ENVIRONMENTAL PERCEPTION AND BEHAVIOUR OF FARMERS TOWARDS THE 1980 COLD WEATHER HAZARD IN SANBONGIHARA, AOMORI PREFECTURE

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Abstract This paper analyses environmental perception and adjustment behaviour using the method for the study of natural hazard perception developed by the Chicago school. In the summer of 1980, northern Japan was damaged by a cold weather hazard. Using questionnaires we studied the perception of rice cultivation farmers in two separate villages in the Sanbongihara area of Aomori Prefecture, where the loss was the most severe to the low temperature, and their long and short term adjustment behaviour. The results revealed that the two areas were differenciated in several respects.

1. Introduction

The empirical study of natural hazard perception was originally developed in the 1960s by the Chicago school in an attempt to establish a policy to reduce flood damage. In order to examine flood plain invasion, recognized as the fundamental cause of the flood damage, the study of human perception and behaviour toward flood hazards has inevitably become an important issue. Perception study formed a new trend within hazard research, for previous research has focussed only on the mechanism of hazard occurrence and the estimation of the area, magnitude and frequency of hazards. In an early representative paper, Kates (1962) pointed out that "the way men view the risks and opportunities of their uncertain environment plays a significant role in their decisions as to resource management". In this vein, early natural hazard perception research appeared emphasizing the applied aspects of the problem.

Later, as the geographical study of perception and human behaviour progressed, natural hazard perception research acquired one position within the field and methodology become a topic of discussion. Downs (1970) considered natural hazard perception research as an "evaluative approach" and as the starting point of empirical studies. He established the conceptual framework for perception research, that is, the "real world – perception – behaviour" approach. But, actually the empirical study of natural hazard perception had focussed on the way to treat the uncertainty of hazard, and the relationship between the

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perception or image and the hazard experience. Later, issues concerned with people's view of hazard and with individual personality, for example 'Internal – External Locus of Control', were tackled.

Since the 1970s, with appearance of critical reviews of previous perception research (Bunting and Guelke, 1978), the actual behaviour towards hazard become an object of analysis. This unexpectedly resuted in re-examination of the effectiveness of previous study as an explanation of behaviour under the presupposition that the ultimate aim of perception research was an explanation of human behaviour (White, 1973). Surveying earthquake hazard perception and the adoption of adjustment, Jackson (1981) noted that "it was surprising to discover that no significant association emerged between future expectations and the adoption of precautions". He ascribed this fact to the differences between earthquakes and other hazards. The authors admit that although hazard perception has not been discussed in the same framework as behavioural geography, the actual hazard related behaviour must be the central subject of study.

Natural hazard perception research, accumulating empirical works, has gradually extended the objects of study, that is, from river floods to tidal waves by hurricanes, droughts, snow hazards, tornados, earthquakes, volcanic explosions, frost hazards, hail hazards and so on. On the other hand, the research has been expanded also globally in terms of study areas treated.

In Japan, there have been some works relating to human perception of hazards. But, these are seldom based on the results of natural hazard perception research initiated by the Chicago school. Most of them aimed studying human behaviour in hazardous situations from a sociological rather than geographical viewpoint. The only geographical paper concerned with human behaviour in hazardous situations was that of Fujiwara and Tenma (1981) studying residents' behaviour during flooding in the Miyoshi River. A case study based on the Chicago school's framework was conducted by Nakano (1972), Part III of which treated the results of interviews carried out in four areas. Ando (1982) examined the relation between residents' image of flood hazard and their adoption of adjustment responses by using the semantic differential method combined with factor analysis.

Among previous works, that of Saarinen (1966) on the perception of drought hazard by farmers in the Great Plains is the most significant. Because drought hazard occupies an important position in the lives of farmers, research into the farmers' perception and behaviour toward drought hazards in a certain region may lead to a better understanding of that region's character. Selecting several study areas of divergent dryness, Saarinen examined farmers' perceptions in each area and put his results in a regional study framework. The authors view his research as one fruitful future direction of natural hazard perception researchs within a regional framework.

The case study presented in this paper deals with the hazard associated with the damage caused to rice by the cold spell experienced in northern Japan in the summer of 1980. The authors will examine the perception of farmers and their responses to the cold weather hazard. This paper's viewpoint is as follows: cold weather hazard caused severe damage to rice crops in the growing period, and the magnitude of its damage is easily influenced by human behaviour in this process. Therefore, the grasp of and examination of the pattern of human responses in the time of hazard occurrence is an important issue in behavioural geography. Saarinen (1966) referred to the problem of how man might respond to weather changes in the short-term. He asked "how do short-run changes in weather conditions affect the attitudes and actions of people in drought areas?". Jackson (1974) who examined the farmers' perception and behaviour towards frost hazard also noticed this problem, but the details of it have not been investigated.

2. Cold Weather Hazard in Northern Japan

Rice is the most important crop grown in Japan. It was originally cultivated in tropical land, but now by the improvement of varieties it can be grown over a wide area even extending to northern Japan. The history of the expansion of rice cultivation in Japan is that of the farmers trying to combat the hazard of cold weather. Even so, rice is grown well beyond its optimal habitat, so the farmer of this region is very sensitive to the temperature level in summer.

Before the Meiji era, cold weather hazard caused very terrible disasters directly resulting in hunger. According to one survey of the records of the Edo era (1601 – 1866), cold weather hazards occurred 86 times during the 265 years in the Tohoku Region (Nanbu han, today's Iwate Prefecture). The most severe damage was in the Tenmei period (1783 – 1789) when more than 140,000 people died of hunger in 1783 alone in Tsugaru han and Nanbu han. The disaster had a major effect on this region, with the total population falling from 2,840,000 in 1721 to 2,368,000 in 1786, a rate of population decrease of 2.55 permill a year.

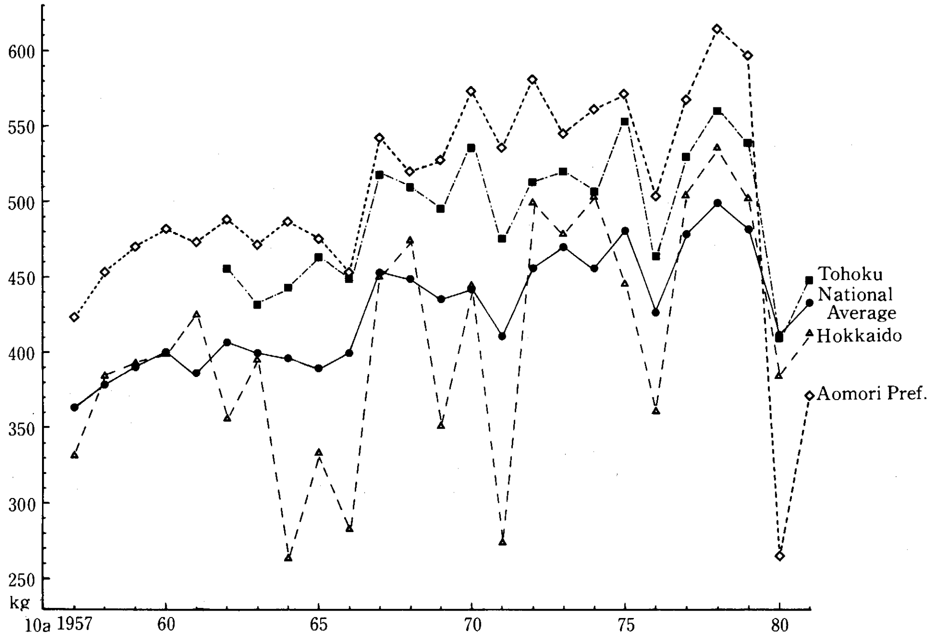

Fig. 1 The rice yield per unit during recent 25 years

In this century, cold weather hazards have occurred in 1902, 1905, 1913, 1931, 1934, 1935, 1941, 1945, 1953 in the Tohoku Region. After the Second World War, it seems that the cold weather hazard to rice has been overcome by the improvement of cold-hardy and early-maturing varieties, development of agricultural technologies (the use of vinyl covers for rice plants, the management of irrigation and fertilizers), land reform and so on. It is true that the Tohoku Region has not suffered from a cold hazard disaster since 1953, and the yield of rice per unit has increased rapidly. Until the 1930s, the yield per unit in the Tohoku Region was below the national average, but today this region belongs to the highest class in Japan (Fig. 1). Therefore, the Tohoku Region is viewed as the main rice supply region of Japan. On the other hand, in Hokkaido the history of rice cultivation is only a little over one hundred years old, and constant attempts to cultivate further and further north resulted in cold weather hazards of various degrees of severity often occurred about once in every three years.

Extraordinarily cold weather attacked these regions in 1980 and continued into 1981. The temperature in July and August 1980 was the lowest since 1902, and the Tohoku Region experienced its most severe damage since 1934 with the rice crop being reduced by 38.8 per cent compared with the average year. In particular, Aomori Prefecture which has the highest rice yield per unit in Japan, was damaged more than anywhere else. Many rice fields yielded zero harvest.

The cold weather hazard which threatens rice cultivation in northern Japan is caused by the 'Yamase' local cold wind which prevails several days during the growing period of rice (from May to August). This brings a cold spell to the Pacific coast of northern Japan. It rages from the Okhotsk Anticyclone to the depressions passing through Japan and her environ, and brings cloudy, rainy and foggy cold summer weather. The cold wind blows

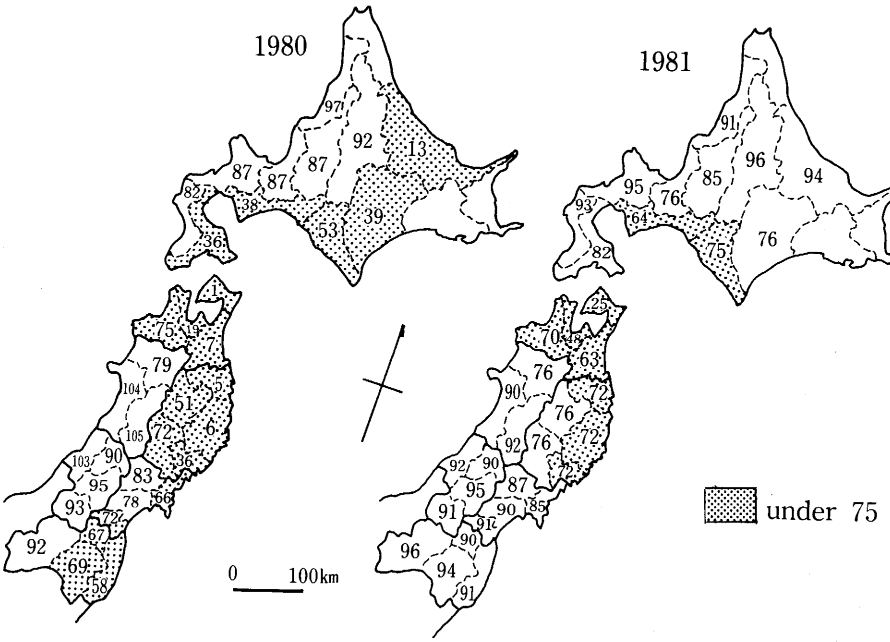

Fig. 2 The rice yield index of northern Japan by agriculture zone in 1980 and 1981

easterly for three to seven days, and the air temperature falls by 2 – 6°C, and the duration of sunshine is reduced by fog or drizzle. This occurs at a critical time in rice cultivation namely from the vegetative growing period to the reproductive growing period (the ear emergence period to the blooming period) when rice requires as high a temperature as possible. If the Yamase blows continually for a given time in this period, a cold weather hazard is likely to result. The cold weather hazard may be of two types. One is the 'delayed' type: rice growing is delayed by low temperatures over the whole period. The other is the 'obstacle' type: rice can not ripen because of low temperatures in the growing period. The 1980 hazard was of the second type.

Cold weather hazards caused by environmental change from low temperature are similar to drought hazard with respect to frequency and duration. This occurrence of this type of hazard is limited to northern Japan, and the degree of damage varies by the type of local climate and relief. The most heavy damaged area was as follows: eastern and Pacific coast of Hokkaido, Shimokita and Nanbu in Aomori Prefecture, and Shimohei and northern part of Iwate Prefecture (Fig. 2).

Important as climate is, we must also recognize that social and political events have had profound effects on the yield of rice. Because for more than ten years rice has in surplus supply, the government has adopted a policy of requiring farmers to reduce the amount of land devoted to rice production. As a result, farmers have been inclined to choose varieties of rice of high quality (good taste) in preference to cold- hardy types suited to mass production. Furthermore the price of rice is not rising, production has not been assigned a high level of priority by the government, and as farmers have been released from farm work due to mechanization the labour force has shift to other jobs. These factors have exacerbated the damage to rice production caused by the cold weather.

3. The 1980 Cold Weather Hazard and Study Area

Until June 1980 fine and warm days continued in the Tohoku Region and climatic condition was good for agriculture. From July to September, a cold spell brought low temperatures and less sunshine. In Aomori Prefecture, cold summer weather of the first order appeared. Influenced by the 'Yamase' which began to blow at the end of June, the average temperature in July and August fell below 20°C (Fig. 3). This period of cool weather and limited sunshine damaged the growing rice plants.

The rice yield index for Aomori Prefecture in 1980 (Fig. 4) shows an obvious difference between the Pacific Ocean side and that of the Japan Sea side. The yearly rice crop of the Thugaru region on the Japan Sea side was almost half of the average as compared with highly reduced crop in the Shimokita and Nanbu regions facing the Pacific Ocean, where the influence of the Yamase was intense.

Sanbongihara was one of the most severely damaged areas, and two rural administrative districts were selected for study: Tenmabayashi-mura and Towadako-cho. The former has less favourable conditions for rice crop than the latter. The Yamase directly blows deep into this area from the Pacific Ocean through over the Lake Ogawara located east of Tenmabayashi. The north-east tableland of Tenmabayashi is devoted to field crops. After the

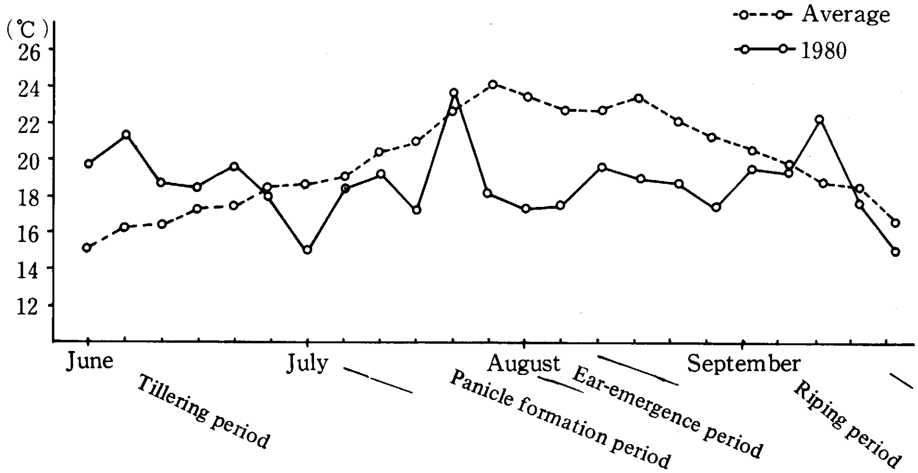

Fig. 3 The transition of average temperature in every 5 days (at Fujisaka, Towada City, Aomori Prefecture) during the growing period of rice

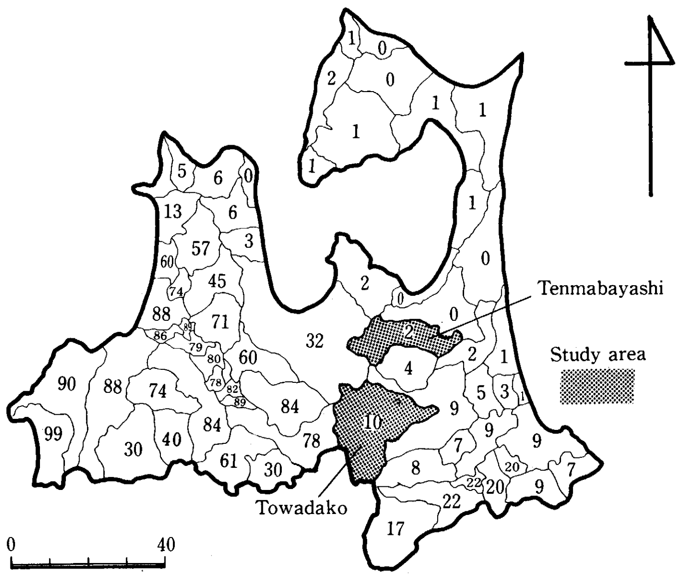

Fig. 4 The rice yield index in Aomori Prefecture

establishment of Tenma-dam, rice fields have been expanded in this part. The rice field in Towadako mainly extends over the Oirase basin.

There are no particular difference between the climate of the above two areas. During August 1980, however, the temperature at Sozen (Tenmabayashi) remained lower than that at Fujisaka (Towada City). As a result, the rice yield index for Tenmabayashi was 2 against 10 for Towadako (Fig. 4).

It is expected from the above fact that differences in the conditions of cold weather hazard may be perceived by farmers in the two areas. How were the differences in conditions and actual damage reflected in farmers' perceptions and adjustments towards the cold weather hazard?

Interviews regarding the cold weather hazard in 1980 was given in December 1982. These were mainly concerned with the details of the damage, its effect, farmers' responses and so on. With respect to the farmers' responses in the progress of the damage, diaries were also used as source materials. Further, a questionnaire was carried out in January 1983. The sample was restricted to full-time farmers owning 3 hectares or more of rice fields. The number of respondents were 48 in Tenmabayashi and 69 in Towadako.

4. Perception and Adjustment to the Cold Weather Hazard

The damage caused by cold weather hazard in Tenmabayashi differed from that in Towadako, as shown by the result of the questionnaires (Table 1). In 1980, 80 percent of sampled farmers in Tenmabayashi could not obtain even a level of self-sustenance, while the figure for Towadako was about 50 percent. In Towadako, about 10 percent of respondents were able to ship rice for sale. In 1981, when the cold weather damage was slighter than that of 1980, Tenmabayashi was damaged more heavily than Towadako. This areal difference in damage may be caused by differences in natural conditions.

Farmers' cold weather hazard perception and responses to temperature anomalies

In the summer of 1980, low temperature warnings were issued six times in Aomori Prefecture. The first one lasted for three days from July 3 to 5. Most farmers interviewed anticipated the cold weather hazard in the period from July to the middle of August. Generally, rice is susceptible to damage from low temperature during the panicle formation

Table 1 The damages of cold weather hazards in 1980 and 1981

	Not even self-sustenance rice	Only self-sustenance rice	Shipping rice	Total
Tenmabayashi				
1980	38 (79.1)	9 (18.8)	1 (2.1)	48 (100.0)
1981	4 (8.5)	13 (27.7)	30 (63.8)	47 (100.0)
Towadako				
1980	38 (55.1)	24 (34.8)	7 (10.1)	69 (100.0)
1981	0 (0.0)	8 (11.6)	61 (88.4)	69 (100.0)

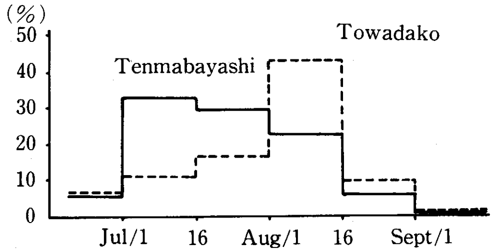

Fig. 5 Farmers' prediction of cold hazard

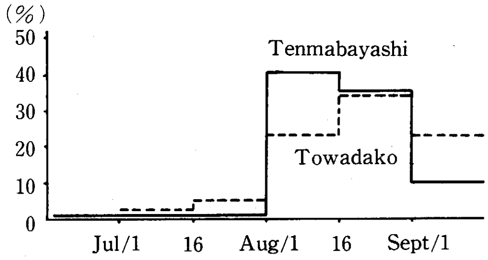

Fig. 6 Farmers' time of conviction of cold hazard

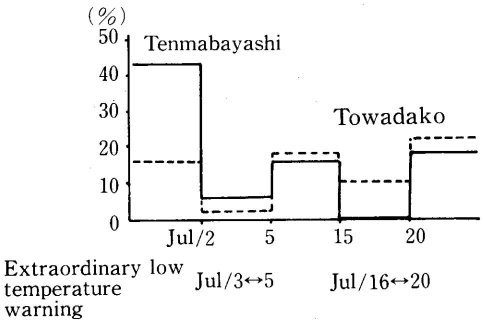

Fig. 7 Farmers' memory of the first low temperature

period and the earing and blooming period: the former is from the middle to the end of July and the latter from the beginning to the middle of August. The above fact indicates that cold weather hazard was anticipated during the above mentioned two periods. Fig. 5, however, reveals a difference in the time of anticipation between Tenmabayashi and Towadako. Whereas more than 60 percent of farmers interviewed in Tenmabayashi anticipated the hazard by the end of July, the figure for Towadako was only 30 percent during July and 40 percent in the first half of August. While many farmers in Towadako were likely to anticipate the rice crop damage from the low temperature during the earing and blooming periods, those in Tenmabayashi appear to have anticipated the damage during the panicle formation period. It may safely be said that the farmers in Tenmabayashi perceived cold weather hazard earlier than those in Towadako. The time when farmers were convinced that cold weather damage had occurred is shown in Fig. 6. Few respondents were convinced of the damage during July. Many respondents in both Tenmabayashi and Towadako became convinced in August. Though the areal difference in the timing of recognition in the two areas is not entirely clear, it is safe to say that farmers in Tenmabayashi were likely to be convinced earlier than those in Towadako: about 40 percent of respondents in Tenmabayashi became convinced by early August and 80 percent in the end of August; only a little over 20 percent of respondents in Towadako had become convinced by early August. Fig. 7 shows the memory farmers had of the first abnormally low temperature. It might also be noted that the sampled farmers in Tenmabayashi were more sensitive to the low temperature.

The next question to be considered here is why there is a temporal difference between the farmers' perception of cold weather damage in the two areas. When rice has been damaged by low temperatures in the panicle formation period, it is difficult to perceive whether damage to the rice has occurred by its external appearance. Perception of cold weather hazard comes about by observing the appearance of rice plants up until the flowering and harvest. Without checking the degree of damage to the rice, the cold weather damage can be perceived. The degree of damage and the occurrence of damage might be anticipated

Table 2 A part of diaries from Tenmabayashi farmers

	Mr. A		Mr. B	
July	1	The Yamase blew hard and it was chilly.		
	2	At dusk, the Yamase had changed into rain.		
	6	It was a warmer day. Drained the field, cultivated *Akihikari* (a kind of rice)		
	9	At dusk, planed to stop draining and irrigate with water but had no water.		
			17	Confirmed the panicle formation.
	18	The Yamase blew this day too. *Hamaasahi* (a kind of rice) is in danger.		
			19	Finished the follow-up fertilizing.
	26	The Yamase began to blow in the evening and it became cool.		
	27	It was a cold day because of the Yamase.		
	29	It was also cool weather today because of the Yamase.		
	30	It was cool because of the Yamase. *Hamaasahi* is in ear, but the weather is not right for pollination.		
August			3	It was cloudy too and cold. Fear a cold weather hazard.
	8	*Akihikari* began to come into ear.	8	It was warm from the morning to the evening. Pray for the fine weather to continue.
	10	The Yamase was blowing and the temperature remained low in spite of a little sunshine. A cold weather damage looks to be unavoidable.		
	11	The Yamase blew. *Hamaasahi* will have little crop.		
	15	The Yamase rained.		
	16	The Yamase rained.		
	17	The Yamase rained all day.	17	Rice is flowering sparsely.
			19	Flowering of rice is not favorable.
	25	Disappointed because of the low temperature warning.		
			26	All day it was cold as under the snowy weather. Severe damage by cold weather hazard is surely to occur.
	27	The trouble is that there was the Yamase rained all day.		
			29	There is little likelihood of ripening. Drained rice fields.

Table 3 Farmers' responses to low temperature anomalies in 1980 summer
– the quickness of change from draining to irrigating –

Response to low temperature	Tenmabayashi	Towadako
Changed quickly deep irrigation	25 (73.5)	38 (64.4)
Left as it was	9 (26.5)	21 (35.6)
Total	34 (100.0)	59 (100.0)

based on the intensity and the duration of low temperature in certain growing periods. When the temperature drops below 20°C in the reduction division period following the panicle formation period, rice is damaged severely. According to one farmer, a Yamase blowing for a week in July will damage the rice crop to some degree. Another farmer stated that little harvest would be expected, if the temperature dropped below 17°C for two or three days in late July. To investigate how they perceive cold weather hazard, farmers' diaries about agricultural affairs were examined in detail.

Table 2 shows a part of the agricultural diaries written by two Tenmabayashi farmers. Both Mr. A and Mr. B owned more than 3 hectares of rice fields. In Mr. A's diary, the weather condition was always recorded. This indicates that Mr. A was very sensitive to the weather during the rice growing period. He had anticipated the cold weather hazard on July 18, and was convinced by August 10 that some damage had occurred. On the other hand, Mr. B, whose diary is less detailed than that of Mr. A, referred to cold weather hazard on August 3 for the first time, and was convinced of damage by August 26 when rice would have been ripening normally.

Why did such temporal differences of perception between Mr. A and Mr. B occur? Because the perception of cold weather hazard during July is mainly based on the intensity and duration of temperature anomalies, Mr. A who paid considerable attention to the weather condition may have perceived the hazard by means of the above-mentioned character of the low temperature. In this way, famers could perceive the occurrence of damage by cold weather earlier, compared with observation of the conditions of the rice as it was growing. Needless to say, the awareness of low temperture and the observation of rice plant do not operate on the perception separately but together. But it seemed that, the temporal difference in perceiving the cold weather hazard may be explained by considering which aspect mainly contributes to the formation of the perception.

The response to temperature anomalies is shown in Table 3. When the abnormally low temperature appeared, one of the farmers' responses was to irrigate the rice fields with much more water than usual to protect the rice plants from cool air. The quickness of the conversion from draining to irrigating was questioned. The difference between Tenmabayashi and Towadako is not so clear, but the percentage of respondents who had changed to the above kind of irrigation is slightly higher in Tenmabayashi than in Towadako.

Adoption of adjustment after the 1980 cold weather hazard

The severe damage caused by the cold weather hazard in 1980 gave a major shock to rice farmers. Since the disaster occurred, many kinds of adjustments to cold weather hazard have been adopted. First, the varieties of rice under cultivation have changed. Table 4 shows what character of rice had come to give priority after the disaster, but it is difficult to say

Table 4 Changes of the choice of rice varieties

	A	A + B	A + C	B + C	B	C	Total
Tenmabayashi							
1980	7 (14.6)	8 (16.7)	8 (16.7)	17 (35.3)	5 (10.4)	3 (6.3)	48 (100.0)
1982	11 (23.4)	13 (27.8)	9 (19.1)	9 (19.1)	4 (8.5)	1 (2.1)	47 (100.0)
Towadako							
1980	3 (4.4)	24 (35.3)	9 (13.2)	24 (35.3)	3 (4.4)	5 (7.4)	68 (100.0)
1982	6 (8.7)	27 (39.3)	9 (13.0)	19 (27.5)	3 (4.3)	5 (7.2)	69 (100.0)

A: Early-maturing and cold-hardy rice plant
B: Quality of rice
C: Others

Table 5 Farmers' future expectations of cold weather hazards

	Damage	No damage	Total
Tenmabayashi	44 (91.7)	4 (8.3)	48 (100.0)
Towadako	64 (94.1)	4 (5.9)	68 (100.0)

Table 6 Farmers' views of cold weather hazards

	Tenmabayashi	Towadako
Cold weather hazards depend entirely on 'Nature' and man can do nothing	10 (20.8)	10 (14.7)
Man can overcome cold weather hazards by means of improvement of agricultural technology	6 (12.5)	9 (13.2)
Cold weather hazards depend on "Nature' but man can overcome them to some degree	32 (66.7)	49 (72.1)
Total	48 (100.0)	68 (100.0)

Table 7 Adoption of adjustments after the 1980 disaster

	Tenmabayashi	Towadako
Introduction of early-maturing rice plant	25 (52.1)	16 (23.2)
Changes in fertilizing	34 (70.4)	52 (75.4)
Intorudction of other field crops and Livestocks	13 (27.1)	18 (26.1)
Windbreak equipment	4 (8.3)	0 (0.0)
Control of irrigation water	3 (6.3)	5 (7.2)
Others	1 (2.1)	4 (5.8)
No adjustment	2 (4.2)	8 (11.6)
Combination of some adjustments	27 (56.3)	26 (37.7)

that these criteria could have been reflected in choosing varieties actually. Characters were categorized into three groups: A) measure for cold weather hazard, especially adoption of an early-maturing and cold-hardy rice plant, B) quality of rice which is related to good taste, C) other characters, that is, disease-resistance, quantity of yield and so on. It is clear that criterion A came to be more important in both areas. In Towadako, 'A and B' has slightly increased against a decrease of 'B and C'. This change is more remarkable in Tenmabayashi. It just indicates, of cource, that the 1980 disaster had changed the farmers' image of the cold weather hazard more greatly in Tenmabayashi. The future expectation of cold weather hazards shown in Table 5 may be considered as representing farmers' changing environmental image. 90 percent of respondents in both areas expected future damage by cold weather. As an example, one farmer interviewed had the following view: cool air in summer which causes damage is the result of cool air which would have normally been dissipated during winter being carried over into summer. As for farmers' views of cold weather hazard, about 70 percent of respondents answered that man can overcome cold weather hazards to some degree (Table 6). There is little difference in the future expectation and views between the two areas.

The next problem is to examine the private adjustment actually carried out since the 1980 disaster (Table 7). Adjustments included the following: introduction of early-maturing rice plants, changes in fertilizing, introduction of other field crops and livestock to mitigate risk, installation of windbreak equipment, control of irrigation water and the like (Fig. 8). According to Table 7, almost all respondents have adopted some adjustments. Comparing Tenmabayashi and Towadako, however, it is clear that Tenmabayashi farmers have adopted adjustments more positively. In particular, early-maturing rice plants have been adopted by more than 50 percent of Tenmabayashi respondents, and windbreak equipment was installed only in this area. Furthermore, 56 percent of Tenmabayashi samples have made combinations of some adjustments. Though the difference between two areas is not clear from Tables 5 and 6, clear difference regarding the actual adoption of adjustments was revealed from the field work.

Fig. 8 (a) Example of one of the adjustments – windbreak net

Fig. 8 (b) Facility for warming irrigation water

5. Concluding Remarks

This paper has examined the perception of farmers and their adjustment to the 1980 cold weather hazard in the Sanbongihara area of Aomori Prefecture. The results obtained are summarized as follows:

1) Farmers of Tenmabayashi were more sensitive to the low temperature, and perceived cold weather hazard earlier than those of Towadako.

2) Farmers of Tenmabayashi have started to pay more attention to early-muturing and cold-hardy rice plant in selecting rice varieties since the disaster.

3) Farmers of Tenmabayashi have aggressively adopted adjustments such as early-maturing rice plant and windbreak equipment to cope with cold weather hazard.

These perceptural and behavioural differences between farmers of Tenmabayashi and those of Towadako have been explained with reference to natural conditions and/or actual damage magnitude in this paper. According to natural hazard perception study's framework, however, the time lag of each farmer's perception to cold weather hazard should be related to that individual's experience. Also adjustment-adopting behaviour should be explained in terms of farmer's perception of cold weather hazard. Compared with something like flood damage, the individual's perception and adjustment in the case of cold weather hazard appear to play a significant role in reducing damage. Consequently images accrued from cold weather hazard views or associated with hazard occurrence expectations may prove to be useful in accounting for farmers' avoidance behaviour towards cold weather hazard. These points await further empirical investigation.

Acknowledgements

The authors wish to express many thanks to the people of the Towada area and Mr. A. Igarashi, Mr. K. Kushiya, Mr. T. Shimura, students of Tokyo Metropolitan University, who assisted the execution of this research.

This study was performed as a part of "The perception of farmers and their behaviour towards the cold weather hazard in 1980 and 1981 in the Tohoku and Hokkaido Regions (Convener, A. Terasaka, Associate Professor of Tokyo Metropolitan University)" with the financial assistance of Grant-in-Aid 1982 (57580149) of the Ministry of Education.

The assistance of Paul Sheard, Department of Human Geography, Australian National University, in correcting English mistakes is gratefully acknowledged.

This paper is dedicated to Professor Takamasa Nakano, who is only one splendid pioneer setting the pace for much of the future work on natural hazard perception in Japan, on the occasion of his retirement from Tokyo Metropolitan University.

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