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Contents:

Abstract

Many natural disasters had occurred in Japan during the second half of the 9th century. It corresponds to the "Medieval climate anomaly (MCA)" or "Medieval warm period (MWP)" existed from 9th to 12th centuries pointed out by the climatology in Europe and U.S.A. In the history of Japan, however, this period is called "ancient period".

In this study, the authors reconstruct a chronology of climatic disasters based on 1,220 cases from 7th to 12th centuries that were obtained by historical documents and clarify according to their kinds and areas. It can be said that numbers of climatic disasters increase in the period with increasing temperature. Especially that is remarkable during the second half of 9th century and the early 10th century. On the kinds of climatic disasters, the most common disaster is storm (26.1%) and the next is drought (19.8%). As for place names related to all climatic disasters, most frequency is Kyoto (48.3%) and second is Nara (7.9%).

From these results, before the 9th century, droughts in Nara were the major climatic disasters. On the other hand, descriptions of disasters caused by too much rain as heavy rains and long rains in Kyoto were found from the 9th century.

Key words: paleoclimate, floods, droughts, medieval climatic period, Nara, Kyoto

Introduction

It is well known that the climate was warmer corresponding with "Medieval climate anomaly (MCA)" or "Medieval warm period (MWP)" in Europe from 9th to 12th centuries. In Japan, Maejima and Tagami (1986) clarified that the 7th to 9th centuries were cool period and the 10th to 14th centuries were warm

period, by analyzing the historical records such as "*Nihonkishoshiryo*". Aono (2013) stated that the period from early to middle in 10th centuries was as warm as the present basing on the records of cherry blossoming. Yoshino (2009) argued that the warm period continued from the 4th to 10th centuries with various scales of fluctuations. According to Kitagawa and Matsumoto (1998) on carbon isotope variations in tree rings of Yakusugi cedars, the estimated temperature deviations from 8th to 12th centuries were 1.0℃ higher than the average during the last 2,000 years.

Moreover, it is historically known that the serious disasters have occurred in Japan during the same warm period. Seismologically, the Jogan Tsunami in 869 has been studied from remains, sediments and old documents by Okamura (2012) and Sangawa (2013) and so on. In "*Nihon sandai jitsuroku*", it is noted that *Mt. Fuji* erupted in 864 and it was one of three major eruptions (Nishikawa 2002). Hotate (2012) discussed also the social impacts of earthquakes in the 7th and 8th centuries and he concluded that this period can be described as "a peculiar period with earthquakes, global warming and pandemics".

As mentioned above, Japan has been suffering from various disasters frequently not only by earthquakes and eruptions but also by climatic disasters such as heavy rains, droughts and so on from7th to 12th centuries.

Japan is very vulnerable to climatic disasters. Even in nowadays, social anxiety is increasing in relation to climatic disasters caused by the global warming. Concerning the effects of global warming, it is expected in Japan that the numbers of extremely hot days (with a maximum temperature above 35℃), unusual extremes of rainfall, and others will increase (IPCC and the Ministry of the Environment of Japan 2013). It has been recognized that climatic disasters tend to increase when air temperature fluctuates violently. Therefore clarification of climatic disasters during 7th to 12th centuries is valuable for predicting the natural and human impacts of global warming at present.

The authors reconstruct chronologies of climatic disasters from 7th to 12th centuries and clarify the regional and species changes of climatic disasters.

Study method

The descriptions of climatic disasters from the ancient times have been founded in the historical documents, such as "*Nihonshoki*", "*Fusoryakuki*", "*Nihon-sandai-jitsuroku*" and the like. These descriptions have been keeping in the meteorological archives.

At first, the authors collected the data of climatic disasters from 7th to 12th centuries from as follows meteorological archives. (1) "*Nihon no kishoshiryo* (Chuo Kishodai and Kaiyo Kishodai 1976)", (2) "*Nihon kanbatsu rin-u shiryo* (Arakawa, et al 1964)", (3) "*Nihon no tensai chihen* (The civic section of Tokyo Metropolitan government 1976)", (4) "*Naraken kishosaigaishi* (Aoki 1956)" and (5) "*Kyoto kishosaigainempyo* (Kyoto Local Meteorological Office 1951)". These archives include descriptions of climatic disasters from the prefectural histories, records of temples and shrines, diaries of prayers for rain and other similar sources. In some cases, place names, sources and detail contents of climatic disasters are also described. Table 1 shows characteristics of used material.

Secondly, these data are grouped into 9 categories according to their kinds: (1) storms, (2) floods, (3) long rains, (4) thunder storms, (5) whirlwinds, (6) droughts, (7) hail storms, (8) heavy snows and (9) frosts. In

these climatic disasters, the cases of storms, floods, long rains and thunder storms may be difficult to distinguish from each other because storms and long rains could have been accompanied with floods. In this paper, we classified these data basing on the way of "*Nihonkishoshiryo*" [i]. The names of places where climatic disasters occurred are collected from these archives. The old place names are arranged into 6 categories as follows:

(1) "Nara" includes its old names "Yamatokoku" and "Yamato".
(2) "Kyoto" includes its old names "Yamashiro-koku" and "Yamashiro".
(3) "Kinki district" includes "Kinai" and "Kinki-Shokoku", but excludes the cases classified as (1) or (2). It means that climatic disasters occurred in Kyoto, Nara and neighboring area simultaneously.
(4) "All provinces" includes "Shokoku" and "Zenkoku", but excludes the cases classified as (1), (2) or (3).
(5) Description, excludes, the above place names, is classified into "the others".
(6) Nameless places are grouped into "Unknown".

If the kinds, place names and dates of climatic disasters obtained from some of five archives are same, the authors counted as one disaster.

Results

The secular change of climatic disasters from 7th to 12th centuries

As mentioned above, the authors describe 1,220 climatic disasters and 1,281 place names in this study and these data are more than the studies of Kusakabe (1977) and Nishikawa (1963) who obtained 174 and 510 data respectively during the same period [ii].

The numbers and percentages of classified climatic disasters from 7th to 12th centuries counted by every decadal years expressed in Table 1.In the 7th century, description of climatic disasters are less than other periods, however drought (30.9%) is most significant disaster and next is storms (18.2%). During the 8th century descriptions is increasing gradually and droughts and storms are occurred the same percentage 29.9%). Descriptions of climatic disasters has increased rapidly in 9th century and significant disasters are storm and thunder storm (19.7%). In 10th century descriptions of climatic disasters are more or less decreased. Descriptions of climatic disasters less further in the 11th century. The most remarkable disaster is storm (31.4%) and its conditions go on the 12th century.

Figure 1 shows the secular change of climatic disasters compared with the estimated temperature deviations reconstructed from tree ring analysis by Kitagawa and Matsumoto (1998) based on every decadal totals. As shown in Figure 1, the fluctuations of the number of climatic disasters are in parallel approximately with the estimated temperature deviations. That is, climatic disasters tend to increase when estimated temperature deviations are greater. Especially, two peaks in the number of climatic disasters are found. They are the periods from the latter half of the 9th Century and the first half of the 11th century simultaneously with rises in temperature. Around the middle of 11th century, there was a significant decrease in number of climatic disasters. In this respect, Katahira (2010) examined the number of times floods occurred in Kyoto from database of Historiographical Institute the University of Tokyo. From these result, it was clarified that

the number of floods in Kyoto is minimum from 8th to 14th centuries. And Takahashi (2012) stated that the level in riverbed of Kamogawa River is dropped from the end of the 10th to the early of the 12th centuries and it would keep the river from overflowing but which details are not cleared. The correlation coefficient between them is 0.35, which is a positive correlation at 95% level of significance.

The regional and species changes of climatic disasters from 7th to 12th centuries

Table 2 summarizes the chronology by the number of climatic disasters counted for every decade on kinds disasters by their kinds and areas. The most common climatic disaster is storm (26.1%), next is drought (19.8%) and third is thunder storm (18.9%). The disasters caused by rain such as storms, floods and long rains occupy about half of them. The most common area is Kyoto making up 48.3%. The second is Nara 7.9% and third is the Kinki District 4.1%. Some of the other place names and percentages are Ise 3.8%, Kamakura 0.7%, Kii 0.5%, Omi 0.5%, Kawachi 0.5% and Kyushu District 0.5%.

Figure 3-a shows secular changes of percentages (%) of climatic disasters. Droughts account for the greatest percentage before 8th century and since then they decrease gradually. Conversely, disasters caused by heavy rain represent the majority of disasters after 9th century. According to Tanioka (2010), major disasters were droughts from the end of 7th to 8th centuries whereas they were long rains in the latter half of the 9th century. Kusakabe (1977) also stated that droughts were more than half of climatic disasters in 7th and 8th Centuries, in contrast to rain and flood damages in 10th to 12th centuries. Although the present study comes to almost similar conclusion to them as secular change, we make attention to spatial changes of climatic disasters (Figure 3-b). As shown in this figure, the percentage of disasters is remarkable covered by Nara until the latter half of 8th century. On the contrary, Kyoto occupies half of them, whereas historical description in Nara nearly vanished from the 9th century because, historical descriptions concentrate into capital city. That is, Nara was the capital of Japan from 593 to 794 and Kyoto was the capital of Japan from 794 to 1192[iii]. From this analysis we can conclude that, records of climatic disasters indicate that there were frequent droughts in Nara before 9th century while there were more disasters caused by much rain in Kyoto from 9th to 12th centuries.

Figure 4 shows that the percentages of climatic disasters from 7th to 12th centuries in Nara, compared with Kyoto. Droughts in Nara makes up 23.8%, in contrast to Kyoto which shows only 7.4%. On the contrary, about the floods, Kyoto shows about 10% higher than Nara. Especially, climatic disasters relative to rainfall are more than 70% in Kyoto.

Marumoto (2014) calculated the P.E. (potential evapo-transpirations) and water budgets in Nara and Kyoto by Thornthwaite's method and confirmed that the water deficit in Nara is more than Kyoto and vice versa on water surplus. From these results, it can be said that the droughts occurred more frequently in Nara due to water deficit while the floods occurred more often due to water surplus in Kyoto.

Summary

In this study, the authors reconstruct the chronology of climatic disasters from 7th to 12th centuries and clarify their regional and species changes. The following results were obtained.

(1) Climatic disasters increased during the latter half of the 9th and first half of the 11th centuries.

(2) Droughts were the major climatic disasters before the 9th century while disasters caused by too much rain prevailed from the 9th century. But the areas of descriptions on climatic disasters changed from Nara to Kyoto in the latter half of the 8th century.

From these results, it is considered that the climatic disasters may have effects on the local climate.

Prospects

Generally, studies of the paleoclimate previously has been studied only on their secular changes, and little attention has been to local differences of paleoclimate. But climate is a comprehensive or synthetic condition of atmosphere and consists of the secular changes as global warming, the spatial features as local climate and so on. In order to reconstruct the paleoclimate, it is necessary to consider not only climatic changes but also local climates. The Nara and Kyoto basins belong to the Setouchi climate that has relatively less of rain in Japan. Nevertheless, in Nara a lot of irrigation ponds were built due to frequently occurring droughts from the ancient times and there were more than ten thousand irrigation ponds [iv]. In "Nihonshoki", some of irrigation ponds in Nara had been built in 607 and 613. Moreover, a number of hidden wells were constructed at rice fields in addition to irrigation ponds (Aoki 1961; Nara Local Meteorological Office 1997; Nara Prefecture 2014). Meanwhile, some significant proverbs meaning that Nara had a distressing lack of water remain such as "Yamato Hideri (weather in Nara is dry)", "Yamato Honen Komekuwazu" which means that it rains properly to fruitful harvest in Nara while poor harvest in other areas caused by much rains. It is also said that droughts in Nara have been fateful events since the dawn of history (Tsujita 1961) and it has brought civilizations of poor water supply, as mentioned above to the people in Nara.

On the contrary, the Kyoto Basin had been frequently tormented with floods by heavy rains from 9th century in spite of belonging to the Setouchi climate same as the Nara Basin. Another factor, it is assumed that the flood disasters in Kyoto are brought about by the concentration of rivers such as the Kamogawa, Katsuragawa and others. As a matter of fact, the people of Kyoto have suffered Kamogawa River floods frequently since ancient times (Yoshikoshi and Katahira 2012). In addition, Kyoto is the so-called "metropolis of water" which means that plenty water has brought about cultures as tea, sake, tofu, dyeing and so on (Suzuki 2003, 2010, Kappa Kenkyukai 2013).

Fig.5 shows the concept of components on paleoclimate from 7th to 12th centuries in Nara and Kyoto. These comprehensive or synthetic climates bring about indigenous civilization to people as Figure 5. Climate usually changes in time and in space. We would like to emphasize that there are no geographical studies without considering "its place" which geographical place itself. On the differences of local climate in Nara and Kyoto, it is necessary to investigate especially both basin-climate and the Setouchi climate.

Notes

[i] According to Chuo Kishodai and Kaiyo Kishodai (1976), storms are classified into not only heavy rain coinciding with gales but also gales without rain. Storms are regarded as just gales observed in one district

while heavy rain and floods are observed in other district, but they are not regarded to heavy rains and gales occurring with thunder or whirlwinds. The floods represent some damages from both heavy-rains and long rains without gales. Furthermore the floods caused by storms and thunder storms are excluded to avoid duplication. The thunder storms consist of lightning, hailstones, gales or heavy-rains which are able to bring disasters. However, thunder storms with whirlwinds are classified as whirlwinds. The whirlwinds contain mainly tornados and include the episode of dragon, huge serpent or "*Mizuchi* "(imaginary animal) because these animals were considered related to tornados in the past. Moreover, singular winds as "*Shofu*" or "*Ichimokuren*" are also classified into the whirlwinds. On the other hand, droughts mean that no rainfall continued for one to several months and a few records of prayers for rain are also counted to the droughts. The rainfalls go on so long as a month or more that they are added to the long rains if they caused disasters. However, the long-rains that obviously caused floods are classified into floods to keep out duplication. The heavy snows involve the cases of the snowfall more than 1 *shaku* (about 33*cm*) around Kinki and Kanto districts. The damages by hail storms are classified mainly into hail storms. But the hail storms with thunder are classified into thunder storms.

[ii] Kusakabe (1977) counted only climatic disasters that occurred in two or more areas from "Nihonkishoshiryo" and Nishikawa(1963) used just "Nihonsaiishi" for accounting climatic disasters, which show why their disaster's data are less than ours.

[iii] The period when there was a capital in Kyoto is estimated until 1185 or 1192 and so on. In this study, the authors used 1192 as the end of period.

[iv] According to Hall (1932), there were 10,056 irrigation ponds in the Nara Basin at the first half of the 20 century and 70.9% of the area was irrigated. On the details of irrigation area, it is said that the areas irrigated by ponds, rivers and wells were 72.4%, 25.6% 1.6% respectively.

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Table 1-(a). The contents of climatic disasters from7th to 12th centuries

	Storms	Floods	Long-Rains	Thunder storms	Whirlwinds	Droughts	Hail storms	Heavy-Snows	Frosts	subtotal
601~610	0	1	0	0	0	1	0	0	0	2
	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(100.0)
611~620	0	0	0	0	0	0	0	0	0	0
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
621~630	0	1	1	0	0	2	2	0	1	7
	(0.0)	(14.3)	(14.3)	(0.0)	(0.0)	(28.6)	(28.6)	(0.0)	(14.3)	(100.0)
631~640	2	1	1	0	0	1	0	0	0	5
	(40.0)	(20.0)	(20.0)	(0.0)	(0.0)	(20.0)	(0.0)	(0.0)	(0.0)	(100.0)
641~650	2	1	1	1	0	1	6	0	1	13
	(15.4)	(7.7)	(7.7)	(7.7)	(0.0)	(7.7)	(46.2)	(0.0)	(7.7)	(100.0)
651~660	0	1	0	0	0	1	0	0	0	2
	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(100.0)
661~670	0	1	0	2	0	0	0	1	0	4
	(0.0)	(25.0)	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(25.0)	(0.0)	(100.0)
671~680	3	1	0	0	0	4	1	0	0	9
	(33.3)	(11.1)	(0.0)	(0.0)	(0.0)	(44.4)	(11.1)	(0.0)	(0.0)	(100.0)
681~690	2	0	0	1	0	6	0	0	0	9
	(22.2)	(0.0)	(0.0)	(11.1)	(0.0)	(66.7)	(0.0)	(0.0)	(0.0)	(100.0)
691~700	1	2	0	0	0	1	0	0	0	4
	(25.0)	(50.0)	(0.0)	(0.0)	(0.0)	(25.0)	(0.0)	(0.0)	(0.0)	(100.0)
701~710	7	0	3	2	0	7	0	0	0	19
	(36.8)	(0.0)	(15.8)	(10.5)	(0.0)	(36.8)	(0.0)	(0.0)	(0.0)	(100.0)
711~720	5	0	0	0	0	4	0	0	0	9
	(55.6)	(0.0)	(0.0)	(0.0)	(0.0)	(44.4)	(0.0)	(0.0)	(0.0)	(100.0)
721~730	1	2	0	3	1	1	0	0	0	8
	(12.5)	(25.0)	(0.0)	(37.5)	(12.5)	(12.5)	(0.0)	(0.0)	(0.0)	(100.0)
731~740	1	0	0	0	0	3	0	0	0	4
	(25.0)	(0.0)	(0.0)	(0.0)	(0.0)	(75.0)	(0.0)	(0.0)	(0.0)	(100.0)
741~750	3	1	1	3	0	6	1	0	0	15
	(20.0)	(6.7)	(6.7)	(20.0)	(0.0)	(40.0)	(6.7)	(0.0)	(0.0)	(100.0)
751~760	5	0	0	0	1	0	0	2	0	8
	(62.5)	(0.0)	(0.0)	(0.0)	(12.5)	(0.0)	(0.0)	(25.0)	(0.0)	(100.0)
761~770	4	4	1	1	0	10	1	0	0	21
	(19.0)	(19.0)	(4.8)	(4.8)	(0.0)	(47.6)	(4.8)	(0.0)	(0.0)	(100.0)
771~780	11	3	1	6	0	6	2	0	0	29
	(37.9)	(10.3)	(3.4)	(20.7)	(0.0)	(20.7)	(6.9)	(0.0)	(0.0)	(100.0)
781~790	2	2	0	2	0	3	0	0	0	9
	(22.2)	(22.2)	(0.0)	(22.2)	(0.0)	(33.3)	(0.0)	(0.0)	(0.0)	(100.0)
791~800	4	5	1	3	0	3	2	4	0	22
	(18.2)	(22.7)	(4.5)	(13.6)	(0.0)	(13.6)	(9.1)	(18.2)	(0.0)	(100.0)

Table 1-(b). The contents of climatic disasters from7th to 12th centuries

	Storms	Floods	Long-Rains	Thunder storms	Whirlwinds	Droughts	Hail storms	Heavy-Snows	Frosts	subtotal
801~810	5 (25.0)	3 (15.0)	4 (20.0)	0 (0.0)	0 (0.0)	5 (25.0)	2 (10.0)	1 (5.0)	0 (0.0)	20 (100.0)
811~820	2 (10.0)	2 (10.0)	2 (10.0)	1 (5.0)	1 (5.0)	7 (35.0)	1 (5.0)	4 (20.0)	0 (0.0)	20 (100.0)
821~830	1 (6.7)	2 (13.3)	3 (20.0)	3 (20.0)	0 (0.0)	5 (33.3)	0 (0.0)	1 (6.7)	0 (0.0)	15 (100.0)
831~840	7 (33.3)	2 (9.5)	1 (4.8)	4 (19.0)	1 (4.8)	6 (28.6)	0 (0.0)	0 (0.0)	0 (0.0)	21 (100.0)
841~850	3 (13.0)	5 (21.7)	2 (8.7)	4 (17.4)	1 (4.3)	3 (13.0)	1 (4.3)	3 (13.0)	1 (4.3)	23 (100.0)
851~860	14 (29.2)	11 (22.9)	1 (2.1)	10 (20.8)	1 (2.1)	3 (6.3)	2 (4.2)	3 (6.3)	3 (6.3)	48 (100.0)
861~870	13 (28.3)	3 (6.5)	9 (19.6)	7 (15.2)	0 (0.0)	8 (17.4)	1 (2.2)	1 (2.2)	4 (8.7)	46 (100.0)
871~880	5 (10.9)	3 (6.5)	7 (15.2)	14 (30.4)	3 (6.5)	7 (15.2)	1 (2.2)	5 (10.9)	1 (2.2)	46 (100.0)
881~890	6 (13.3)	4 (8.9)	9 (20.0)	15 (33.3)	3 (6.7)	2 (4.4)	0 (0.0)	4 (8.9)	2 (4.4)	45 (100.0)
891~900	3 (20.0)	4 (26.7)	1 (6.7)	1 (6.7)	1 (6.7)	3 (20.0)	0 (0.0)	2 (13.3)	0 (0.0)	15 (100.0)
901~910	4 (17.4)	3 (13.0)	5 (21.7)	4 (17.4)	0 (0.0)	7 (30.4)	0 (0.0)	0 (0.0)	0 (0.0)	23 (100.0)
911~920	6 (27.3)	2 (9.1)	2 (9.1)	2 (9.1)	0 (0.0)	7 (31.8)	3 (13.6)	0 (0.0)	0 (0.0)	22 (100.0)
921~930	5 (20.8)	5 (20.8)	2 (8.3)	4 (16.7)	1 (4.2)	6 (25.0)	0 (0.0)	1 (4.2)	0 (0.0)	24 (100.0)
931~940	4 (16.7)	2 (8.3)	3 (12.5)	6 (25.0)	1 (4.2)	5 (20.8)	0 (0.0)	2 (8.3)	1 (4.2)	24 (100.0)
941~950	8 (22.2)	3 (8.3)	10 (27.8)	4 (11.1)	0 (0.0)	8 (22.2)	0 (0.0)	2 (5.6)	1 (2.8)	36 (100.0)
951~960	4 (25.0)	1 (6.3)	2 (12.5)	2 (12.5)	0 (0.0)	6 (37.5)	0 (0.0)	0 (0.0)	1 (6.3)	16 (100.0)
961~970	4 (19.0)	6 (28.6)	5 (23.8)	3 (14.3)	0 (0.0)	3 (14.3)	0 (0.0)	0 (0.0)	0 (0.0)	21 (100.0)
971~980	7 (24.1)	3 (10.3)	3 (10.3)	6 (20.7)	0 (0.0)	4 (13.8)	4 (13.8)	2 (6.9)	0 (0.0)	29 (100.0)
981~990	8 (38.1)	1 (4.8)	3 (14.3)	2 (9.5)	0 (0.0)	6 (28.6)	1 (4.8)	0 (0.0)	0 (0.0)	21 (100.0)
991~1000	6 (21.4)	4 (14.3)	3 (10.7)	7 (25.0)	0 (0.0)	6 (21.4)	1 (3.6)	1 (3.6)	0 (0.0)	28 (100.0)

Table 1-(c). The contents of climatic disasters from from7th to 12th centuries

	Storms	Floods	Long-Rains	Thunder storms	Whirlwinds	Droughts	Hail storms	Heavy-Snows	Frosts	subtotal
1001～1010	7	2	7	12	1	4	0	0	0	33
	(21.2)	(6.1)	(21.2)	(36.4)	(3.0)	(12.1)	(0.0)	(0.0)	(0.0)	(100.0)
1011～1020	19	2	2	16	0	3	1	1	0	44
	(43.2)	(4.5)	(4.5)	(36.4)	(0.0)	(6.8)	(2.3)	(2.3)	(0.0)	(100.0)
1021～1030	11	3	2	4	0	5	1	1	0	27
	(40.7)	(11.1)	(7.4)	(14.8)	(0.0)	(18.5)	(3.7)	(3.7)	(0.0)	(100.0)
1031～1040	5	3	2	3	0	6	0	1	0	20
	(25.0)	(15.0)	(10.0)	(15.0)	(0.0)	(30.0)	(0.0)	(5.0)	(0.0)	(100.0)
1041～1050	1	2	0	0	0	3	0	0	0	6
	(16.7)	(33.3)	(0.0)	(0.0)	(0.0)	(50.0)	(0.0)	(0.0)	(0.0)	(100.0)
1051～1060	3	2	1	2	0	1	0	0	0	9
	(33.3)	(22.2)	(11.1)	(22.2)	(0.0)	(11.1)	(0.0)	(0.0)	(0.0)	(100.0)
1061～1070	3	1	1	2	0	5	1	0	0	13
	(23.1)	(7.7)	(7.7)	(15.4)	(0.0)	(38.5)	(7.7)	(0.0)	(0.0)	(100.0)
1071～1080	0	4	0	1	0	1	1	0	0	7
	(0.0)	(57.1)	(0.0)	(14.3)	(0.0)	(14.3)	(14.3)	(0.0)	(0.0)	(100.0)
1081～1090	4	2	0	3	0	5	0	0	0	14
	(28.6)	(14.3)	(0.0)	(21.4)	(0.0)	(35.7)	(0.0)	(0.0)	(0.0)	(100.0)
1091～1100	11	6	3	3	0	6	0	2	0	31
	(35.5)	(19.4)	(9.7)	(9.7)	(0.0)	(19.4)	(0.0)	(6.5)	(0.0)	(100.0)
1101～1110	5	1	4	8	0	3	2	1	0	24
	(20.8)	(4.2)	(16.7)	(33.3)	(0.0)	(12.5)	(8.3)	(4.2)	(0.0)	(100.0)
1111～1120	9	4	1	5	0	4	2	0	1	26
	(34.6)	(15.4)	(3.8)	(19.2)	(0.0)	(15.4)	(7.7)	(0.0)	(3.8)	(100.0)
1121～1130	7	6	1	3	0	2	2	0	0	21
	(33.3)	(28.6)	(4.8)	(14.3)	(0.0)	(9.5)	(9.5)	(0.0)	(0.0)	(100.0)
1131～1140	6	4	2	5	0	1	1	0	0	19
	(31.6)	(21.1)	(10.5)	(26.3)	(0.0)	(5.3)	(5.3)	(0.0)	(0.0)	(100.0)
1141～1150	14	8	0	8	4	0	1	0	0	35
	(40.0)	(22.9)	(0.0)	(22.9)	(11.4)	(0.0)	(2.9)	(0.0)	(0.0)	(100.0)
1151～1160	14	4	1	5	0	4	0	0	0	28
	(50.0)	(14.3)	(3.6)	(17.9)	(0.0)	(14.3)	(0.0)	(0.0)	(0.0)	(100.0)
1161～1170	6	2	3	2	0	7	2	1	0	23
	(26.1)	(8.7)	(13.0)	(8.7)	(0.0)	(30.4)	(8.7)	(4.3)	(0.0)	(100.0)
1171～1180	7	6	0	7	4	5	0	0	0	29
	(24.1)	(20.7)	(0.0)	(24.1)	(13.8)	(17.2)	(0.0)	(0.0)	(0.0)	(100.0)
1181～1190	11	6	3	11	0	6	1	1	0	39
	(28.2)	(15.4)	(7.7)	(28.2)	(0.0)	(15.4)	(2.6)	(2.6)	(0.0)	(100.0)
1191～1200	8	6	2	8	0	4	0	2	0	30
	(26.7)	(20.0)	(6.7)	(26.7)	(0.0)	(13.3)	(0.0)	(6.7)	(0.0)	(100.0)
Totals	319	169	122	231	24	242	47	49	17	1220
	(26.1)	(13.9)	(10.0)	(18.9)	(2.0)	(19.8)	(3.9)	(4.0)	(1.4)	(100.0)

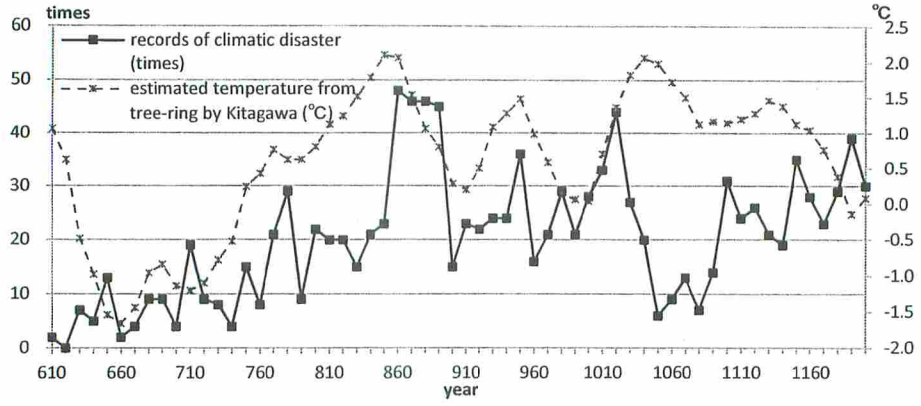

Figure 1. The secular changes of estimated temperature deviations by Kitagawa(1998) and climatic disasters from 601 to 1200.

* On this estimated temperature deviations, the authors read the data from the figure on the tree-ring analysis of carbon isotope by Kitagawa (1998) and calculated five decadal movement averages of the estimated temperature deviations in order to smooth out the fluctuation of temperature deviations.

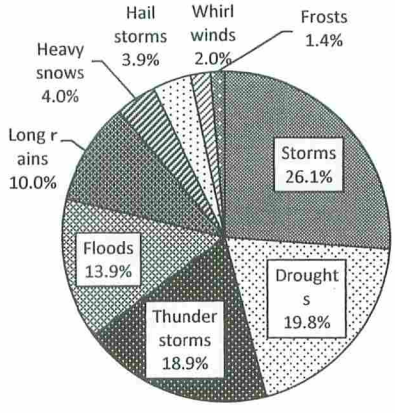

Figure 2-(a). The ratio of contents of climatic disasters from 7th to 12th centuries

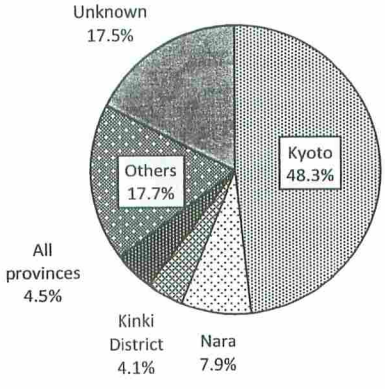

Figure 2-2(b) The ratio of place names of climatic disasters from7th to 12th centuries

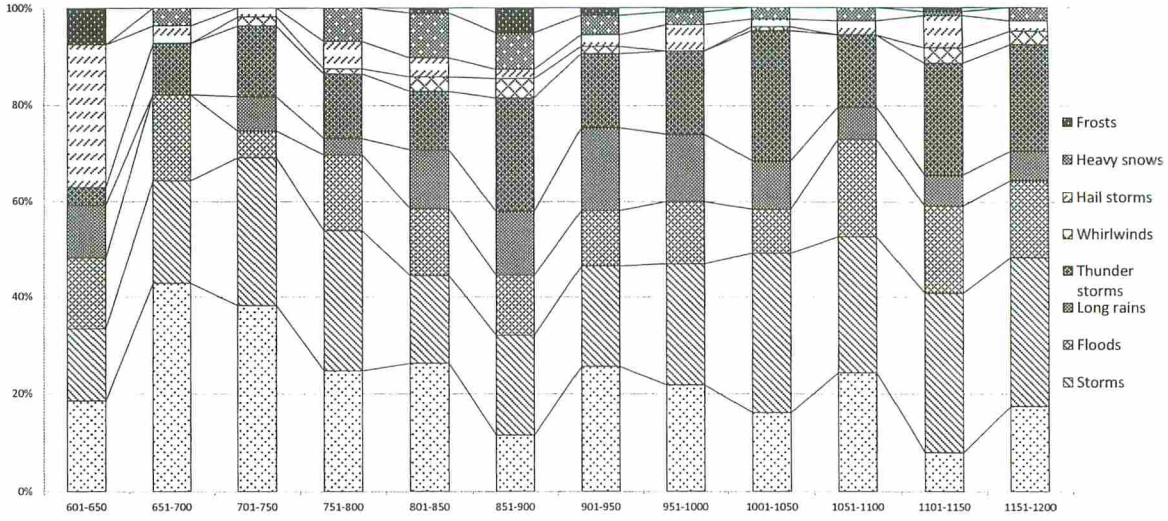

Figure 3-1. The decadal change of percentage on climatic disasters from7th to 12th centuries

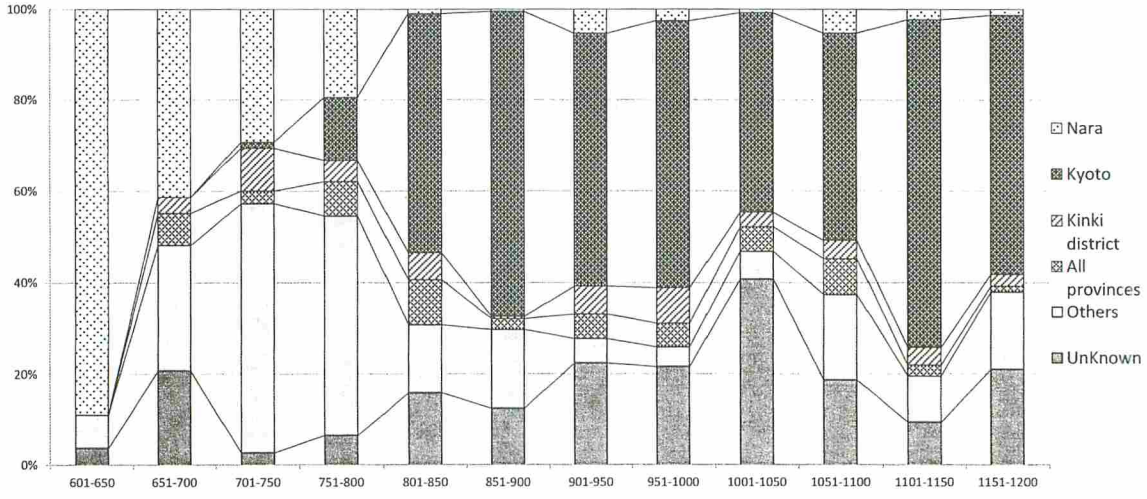

Figure 3-2. The decadal change of place names of climatic disasters from 7th to 12th centuries

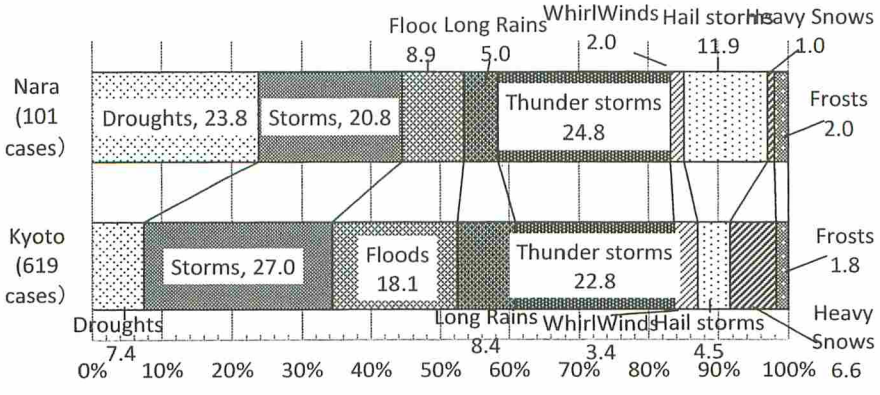

Figure 4. The percentages of climatic disasters from 7th to 12th centuries in Nara and Kyoto

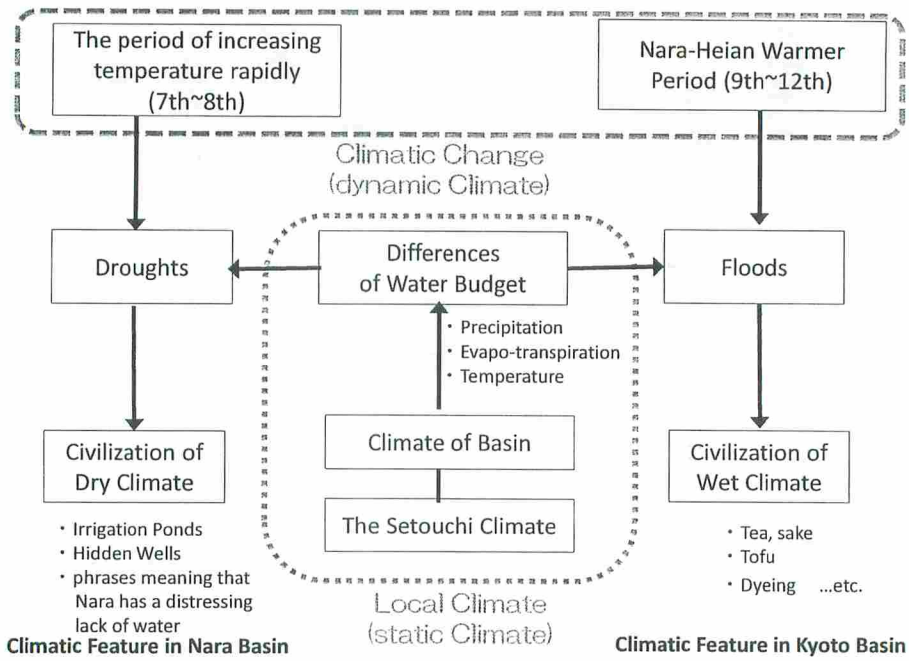

Figure 5. Concept of reconstruction of climates in Nara and Kyoto