Climatic Disasters from the 7th to the 12th Centuries: Considerations of Influences on Climatic Disasters by Local Climates in Nara and Kyoto

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Abstract Many natural disasters have occurred in Japan since ancient times. It corresponds to the “Medieval climate anomaly (MCA)” or “Medieval warm period (MWP)” which existed from the 9th to the 12th centuries, as pointed out by the climatologists in Europe and U.S.A. In the history of Japan, however, this period is called “ancient period”. In this study, the authors collected 1,220 records of climatic disasters and constructed a chronology of climatic disasters in Japan from the 7th to the 12th centuries. Furthermore, their secular changes of kinds and regions were clarified. It can be said that number of climatic disasters increased remarkably during the second half of the 9th century, the early 11th century and the latter half of the 12th century. Concerning kinds of climatic disasters, the most common disaster was storm (26.1%) and the next was drought (19.8%). As for place names related to all climatic disasters, the most frequent place was Kyoto (48.3%) and the second was Nara (7.9%). From these investigations, it was clarified that drought was the major climatic disaster before the 9th century. On the other hand, disaster caused by too much rain prevailed from the 9th century. But the regions with records on climatic disasters clearly changed from Nara to Kyoto at the end of the 8th century. Therefore, the authors proposed that local climates in Nara and Kyoto influenced the change of climatic disasters.

Key words Paleoclimate, drought, flood, regional features, Nara, Kyoto

Introduction

It has been recognized that climatic disasters tend to increase when air temperature fluctuates violently. Even nowadays, social anxiety is increasing in relation to climatic disasters caused by 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°C), unusual extremes of rainfall, and so on will increase (Japan Meteorological Agency 2013; IPCC and Ministry of the Environment, Government of Japan 2013).

Similarly, the climate in Japan was warmer corresponding with “Medieval warm period (MWP)” from the 9th to the 12th centuries. For example, Maejima and Tagami (1986) clarified by analyzing “*Nihon kishoshiryō*” that the 7th to the 9th centuries were a cool period and the 10th to the 14th centuries were a warm period. In addition, the climate reconstructed by the records of cherry blossoming was warm around the 10th century (Sekiguchi 1969; Yamamoto 1976; Aono 2013). Moreover, Yoshino (2009) argued that the warm period with various scale of fluctuations continued from the 4th to the 10th centuries.

Mizukoshi (2004, 2006, 2008, 2010, 2012, 2014) collected diurnal weather records from the 11th to the 16th centuries in Japan and he referred that the 11th and the 12th centuries were relatively warm periods. According to Kitagawa and Matsumoto (1998) who analyzed carbon isotope variations in tree rings of *Yakusugi* cedars, the estimated temperature deviations from the 8th to the 12th centuries were 1.0°C higher than the average during the last 2,000 years.

In this period, it is historically known that serious natural disasters occurred in Japan. 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 was noted that *Mt. Fuji* erupted in 864 and it was one of the three major volcanic eruptions (Nishikawa 2002). Hotate (2012) concluded that the 7th and 8th centuries can be regarded as “a peculiar period with earthquakes, global warming and pandemics”.

From the 7th to the 12th centuries, Japan also suffered from various climatic disasters such as heavy rains, floods, droughts, and the like. Kusakabe constructed the chronology of climatic disasters from the 6th to the

19th centuries according to provinces of Shikoku, Kanto, Chubu and Mie, Kinki, Chugoku and Ou of Japan by using “*Nihon kishoshiryo*” (Kusakabe 1969, 1973a, 1973b, 1975a, 1975b, 1975c, 1975d, 1977, 1978, 1981). Focusing on Kinki province in these results shows, the drought was the major climatic disaster in the 7th and 8th centuries where as floods caused by much rain increased in the 9th century. From the 10th to the 11th centuries, drought increased again while flood related to typhoon increased in the 12th century. Moreover, Nishikawa (1968) made a table of climatic disasters from the 6th to the 20th centuries based on “*Nihonsaishi*” and obtained that the most remarkable disaster was plague and the second one was drought from the 6th to the 16th centuries.

However, these studies showed a lesser number of climatic disasters because these studies were analyzed by only one document and were not referred sufficiently to local climates. Furthermore, Maejima and Tagami (1986) pointed out the problem that the paleoclimate reconstructed from historical documents is reflect only local

climate. Therefore, collecting as many cases of climatic disasters from historical documents as possible is important for paleoclimate study and it is necessary to clarify by more detailed information. Besides, clarification of climatic disasters during the 7th to the 12th centuries is valuable for predicting the natural and human impacts by global warming at the present.

The purposes of this study are to construct a chronology of climatic disasters by using a greater number of historical documents and to clarify changes of kinds and regions of climatic disasters from the 7th to the 12th centuries especially making point of Nara and Kyoto where most of the historical documents were concentrated. We will also discuss geographically that differences in the respective local climates in Nara and Kyoto could reflect climatic disasters.

Study Method

The records of climatic disasters in Japan from ancient

Figure 1. The place of Nara and Kyoto basins.

A, B and C in this figure present the capital of Asuka and Fujiwarakyo (593–710), the capital of Heijokyo (710–784) and the capital of Heiankyo (794–1192) respectively³. This figure was recomposed from the climatic divisions by Sekiguchi (1959) and capital locations by Geospatial Information Authority of Japan (2000).

times have been found in some historical documents, such as “*Nihon shoki*”, “*Fuso ryakuki*”, and “*Nihon sandai jitsuroku*”. Furthermore, these records have been edited in several meteorological archives. First, the authors collect the data and construct a chronology of climatic disasters from the 7th to the 12th centuries from the following meteorological archives: (1) “*Nihon no kisho shiryo* (The Central Meteorological Observatory and The Imperial Marine Observatory 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 kisho saigai shi* (Aoki 1956)” and (5) “*Kyoto kisho saigai nempyo* (Kyoto Local Meteorological Office 1951)”. These archives include records of climatic disasters from the prefectural histories, documents of temples and shrines, diaries of prayers for rains and the like. In some cases, place names, sources and detailed contents of climatic disasters are also collected.

Secondly, these data are classified according to kinds and regions of climatic disasters. Namely, they are grouped into 9 categories according to their kinds: (1) storm, (2) flood, (3) long rain, (4) thunder storm, (5) whirlwind, (6) drought, (7) hail storm, (8) heavy snow and (9) frost. In these climatic disasters, the cases of storm, flood, long rain and thunder storm may be difficult to distinguish from each other because storm and long rain could have been accompanied with flood. In this paper, we classified these data based on the way of “*Nihon no kisho shiryo*”¹. As to the place names where climatic disasters occurred, the old place names are arranged into 6 categories as follows:

(1) “Nara” includes its old names “Yamato koku” 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 wide area such as Kyoto, Nara and neighboring region simultaneously.

(4) “All provinces” include “Shokoku” and “Zenkoku”, but exclude the cases classified as (1), (2) or (3).

(5) Place names which do not refer to (1), (2), (3) and (4) are classified into “others”.

(6) Nameless places are grouped into “Unknown”.

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

Results

Features of climatic disasters from the 7th to the 12th centuries

The authors collected 1,220 climatic disasters and 1,281 place names in this study. This data is more than the similar studies of Kusakabe (1977) and Nishikawa (1968) who obtained 203 and 510 data respectively during the same period².

Figure 2 shows the secular change of climatic disasters comparing with the estimated temperature deviations reconstructed from tree ring analysis by Kitagawa and Matsumoto (1998). As shown in Figure 2, climatic disasters tend to increase when estimated temperature deviations are greater. Three peaks in the number of climatic

Figure 2. Secular change of estimated temperature deviations by Kitagawa and Matsumoto (1998) and climatic disasters from the 7th to the 12th centuries.

On these estimated temperature deviations, the authors read the data from the figures on the tree ring analysis of carbon isotope by Kitagawa and Matsumoto (1998) and calculated five decadal moving averages of the estimated temperature deviations in order to smooth out the fluctuation of temperature deviations.

disasters were found in this figure. They are the periods from the latter half of the 9th century, the first half of the 11th century and the latter half of the 12th century. Around the middle of the 11th century, there was a significant decrease in number of climatic disasters. In this respect, Kawasumi (2004) and Takahashi (2012) stated that the level of riverbed in the Kamogawa River had dropped from the end of the 10th to the early period of the 12th centuries and this would keep the river from overflowing. From the database of “Historiographical Institute, the University of Tokyo”, Katahira (2010) clarified that the number of floods in Kyoto was at a minimum around the latter part of the 11th century.

The correlation coefficient between the number of climatic disasters and the estimated temperature deviations is 0.35, which is a positive correlation at the significance level of 5%.

Table 1 summarizes the chronology by the number of climatic disasters counted for every decade on their kinds and percentages from the 7th to the 12th centuries. In the 7th century, the number of climatic disasters is 55. Drought (30.9%) is most significant disaster and storm (18.2%) is the next. In the 8th century, the records increased by 144 and drought and storm remarkably occurred in the same percentage (29.9%) respectively. In the 9th century, the records rapidly increased by 299, in which significant disasters are storm and thunder storm (19.7%) respectively. In the 10th century, the records decreased by 244. In the 11th century, climatic disaster dwindled to 204 however, they rose to 274 in the 12th century. The most remarkable disaster was storm (31.4%) in the 11th century and this condition continued until the 12th century.

Kinds and regions of climatic disasters and their secular changes

Figures 3-a and 3-b show the ratios of kinds and regions of climatic disasters from the 7th to the 12th centuries. Concerning all climatic disasters from the 7th to the 12th centuries, the most common climatic disaster is the storm (26.1%), next, the drought (19.8%) and third, the thunder storm (18.9%). The disasters are related to rain such as the storm, flood and long rain, occupy about half of them. On the other hand, the most common region 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 its percentages are Ise (Mie Prefecture, 3.8%), Kamakura (Kanagawa Prefecture, 0.7%), Kii (Wakayama Prefecture, 0.5%), Omi (Shiga Prefecture, 0.5%), Kawachi (Osaka Prefecture, 0.5%) and

Kyushu District (0.5%). From these results, it might be inferred that many records of climatic disasters had been concentrated in the capital around that time.

Figure 4-a shows the secular change of percentages (%) of climatic disasters. Drought accounts for the greatest percentage before the early half of the 9th century and the early half of the 10th century after then they decrease gradually with more or less fluctuations. Conversely, disasters caused by heavy rain represents the majority of disasters after the latter half of the 9th century except the early half of the 10th century. According to Kusakabe (1977) stated that drought was more than half of climatic disasters in the 7th and the 8th centuries, in contrast to rain and flood damages in the 10th to the 12th centuries. Although the present study comes to a similar conclusion as secular change, we want to draw attention to the regional change of climatic disasters. As shown in Figure 4-b, the percentage of disasters is remarkably covered by Nara until the latter part of the 8th century. On the contrary, historical records in Kyoto occupy half of them, whereas the ones in Nara nearly vanished from the 9th century because historical records tended to concentrate in the capital city of the time. That is, Nara was the capital of Japan from 593 to 784 and Kyoto was the capital of Japan from 794 to 1192³. From this analysis we can conclude that there were frequent droughts and records of climatic disasters centered in Nara before the 9th century while there were more disasters caused by much rain and records of climatic disasters concentrated in Kyoto from the 9th to the 12th centuries.

Figure 5 compared the percentages of climatic disasters from the 7th to the 12th centuries in Nara with those of Kyoto. Droughts in Nara make up 23.8%, in contrast to Kyoto which shows only 7.4%. On the other hand, concerning flood, Kyoto shows about 10% higher than Nara. Climatic disasters caused especially by rainfall are more than 70% in Kyoto.

Discussion

Influences of local climate on climatic disasters

As mentioned above, drought frequent occurred before the early half of the 9th century and the early half of the 10th century while disaster caused by heavy rain occurred frequently after the latter half of the 9th century except the early half of the 10th century. However, the concentrated region of the climatic disasters shifted from Nara to Kyoto with the relocation of the capital from Nara to Kyoto in the latter part of the 8th century. Tanioka (2010) obtained that drought was the major climatic disaster

Table 1. Contents of climatic disasters from the 7th to the 12th centuries

	Storm	Flood	Long rain	Thunder storm	Whirl wind	Drought	Hail storm	Heavy snow	Frost	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)
The 7th century	10	9	3	4	0	17	9	1	2	55
	(18.2)	(16.4)	(5.5)	(7.3)	(0.0)	(30.9)	(16.4)	(1.8)	(3.6)	(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)
The 8th century	43	17	7	20	2	43	6	6	0	144
	(29.9)	(11.8)	(4.9)	(13.9)	(1.4)	(29.9)	(4.2)	(4.2)	(0.0)	(100.0)

Table 1. Continued

	Storm	Flood	Long rain	Thunder storm	Whirl wind	Drought	Hail storm	Heavy snow	Frost	Subtotal
801~810	5	3	4	0	0	5	2	1	0	20
	(25.0)	(15.0)	(20.0)	(0.0)	(0.0)	(25.0)	(10.0)	(5.0)	(0.0)	(100.0)
811~820	2	2	2	1	1	7	1	4	0	20
	(10.0)	(10.0)	(10.0)	(5.0)	(5.0)	(35.0)	(5.0)	(20.0)	(0.0)	(100.0)
821~830	1	2	3	3	0	5	0	1	0	15
	(6.7)	(13.3)	(20.0)	(20.0)	(0.0)	(33.3)	(0.0)	(6.7)	(0.0)	(100.0)
831~840	7	2	1	4	1	6	0	0	0	21
	(33.3)	(9.5)	(4.8)	(19.0)	(4.8)	(28.6)	(0.0)	(0.0)	(0.0)	(100.0)
841~850	3	5	2	4	1	3	1	3	1	23
	(13.0)	(21.7)	(8.7)	(17.4)	(4.3)	(13.0)	(4.3)	(13.0)	(4.3)	(100.0)
851~860	14	11	1	10	1	3	2	3	3	48
	(29.2)	(22.9)	(2.1)	(20.8)	(2.1)	(6.3)	(4.2)	(6.3)	(6.3)	(100.0)
861~870	13	3	9	7	0	8	1	1	4	46
	(28.3)	(6.5)	(19.6)	(15.2)	(0.0)	(17.4)	(2.2)	(2.2)	(8.7)	(100.0)
871~880	5	3	7	14	3	7	1	5	1	46
	(10.9)	(6.5)	(15.2)	(30.4)	(6.5)	(15.2)	(2.2)	(10.9)	(2.2)	(100.0)
881~890	6	4	9	15	3	2	0	4	2	45
	(13.3)	(8.9)	(20.0)	(33.3)	(6.7)	(4.4)	(0.0)	(8.9)	(4.4)	(100.0)
891~900	3	4	1	1	1	3	0	2	0	15
	(20.0)	(26.7)	(6.7)	(6.7)	(6.7)	(20.0)	(0.0)	(13.3)	(0.0)	(100.0)
The 9th century	59	39	39	59	11	49	8	24	11	299
	(19.7)	(13.0)	(13.0)	(19.7)	(3.7)	(16.7)	(2.7)	(8.0)	(3.7)	(100.0)
901~910	4	3	5	4	0	7	0	0	0	23
	(17.4)	(13.0)	(21.7)	(17.4)	(0.0)	(30.4)	(0.0)	(0.0)	(0.0)	(100.0)
911~920	6	2	2	2	0	7	3	0	0	22
	(27.3)	(9.1)	(9.1)	(9.1)	(0.0)	(31.8)	(13.6)	(0.0)	(0.0)	(100.0)
921~930	5	5	2	4	1	6	0	1	0	24
	(20.8)	(20.8)	(8.3)	(16.7)	(4.2)	(25.0)	(0.0)	(4.2)	(0.0)	(100.0)
931~940	4	2	3	6	1	5	0	2	1	24
	(16.7)	(8.3)	(12.5)	(25.0)	(4.2)	(20.8)	(0.0)	(8.3)	(4.2)	(100.0)
941~950	8	3	10	4	0	8	0	2	1	36
	(22.2)	(8.3)	(27.8)	(11.1)	(0.0)	(22.2)	(0.0)	(5.6)	(2.8)	(100.0)
951~960	4	1	2	2	0	6	0	0	1	16
	(25.0)	(6.3)	(12.5)	(12.5)	(0.0)	(37.5)	(0.0)	(0.0)	(6.3)	(100.0)
961~970	4	6	5	3	0	3	0	0	0	21
	(19.0)	(28.6)	(23.8)	(14.3)	(0.0)	(14.3)	(0.0)	(0.0)	(0.0)	(100.0)
971~980	7	3	3	6	0	4	4	2	0	29
	(24.1)	(10.3)	(10.3)	(20.7)	(0.0)	(13.8)	(13.8)	(6.9)	(0.0)	(100.0)
981~990	8	1	3	2	0	6	1	0	0	21
	(38.1)	(4.8)	(14.3)	(9.5)	(0.0)	(28.6)	(4.8)	(0.0)	(0.0)	(100.0)
991~1000	6	4	3	7	0	6	1	1	0	28
	(21.4)	(14.3)	(10.7)	(25.0)	(0.0)	(21.4)	(3.6)	(3.6)	(0.0)	(100.0)
The 10th century	56	30	38	40	2	58	9	8	9	244
	(23.0)	(12.3)	(15.6)	(16.4)	(0.8)	(23.8)	(3.7)	(3.3)	(1.2)	(100.0)

Table 1. Continued

	Storm	Flood	Long rain	Thunder storm	Whirl wind	Drought	Hail storm	Heavy snow	Frost	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)
The 11th century	64	27	18	46	1	39	4	5	0	204
	(31.4)	(13.2)	(8.8)	(22.5)	(0.5)	(19.1)	(2.0)	(2.5)	(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)
The 12th century	87	47	17	62	8	36	11	5	1	274
	(31.8)	(17.2)	(6.2)	(22.6)	(2.9)	(13.1)	(4.0)	(11.8)	(6.4)	(100.0)
Total from the 7th to the 12th centuries	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 3. Ratios of kinds of climatic disasters (a) and place names (b) from the 7th to the 12th centuries.

Figure 4. Five decadal changes of percentage on climatic disasters (a) and place names of climatic disasters (b) from the 7th to the 12th centuries.

Figure 5. Percentages of climatic disasters from the 7th to the 12th centuries in Nara and Kyoto.

Figure 6. Concept of climatic disasters in Nara and Kyoto from the 7th to the 12th centuries.

in the 8th and 9th centuries whereas long rain brought about principal disaster in the first part of the 9th century from the data of “*Rikkokushi*” and “*Nihon kiryaku*”. He also stated that the capital in Japan shifted from Nara to Kyoto, which could bring about this result, but he did not refer to their local climates.

Generally, previous studies of the paleoclimate from historical documents have given attention only to climate change. But, it is important to consider that disasters consist of prime, indispensable, induced and expansive factors (Sato et al. 1964). Especially for geographical study, it is valuable to focus on the features of indigenous climate

empirically, such as landscapes and water balances.

The Nara and Kyoto basins are located in the east end of the Setouchi climate, according to climatic divisions in Japan (Fukui 1957; Sekiguchi 1959), and have relatively less rain in Japan. From empirical analysis of the present meteorological data, the annual mean of precipitations of Nara and Kyoto (1981–2010) are 1316.0 mm and 1491.3 mm respectively. In Nara, more than ten thousand irrigation ponds⁴ were made due to frequently occurred droughts from the ancient times. In “*Nihon shoki*”, some of the irrigation ponds in Nara were made from 607 and 613 (Uchida 2003). Moreover, a number of hidden

wells were constructed in 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 been distressed by 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 regions is caused by much rain. It is also said that drought has been fateful events in Nara since the dawn of history (Tsujita 1961) and it has brought about a civilization of poor water to the people in Nara, as mentioned above. On the contrary, the Kyoto basin had been frequently tormented with floods by heavy rains from ancient time in spite of belonging to the Setouchi climate. As a matter of fact, the people of Kyoto have suffered Kamogawa River floods frequently since the 8th century (Katahira 2012). In addition, Kyoto is the so-called “metropolis of water” which means that the abundance of water has given rise to cultures such as Japanese tea, *sake*, *tofu*, dyeing (Suzuki 2003, 2010).

Furthermore, it was clarified that the occurrence of water deficit in Nara is more than Kyoto and vice versa on water surplus from 1954 to 2012 (Marumoto 2014). Water deficit means the lack of water and water surplus represents the amount of water flowing into soil, ground water and river. That is, Nara shows more remarkably the Setouchi climate than Kyoto. Water deficit in Nara and water surplus in Kyoto could potentially influence their disasters⁵.

Figure 6 shows the concept of components on climatic disasters on paleoclimate from the 7th to the 12th centuries in Nara and Kyoto. Concretely, as shown in this figure, occurrences of disasters need the indispensable factor of human existence and the inducement factor of regional vulnerability. And it would be better to consider that climate change does not cause climatic disaster directly, but lead simply to prime factor of climatic disaster. Therefore, it seems quite probable that the difference of local climates in Nara and Kyoto influenced secular change of climatic disasters in addition to climate change. Needless to say, it could be considered that climatic disasters were caused by other geographical factors such as the concentration of rivers like the Kamogawa River, the Katsuragawa River and others in the case of floods in Kyoto.

Climate usually changes in time and in space, and represents the synthetic condition of atmosphere. Yamakawa (1993) states that a synthetic approach will be needed to reconstruct the paleoclimate. Consequently, it is necessary to give attention not only to climate change but also

to various factors such as local climate in order to examine climatic disasters.

Conclusion

In this study, the authors collected climatic disasters from the 7th to the 12th centuries and obtained 1,220 cases and 1,281 place names. From this database, changes of kinds and regions on climatic disasters were clarified. In consequence, climatic disasters in Japan from the 7th to the 12th centuries are characterized as follows. Climatic disasters increased in the latter half of the 9th century, the first half of the 11th century and the latter half of the 12th century. Drought was the major climatic disaster before the early half of the 9th century and the early half of the 10th century while disaster caused by too much rain prevailed after the latter half of the 9th century except the early half of the 10th century. But the regions with records on climatic disasters clearly changed from Nara to Kyoto at the end of the 8th century because of the move of the capital. Therefore, the authors proposed that there are differences of local climate in the climatic disasters in Nara and Kyoto.

Consequently, it is important to take notice of geographical factors such as indigenous local climate and landscape for elucidating climatic disasters in the historical period and a more holistic viewpoint is needed. Since geography is integrative and interactive study, it is necessary to consider not only climate change but also various geographical factors in order to elucidate the environment in any historical period.

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Notes

1. According to The Central Meteorological Observatory and The Imperial Marine Observatory (1976), the storm means heavy rain with gale. In addition, in case of simply gale occurred in one district while heavy rain with flood observed in other district, this record is adopted the storm. However, thunder storm and whirlwind are excluded. The flood represents some damages from both

heavy rain and long rain without gale. Furthermore flood caused by storm or thunder storm is excluded to avoid duplication. The thunder storm consists of lightning with hailstone, gale or heavy rain which is able to bring about disaster. However, thunder storm with whirlwind is classified as the whirlwind. The whirlwind contains mainly tornado and include the episode of dragon, serpent or “*Mizuchi*” (imaginary animal like dragon or serpent) because these animals were considered that they were related to tornado in ancient time. Moreover, singular wind as “*Shofu*” or “*Ichimokuren*” (such as blast) is also classified into the whirlwind. Drought means that no rainfall continued from one to several months. And a few records of prayers for rain are also counted to the drought. Rainfall that goes on as long as a month or more is added to the long rain if they caused disaster. However, the long rain that obviously caused flood is classified into the flood to keep out duplication. The heavy snow involves the case of the snowfall more than 1 *shaku* (about 30.3 cm) around Kinki and Kanto districts. In case of hail storm which caused disaster, the case is classified mainly into the hail storm. But the hail storm with thunder is classified into the thunder storm.

2. Kusakabe (1977) counted only climatic disasters that occurred in two or more regions from “*Nihon no kisho shiryō*”. Nishikawa (1968) used just “*Nihon sai i shi*” for counting climatic disasters. For these reasons, their disaster’s data are less than ours. These data were excluded epidemic, famine, volcanic eruption and tsunami from their original data.
3. The authors did not consider the periods of *Naniwa kyo*, *Kuni kyo* and *Shigaraki kyo* in this study because each of the periods were short (estimated less than ten years) and the established periods are not clear. In addition, the period when Kyoto was capital is estimated until 1192 or 1185. In this study, the authors used 1192 as the end of the period.
4. According to Hall (1932), there were 10,056 irrigation ponds in the Nara basin in the first half of the 20 century and 70.9% of the region was irrigated. On the details of irrigation region, it is said that the regions irrigated by ponds, rivers and wells were 72.4%, 25.6%, and 1.6%, respectively.
5. From “*Nihon kisho saigai nempyō*” (The Central Meteorological Observatory 1949; Japan Meteorological Agency 1960), the climatic disasters occurred 30 times in Nara and 48 times in Kyoto from 1900 to 1952. In these results, the disasters due to droughts occupied 30.0% in Nara but the ones in Kyoto were only 13.0% and the disasters due to floods in Nara were 63.3% whereas the ones in Kyoto were 69.6%. However, the river environments such as embankment changed from the ancient time.

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