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Enclosed Spaces of Ancient Japanese Cites and Watersheds: Analysis of Mountain Ranges and Water Systems of Kyoto, Nara, Dazaifu, and Kamakura Using a Three-dimensional Terrain Model

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Keywords: enclosed space, watershed, basin area, mountain range, water system, Kyoto, Nara, Dazaifu, Kamakura

Abstract: In this paper, we used a three-dimensional terrain model to study the relationships between the enclosed spaces of Kyoto, Nara, Dazaifu, and Kamakura and their watersheds. Most previous studies used two-dimensional maps and concluded that these four cities have similar enclosed spaces surrounded by mountains. However, in this study, we analyzed enclosed spaces through watersheds in a wide area using a three-dimensional terrain model and clarified the following points: 1) The Kyoto's basin area is about nine times as large as that of the Nara Basin. 2) Dazaifu's enclosed space is open to the southeast and the northwest, and its basin area is much smaller than Kyoto and cannot store water like the other three cities. 3) Kamakura's enclosed space is surrounded by mountains in three directions and can store water, but its basin area is the smallest among the four cities. 4) Kyoto has the largest basin area among the four cities.

1. Introduction

1.1. BACKGROUND AND OBJECTIVE

In this paper, we used a three-dimensional model to study the relationships among the enclosed spaces of Kyoto, Nara, Dazaifu, and Kamakura and their watersheds.

An enclosed space surrounded by mountains is one of the characteristics of cities in East Asia. We previously studied the relationships between Feng-Shui[1] and the enclosed spaces of Seoul, Keasong, Changan, Kyoto, and Nara (Tembata and Okazaki, 2012, 2011a, 2012b). In Feng-Shui, an enclosed space surrounded by mountains is considered ideal, because its surrounding mountains can protect it from wind and it can store water. In this paper, we analyzed such enclosed spaces through their watersheds.

Most previous studies used two-dimensional maps around cities and concluded that Kyoto, Nara, Dazaifu and Kamakura have similar enclosed spaces. However, we analyzed the enclosed spaces of these cities through watersheds in a wide area using a three-dimensional terrain model, which, to the best of our knowledge, have never been done before.

We believed that this study identifies useful knowledge for city planning and landscape conservation in future Japan.

1.2. LITERATURE REVIEW

Most previous studies used two-dimensional maps to study enclosed spaces of ancient Japanese cities. There are few studies that analyzed mountain ranges and water system of enclosed spaces using three-dimensional terrain models.

Higuchi (1975) concluded that Nara, Kyoto, and Kamakura have similar enclosed spaces and belong to the Zofu-Tokusui[2] type. Mezaki (1998) concluded that Nara, Kyoto, and Kamakura were influence by Feng-Shui and have similar enclosed spaces. Mori (2003) concluded that Dazaifu has an enclosed space that is similar to Nara and Kyoto. Kawasumi (2011) used a three dimensional urban model and clarified that the realationship between shapes of mountains and the Heian-kyo's central axes, but he did not analyze the water system of Kyoto's enclosed space.

2. Methods

2.1. OBJECTIVE

In this paper, we compare Kyoto (Heian-kyo), Nara (Fujiwara-kyo and Heijo-kyo), Dazaifu and Kamakura to clarify the relationships among their enclosed spaces, which are surrounded by mountains and their watersheds. All four cities have enclosed spaces and are typical Japanese ancient or premedieval cities. Fig. 1 shows the positions of these four cities in Japan.

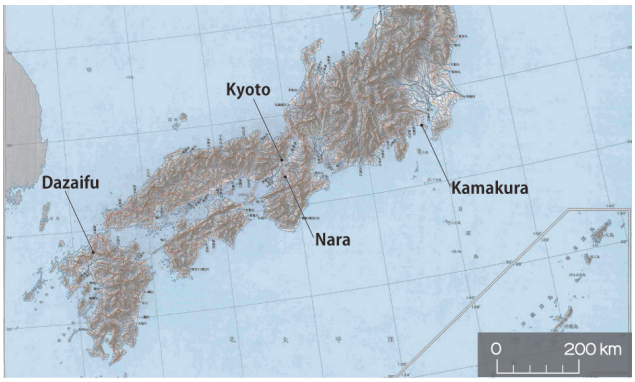


Fig. 1 Positions of Kyoto, Nara, Dazaifu, and Kamakura (based on Geospatial Information Authority of Japan, 1990)

2.2. METHODS

Based on Google Earth, we made a three-dimensional terrain model of the topography to show the enclosed spaces of the four cities. A three-dimensional CG perspective can show spaces that are not expressed in words or by a two-dimensional map. We confirmed the precision of our three-dimensional terrain models by fieldwork or references. Our discussion focused on watersheds in a wide area.

3. Discussion

3.1. KYOTO AND NARA

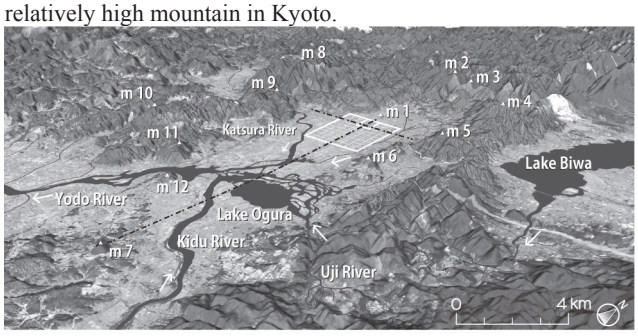
3.1.1. Enclosed space of Kyoto (Heian-kyo)

Kyoto (Heian-kyo) was Japan's capital from 794-1868.

Figure 2 shows a topographical map of Heian-kyo, which is located on the north side of the Kyoto Basin. Its enclosed space is surrounded by mountain ranges on its north, west and east sides and is open to the south side. Kyoto is surrounded by the following mountains: north Kitayama mountain ranges, including Mt. Kibune (700 m) and Mt. Kurama (584 m), east Higashiyama mountain ranges, including Mt. Hiei (848 m), Mt. Daimonji (466 m), and Mt. Inari (232 m), west Nishiyama mountain ranges, including Mt. Atago (924 m), Mt. Sanjogamine (482 m), Mt. Kamose (679 m), and Mt. Tenno (270 m), and a south hilly area, including Mt. Kamnabi (221 m) and Mt. Otoko (143 m). The central axis matches the top of Mt. Funaoka (113 m).

Figure 3 shows a birds-eye view of a three-dimensional terrain model of the enclosed space of Heian-kyo across the Kyoto Basin. The Kamo River flows on the east side of Heian-kyo, and the Katsura River flows on the west side from north to south, because the enclosed space's north side has a higher altitude than the south side. The Kamo and the Katsura Rivers join the Uji River near Lake Ogura, which has been drained. On the west side of Lake Ogura, the Uji and Kidu Rivers join the Yodo River and flow between Mt. Otoko and Mt. Tenno into the Osaka Plain.

Figure 4 shows a view from Mt. Hiei. Fig. 5 shows a view from Kyoto Tower (observation deck, altitude 100 m). West Mt. Atago and Northwest Mt. Hiei are conspicuously seen in a relatively high mountain in Kyoto.



m 1: Mt. Funaoka (113 m) m 5: Mt. Daimonji (466 m) m 9: Mt. Sanjogamine (482 m)
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m 3: Mt. Kurama (584 m) m 7: Mt. Kamnabi (221 m) m 11: Mt. Tenno (270 m)
m 4: Mt. Hiei (848 m) m 8: Mt. Atago (924 m) m 12: Mt. Otoko (143 m)

Fig. 3 Three-dimensional terrain model of enclosed space of Heian-kyo (based on Google Earth[3])

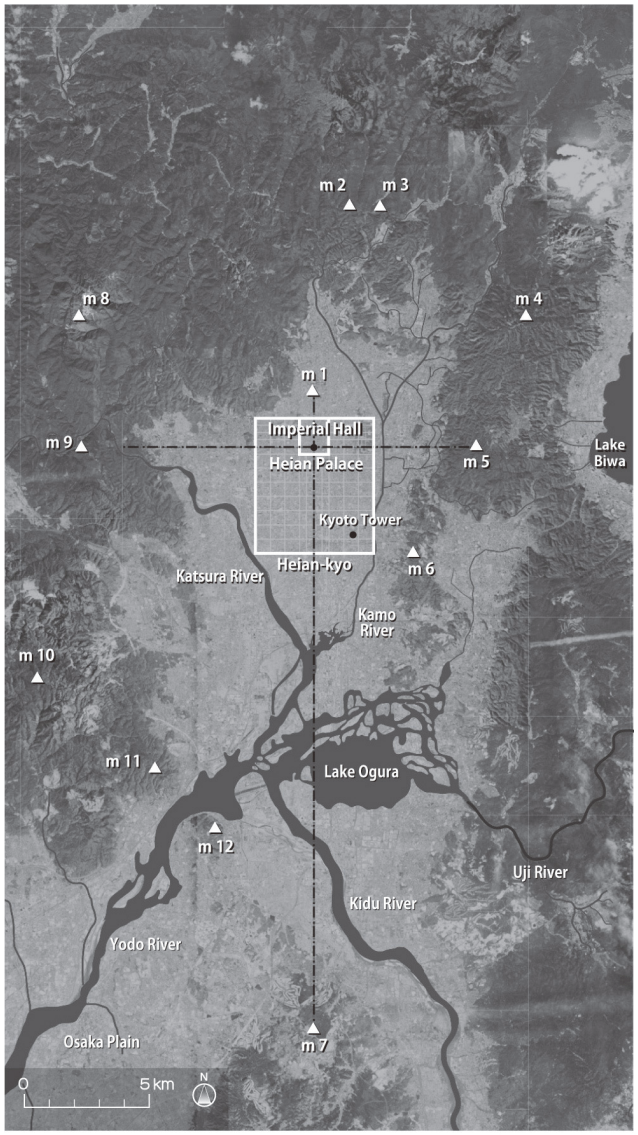

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Fig. 2 Topographical map of Heian-kyo (based on Google Maps and Geospatial Information Authority of Japan)

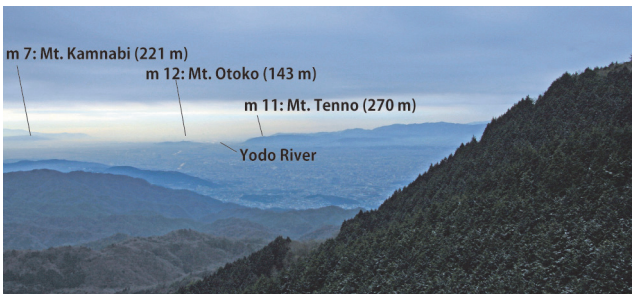


Fig. 4 Overview of Kyoto Basin from Mt. Hiei (photo by author, 2013)

Fig. 5 Overview of Kyoto Basin from Kyoto Tower (based on photos by author, 2004)

3.1.2. Enclosed space of Nara (Fujiwara-kyo and Heijo-kyo)

Fujiwara-kyo was the capital city of Japan from 694-710. Heijo-kyo was the capital city of Japan from 710-740 and again from 745-784.

Figure 6 shows a topographical map of Fujiwara-kyo and Heijo-kyo across the Nara Basin.

Fujiwara-kyo, which is located in the south side of Nara Basin, is surrounded by the Three Mountains of Yamato: to the north Mt. Miminashi (139 m), to the east Mt. Amanokagu (152 m), and to the west Mt. Unebi (199 m). In its more outlying areas, Fujiwara-kyo is surrounded by the following mountains: northeast Mt. Miwa (467 m), eastern mountain ranges including Mt. Otowa (851 m), on the south side, Ochioka Hill (150 m) and mountain ranges including Mt. Oharetsu (618 m), to the far south Mt. Yoshino (500 - 900 m), and to the west mountain ranges including Mt. Nijo (517 m), Mt. Katsuragi (959 m), and Mt. Kongo (1125 m).

Heijo-kyo, which is located on the northern side of the Nara Basin and has an enclosed space, is surrounded by mountain ranges on its north, west and east sides and is open to the south: to the north, Mt. Nara (90 - 100 m), to the east, mountain ranges including Mt. Wakakusa (342m), and Mt. Miwa, to the west, Mt. Matsuo (315 m) and mountain ranges including Mt. Ikoma (643 m) and Mt. Shinki (437 m), to the far southwest, mountain ranges including Mt. Nijo, Mt. Katsuragi, and Mt. Kongo, and to the far south Mt. Yoshino.

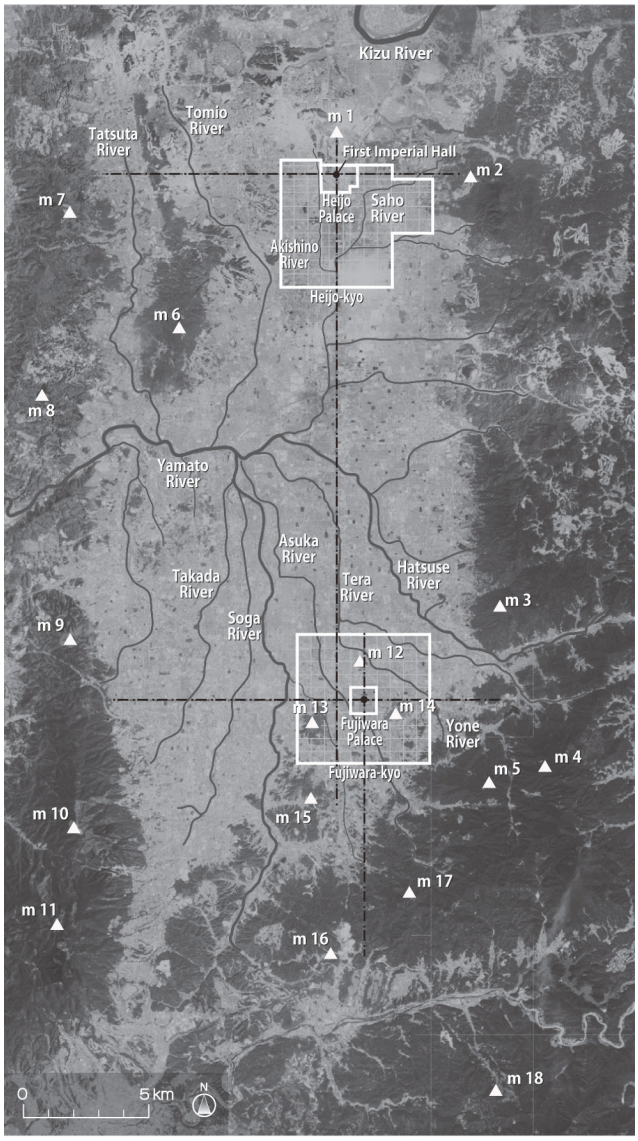
Figure 7 shows a birds-eye view of a three-dimensional terrain model of the enclosed space of Fujiwara-kyo and Heijo-kyo across the Nara Basin.

The south side of Fujiwara-kyo's enclosed space has a higher altitude than the north side. The Asuka River in the center of the city area and the Yone River on the northeast side flow from southeast to northwest. Outside of the city, to the east, the Tera and Hatsuse Rivers flow from southeast to northwest, and to the west the Soga and Takada Rivers flow from south to north. All six rivers join the Yamato River at the center of the Nara Basin.

In Heijo-kyo, the north side of its enclosed space has a higher altitude than the south side. The Saho and Akishino Rivers flow through Heijo-kyo from north to south and join the Yamato River at the center of the Nara Basin. Outside of the city area, to the west, the Tomio and Tatsuta Rivers flow from northeast to southwest. All four rivers join the Yamato River at the center of the Nara Basin. The Yamato River flows from east to west and flows into the Osaka Plain. In the enclosed space of Heijo-kyo, Mt. Nara to the north is lower than the east-west mountain ranges. In the entire Nara Basin, the south side is higher than the north side.

Figure 8 shows the Nara Basin from the ruins of Fujiwara Place. To the north Mt. Miminashi, to the east Mt. Amanokagu, and to the west Mt. Unebi are seen closely. Outside of the three mountains, western mountain ranges from Mt. Nijo to Mt. Kongo, to the east Mt. Otowa and to the south Mt. Yoshino are seen. To the northwest Mt. Ikoma and to the northeast mountain ranges from Mt. Wakakusa to Mt. Miwa can be seen in the distance.

Figure 9 shows the Nara Basin from the First Imperial Hall, which was restored in 2010. Heijo-kyo is surrounded in three directions by mountains. The mountain ranges on the south side are more prominent than those on the north side. To the south, Mt. Kongo and Mt. Yoshino are conspicuously seen as relatively high mountains in Nara. Rolling mountains on the east and west sides and high mountains on the south side enclose Heijo-kyo.



m 1: Mt. Nara (90 - 100 m) m 7: Mt. Ikoma (643 m) m 13: Mt. Unebi (199 m)
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m 5: Mt. OHaretsu (618 m) m 11: Mt. Kongo (1125 m) m 17: Mt. Takatori (584 m)
m 6: Mt. Matsuo (315 m) m 12: Mt. Miminashi (139 m) m 18: Mt. Yoshino (500 - 900)

Fig. 6 Topographical map of Fujiwara-kyo and Heijo-kyo (based on Google Maps and Geospatial Information Authority of Japan)

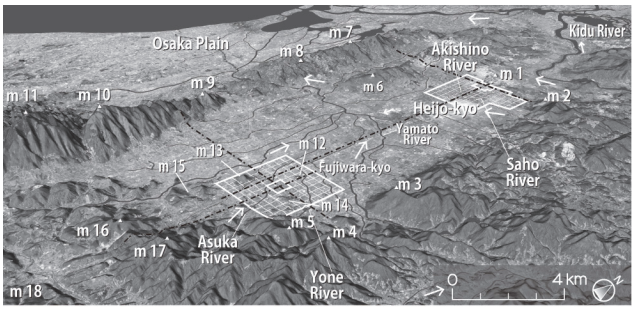

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Fig. 7 Three-dimensional terrain model of enclosed space of Fujiwara-kyo and Heijo-kyo (based on Google Earth[3])

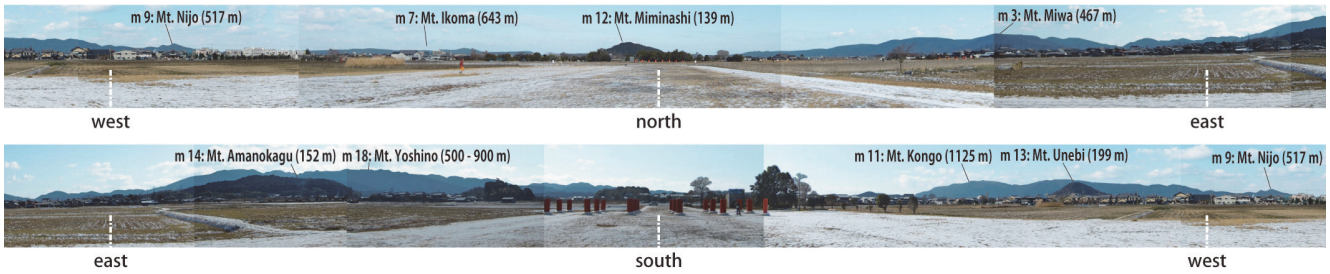


Fig. 8 Overview of Nara Basin from ruins of Fujiwara Place (based on photos by author, 2011)

Fig. 9 Overview of Nara Basin from First Imperial Hall (based on photos by author, 2011)

3.1.3. Watersheds of Kyoto and Nara Basins

Figure 10 shows a topographical map of the Kinai area, which refers to the ancient provinces around the Nara and Heian-kyo capitals. Fig. 11 shows a birds-eye view of a three-dimensional terrain model of the Kinai area. These figures show the watersheds of the Kyoto and Nara Basins in a wide area.

Fig. 10 Watersheds of Kyoto and Nara Basins (based on Google Maps and Geospatial Information Authority of Japan)

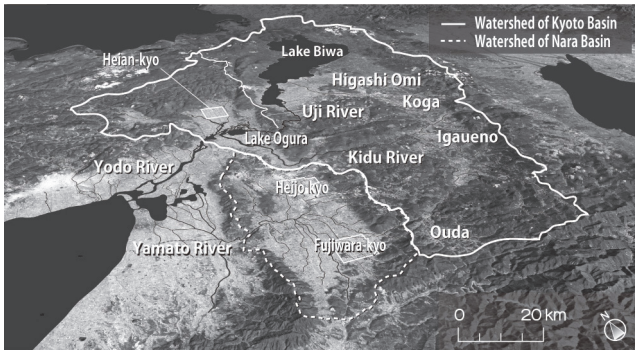


Fig. 11 Three-dimensional terrain model of Kyoto and Nara Basins (based on Google Earth)

The basin area of the water flowing into the Kyoto Basin includes the domain of its penumbra. It also stretches beyond the domain to include all of Shiga prefecture, the eastern part of Nara prefecture (Ouda), and the northwestern part of Mie prefecture (Igaueno and Koga.) Lake Biwa's water, which is gathered from Shiga, becomes the Uji River and flows into the southern part of the Kyoto Basin. The water of the eastern part of Nara prefecture (Ouda) and the northwestern part of Mie prefecture (Igaueno and Koga) becomes the Kidu River and flows into the southern part of the Kyoto Basin. The water of the penumbra of the Kyoto Basin becomes the Kamo and Katsura Rivers, meets the Kidu and the Uji rivers around what used to be Lake Ogura, joins the Yodo River, and flows into the Osaka Plain. The basin area of the water flowing into the Nara Basin is only the domain of the Nara Basin's penumbra. The Kyoto's basin area is about nine times as large as that of the Nara Basin.

3.2. DAZAIFU

3.2.1. Dazaifu's enclosed space

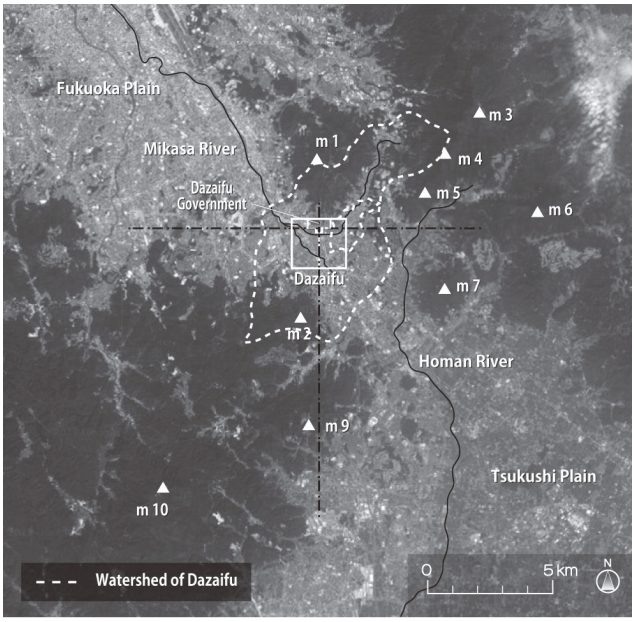
The Japanese term Dazaifu refers to a regional government in Kyushu from the 8th to the 12th centuries. The town of Dazaifu grew up around the civil and military headquarters of the regional government. During the 8th and 9th centuries, records called Dazaifu the "distant capital."

Figure 12 shows a topographical map of Dazaifu, which is surrounded by the following mountains: to the north, Mt. Shioji (410 m), to the northeast, mountain ranges including Mt. Otake (439 m), Mt. Homan (829 m), and Mt. Sangun (936 m), to the east, Mt. Onechi (652 m) and Mt. Miyachi (335 m), and to the south, Mt. Tenhai (256 m) and Mt. Ki (404 m). Dazaifu is

located in a valley between the Fukuoka and Tsukushi Plains in front of Mt. Shioji. Dazaifu is open to the southeast and the northwest.

Figure 13 shows a birds-eye view of a three-dimensional terrain model of Dazaifu's enclosed space. In Dazaifu, the south side of its enclosed space has a higher altitude than the north side. Dazaifu's watershed is located in the valley between Mt. Tenhai and Mt. Otake to the south. The Mikasa River flows from the northeast and through in front of the ruins of Dazaifu government from west to east and to the northwest to the west outside of Dazaifu. The Homan River flows on the east side of Mt. Homan from north to south and into the Tsukushi Plain.

Figures 14,15 and 16 show Dazaifu from Mt. Shiouji, Mt. Tenhai and the ruins of Dazaifu Government.



m 1: Mt. Shioji (410 m)
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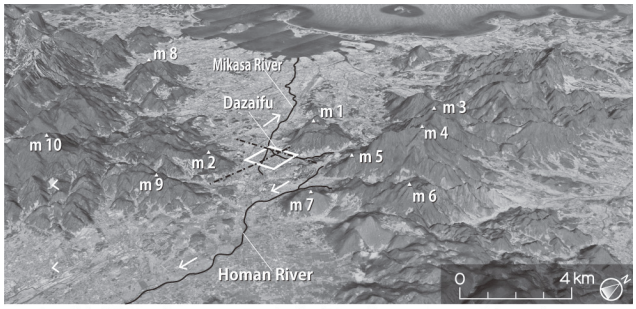
m 6: Mt. Onechi (652 m)
m 7: Mt. Miyachi (335 m)
m 8: Mt. Abura (597 m)
m 9: Mt. Ki (404 m)
m 10: Mt. Kusenbu (848 m)

Fig. 12 Topographical map of Dazaifu (based on Google Maps and Geospatial Information Authority of Japan)



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m 10: Mt. Kusenbu (848 m)

Fig. 13 Three-dimensional terrain model of enclosed space of Dazaifu (based on Google Earth[3])

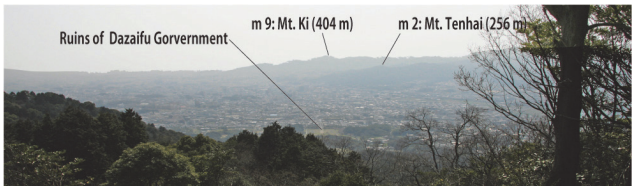


Fig. 14 Overview of Dazaifu from Mt. Shiouji (photo by author in 2013)

Fig. 15 Overview of Dazaifu from Mt. Tenhai (photo by author in 2013)

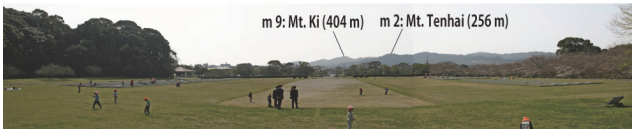


Fig. 16 View from ruins of Dazaifu Government (based on photos by author in 2013)

3.2.2. Dazaifu's Watershed

Figure 17 shows a topographical map of the northern Kyushu area including Dazaifu. Fig. 18 shows a birds-eye view of a three-dimensional terrain model of it. These figures show the watershed of Dazaifu in a wide area.

Dazaifu only has the Mikasa River in a wide area. The water of the east side of the mountain ranges, including nearby Mt. Homan, becomes the Homan River and flows through the Chikushi Plain and joins the Chikugo River. Water cannot gather in Dazaifu's topography like in the Kyoto Basin. The Dazaifu's basin area is much smaller than either the Kyoto or the Nara Basins.

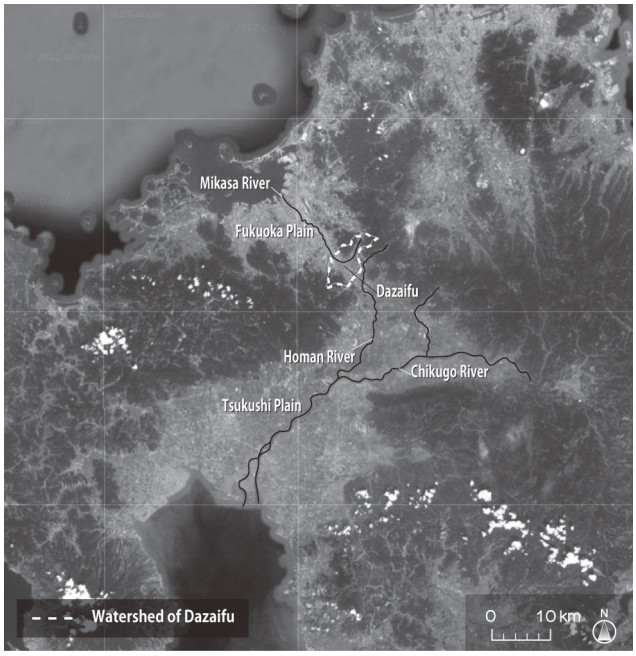


Fig. 17 Watershed of Dazaifu (based on Google Maps)

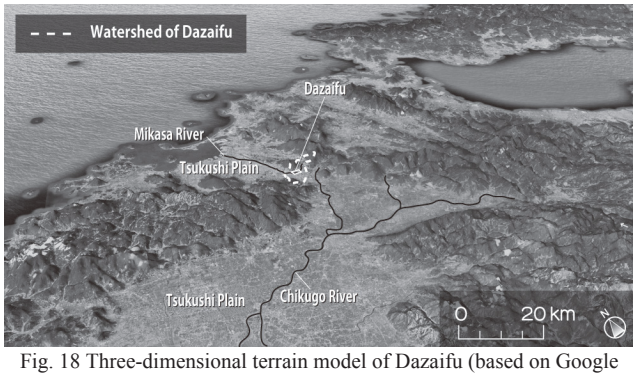


Fig. 18 Three-dimensional terrain model of Dazaifu (based on Google Earth[3])

3.3. KAMAKURA

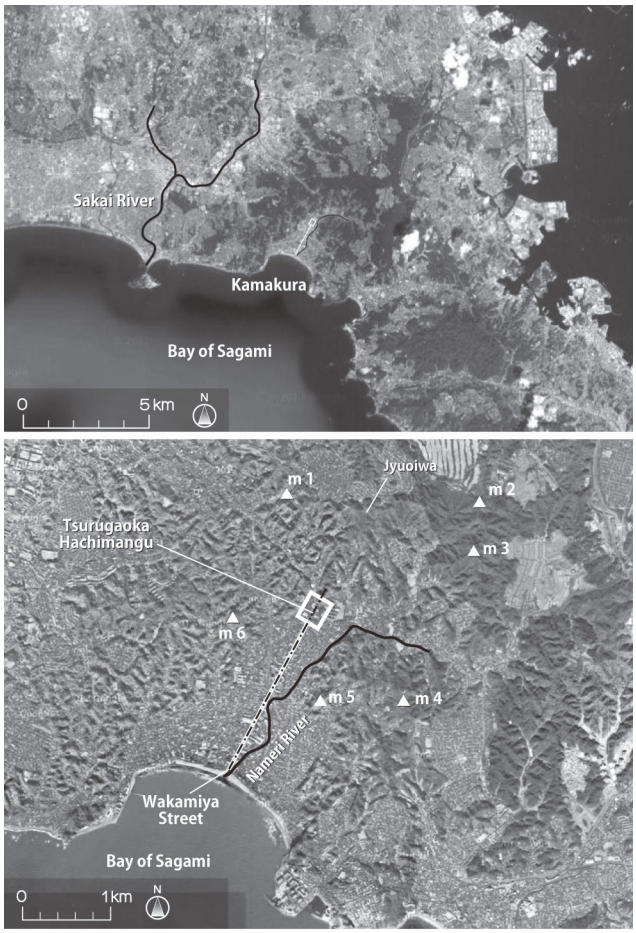
3.2.1. Kamakura's enclosed space.

Kamakura was chosen to be the first shogunate capital of Japan from 1192-1333, because its topography, which is surrounded by mountains in three directions and faces the sea, was suitable for defense.

Figure 19 shows a topographical map of Kamakura, which is surrounded by the following mountains: to the north, mountain ranges including Mt. Rokkokuken (147 m), Mt. Tenhei (159 m), Mt. Tendai (142 m), to the east mountain ranges including Mt. Kinubari (120 m) and Mt. Gion (58 m), and to the west mountain ranges including Mt. Genji (92 m). Tsurugaoka Hachimangu, which is Kamakura's central shrine, is located in front of the northern mountain ranges. The south side faces the sea.

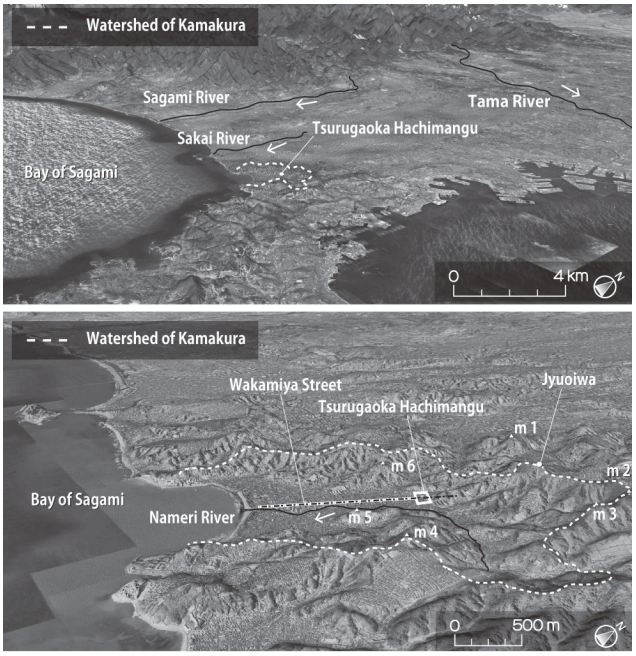
Figure 20 shows a birds-eye view of a three-dimensional terrain model of Kamakura's enclosed space. In Kamakura, the north side of its enclosed space has a higher altitude than the south side. The Nameri River flows to the sea through Kamakura from the northeast to the south. Kamakura's topography can gather water like in the Kyoto Basin.

Figure 21 shows Kamakura from Jyuoiwa in the northern mountains, and Fig. 22 shows it from Mt. Kinubari. Figs. 23 and 24 show Kamakura from the Wakamiya Street and from the Tsurugaoka Hachimangu.



m 1: Mt. Rokkokuken (147 m) m 3: Mt. Tendai (142 m) m 5: Mt. Gion (58 m)
m 2: Mt. Tenhei (159 m) m 4: Mt. Kinubari (120 m) m 6: Mt. Genji (93 m)

Fig. 19 Topographical map of Kamakura (based on Google Maps and Geospatial Information Authority of Japan)



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m 2: Mt. Tenhei (159 m) m 4: Mt. Kinubari (120 m) m 6: Mt. Genji (93 m)

Fig. 20 Three-dimensional terrain model of enclosed space of Kamakura (created based on Google Earth[3])

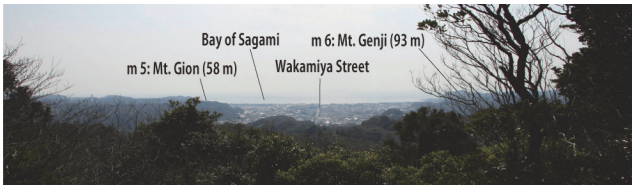

Fig. 21 Overview of Kamakura from Jyuoiwa (photo by author in 2013)

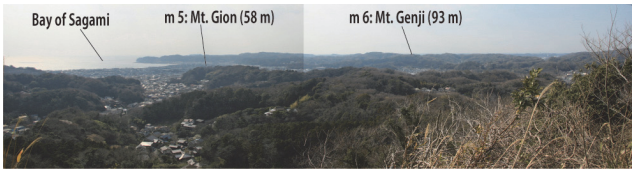

Fig. 22 Overview of Kamakura from Mt. Kinubari (based on photos by author in 2013)

Fig. 23 View of Kamakura from Wakamiya Street (photo by author in 2013)

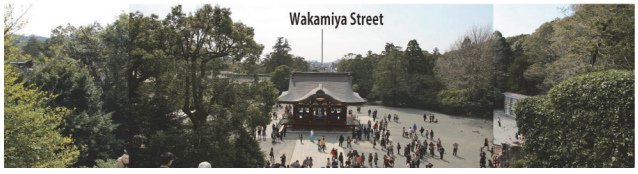

Fig. 24 View of Kamakura from Tsurugaoka Hachimangu (based on photos by author in 2013)

3.3.2. Kamakura's watershed

Figure 25 shows a topographical map of the southern Kanto area including Kamakura. Fig. 26 shows a birds-eye view of a three-

dimensional terrain model of it. These figures show the watershed of Kamakura in a wide area.

The basin area of water flowing into Kamakura is only the domain of Kamakura's penumbra. Its basin area is much smaller than either the Kyoto or Nara Basins and smaller than Dazaifu.

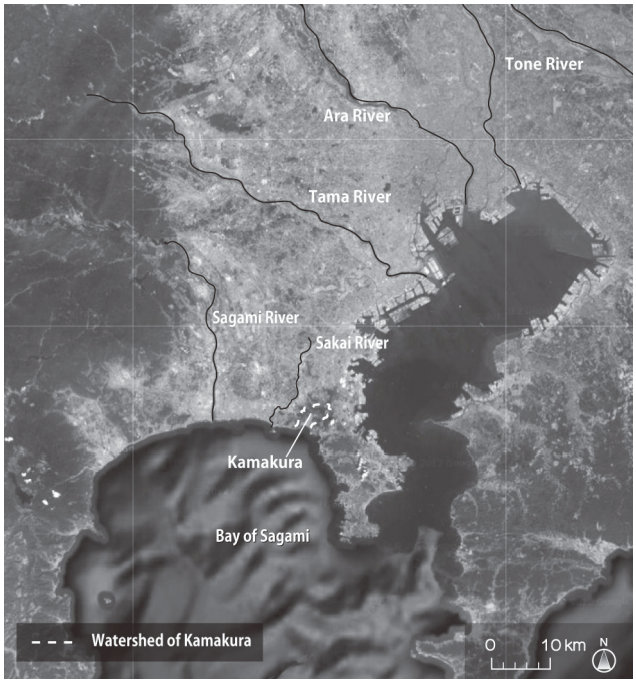

Fig. 25 Watershed of Kamakura (based on Google Maps)

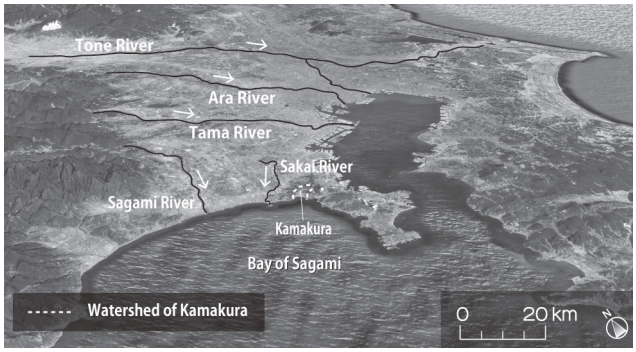

Fig. 26 Three-dimensional terrain model of Kamakura (based on Google Earth[3])

4. Conclusion

We used three-dimensional terrain models to study the relationships among the enclosed spaces of the cities of Kyoto (Heian-kyo), Nara (Fujiwara-kyo and Heijo-kyo), Dazaifu, and Kamakura and their watersheds and clarified the following points:

1) Kyoto (Heian-kyo) and Nara (Fujiwara-kyo and Heijo-kyo) have enclosed spaces that is surrounded by mountains on all four sides in a wide area and can store water. The Kyoto's basin area is about nine times as large as that of the Nara Basin. The Kyoto Basin has much greater water resources than the Nara Basin.
2) Dazaifu has an enclosed space that is open to the southeast and the northwest. Its basin area is much smaller than Kyoto's and cannot store water as the three other cities.
3) Kamakura has an enclosed space that is surrounded by mountains on three directions and can store water, but its basin area is the smallest basin area among the four cities.
4) Kyoto (Heian-kyo) has the largest basin area among the four cities.

Endnotes

1. Feng-Shui is an East Asian system of thought that originated in China and stresses harmony with nature and is also used for selecting locations for cities, houses, and graves (Tembata and Okazaki, 2011a).
2. Higuchi (1975) described it as follows: "Zofu-Tokusui is a term derived from the *fusui* (wind and water) theory, a magical theory of site selection that had a great influence in ancient Japan." (p.167)
3. Unevenness of terrain of three-dimensional models is triply emphasized.

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