanazawa castle-town and catchment

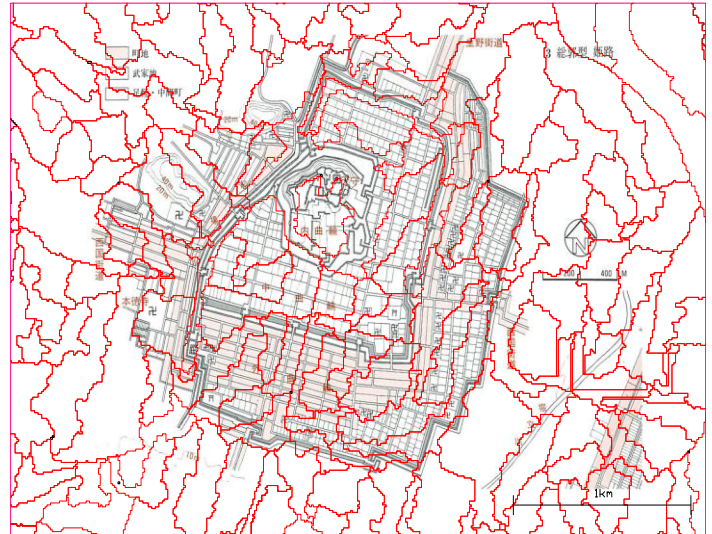


Fig.7b Himeji castle-town and catchment

6. CONCLUSION

Within the 86 case studies of castle locations with 3 types of castle locations: Mountaintop, Hilltop and Flatland was found out that locations of these 3 types of castles were founded located on the catchment edge, near by the catchment edge and middle of the catchment edge. About 34% is located on the catchment edge, 60% of castle locations is located near by the catchment edge and 6% is located at the middle of the catchment edge. 88% of most of the castles locations were 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 as a unit of watershed. 10 case of overlying maps between the urban structure of castle-town and catchment maps showed that the urban structure of edo period had relationship with watershed. Therefore, the watershed can be one of the basic factor for urban planning, urban design, as well as landscape planning for JYOKAMACHI.

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