

Review:

# Snow Damage in Contemporary Japan

## – Progress and Measures –

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We review snowfall disasters, the transition of snow damage in contemporary Japan and its social background, and progress in measures against snow damage. After reviewing how snow damage has changed with social change, we summarize features of contemporary snow damage. We discuss snow damage in 1963, 1981, 1996, and 2006 as examples typical of snowfall disasters, damage conditions, and measures and issues involved. Increasingly sophisticated urban functions have aggravated urban snow damage, urban building reform basically has lagged, and snow damage has recently threatened even the existence of mountainous area suffering due to a shrinking, aging population.

**Keywords:** snow damage, disaster subculture, urban disaster, aged society, depopulation

### 1. Introduction

We give an overview of changes in snow damage in contemporary Japan using typical snowfall disasters to clarify details features, and considering changes and issues on measures against snow damage.

In our view, snow damage differs from other natural disasters, greatly affecting changes in snow damage and measures against it. We start by examining the differences and their effect on the history of snow damage thus far in Sections 2 and 3.

In Sections 4 to 7, we discuss four examples of snowfall event after World War II, i.e., in 1963, 1981, 1996, and 2006. The most recent among them – the 2006 snowfall event – is comparatively recent and brings new lessons regarding measures against snow damage.

We conclude with some comments on prospects for trends in measures against snow damage and prospects.

### 2. Snow Damage Features

Snow disasters are, like storms and floods, natural disasters – but with a difference centering on regionality, spatiality, seasonality, and temporality, all of which give

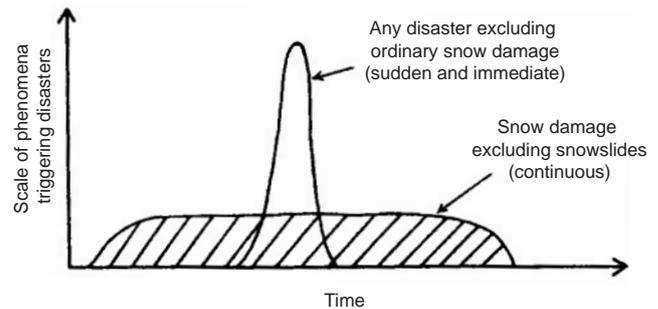


Fig. 1. Comparison of snow damage and other disasters (Nakamura, 1980 [1]).

snow disasters their unique nature.

Compared to transient phenomena such as earthquakes and typhoons, and to disasters relatively limited in scope, such as cold-weather and frost damage, snow affects all aspects of the stricken population, although exactly how may not be immediately clear. Given that snowfall in Japan is limited and tends to be the same year after year, the aspect of regionality becomes more noticeable than spatiality.

Put another way, earthquake, storm, and flood disasters occur suddenly, seasonally, and comparatively quickly. Limited-area cold-weather and frost damage may be comparatively long-term, but resulting damage is limited to a relatively narrow scope, such as the adversely affected agricultural crop involved. Snowfall, however, exerts its influences continuously throughout one particular season, causing continuous, successive damage that victims may only be able to respond slowly to (Fig. 1) [1]. Populations in areas of heavy snowfall must usually face snow as a lifelong threat in which a small failure could lead to a large disaster.

This very long-term pervasiveness of snow damage tends to cloud its disastrous aspect into something of an “ordinary” occurrence, making it often difficult to distinguish clearly between snow-related problems in everyday life and disaster as a distinctly nonordinary phenomenon.

A. H. Barton pointed out that long-term regularly-occurring disasters let society respond on its own to the losses caused by such disasters, and society develops a “disaster subculture,” meaning the accumulation of

**Table 1.** Changes in problems associated with snow – three steps.

Stage	Classical Snow Damage	Modern Snow Damage	Contemporary Snow Damage
Details	Snow-slides, Snowstorms, Floods caused by melted snow	Property losses, Industrial losses, Problems of physical distribution	Difficulty of winter living, Deterioration and paralyses of urban life style
Important Subject	Human lives	Economy	Society
Target	Avoidance of catastrophic natural events	Conquest of regional disadvantages	Creation of regional social systems to withstand snow
Significance of cities	Protection by collective living	Homogeneous cities and villages	Urban problems including expansion and overpopulation
Object to deal with snow	Safety (human lives and properties)	Economy, Convenience	Convenience, Comfort
Subject coping with snow	Individuals, Communities	National and local governments	Local governments and residents associations
Utilization of snow	Utilization of snow in daily lifestyles	Utilization of snow by industry	Utilization of snow by society
Typical concepts of snow damage	Fate or destiny	Regional promotion theory	Urban snow damage theory

knowledge for coping with such disasters. Such a disaster subculture, however, is likely to keep local social systems at a low level or, in the worst case, cause them to fail [2]. Snow damage is a typical example of this. Because the existence of a disaster subculture already increases resistance to snow, damage and confusion when a heavy snowfall occurs depend on how much the damage and confusion differ in the region rather than on the amount of snowfall. Frequently occurring snow damage becomes a structural problem resulting in social stagnation or decline there.

Unlike in an earthquake or sediment-related disaster, for example, which may claim many sudden victims, snowfall is a “silent killer,” stalking its victims over time through their efforts to maintain their lives and livelihoods through such “everyday” efforts as snow removal that, while it does not suddenly kill its victims, it wears them down through indirect economic burden and physical fatigue.

These considerations point up another significant feature of the connection of snowfall disasters with social change. Snow disasters have reflected social change that has radically altered the face of snow disasters. In addition to suffering the damage itself, people’s recognition, for example, of what situations are considered snow damage or what action should be taken to have changed over time. Nishikawa considered this aspect of snow disasters to be unique among natural disasters, in that snow disasters evolve and have only relatively recently come to be even considered as actual disasters [3]. In the sections that follow, we trace the general history and evolution of snow disasters.

### 3. Evolution of Historical and Contemporary Snow Damage

In our view, historical changes in views on snow damage can be divided into three steps – historical, modern, and contemporary, each corresponding to a historical development such as modern industrialization at the beginning of the 20<sup>th</sup> century and the high economic growth

following World War II (**Table 1**).

Historical snow damage was, for example, quite limited. Other than damage directly affecting life and property, such as snowstorms, snow slides, snow-melt flooding, and housing collapse, snow damage historically threatened existence through a blow to occupations, such as triggered by late or early snowfalls [5]. In a historical step, snow damage consists only of events that threaten people’s living at low level equilibrium which was built on the assumption that it adapts itself to snow.

After the Meiji Restoration in 1868, modern economic and social mechanisms began entering areas of heavy snowfall in Japan with the development of an industrial economy mainly in transport, communication, mining and manufacturing, electricity, and agriculture. In nationwide market competition with snow-free regions, snow became a regional handicap as snow began to adversely affect transport facilities, electricity, and communications. Instead of the traditional problems, regions of snowfall now faced economic and social problems involving the collapse of public facilities, the interruption of railroad transport, the closure of schools, damage to fruit trees, the isolation of villages, the interruption of telegraph and power supplies, and an accumulation of stock for supplies [5]. The economic disadvantages caused by snow themselves became a type of disaster.

When Japan entered high economic growth after World War II, new “snow damage” arose in relation to traffic jams and failure and functional suspension of urban infrastructures [5]. Transport was especially affected with the dissemination of motor vehicles. Because of motorization, space to put dumped snow decreased in urban areas and problems related to snow disposal around residential areas became a problem. At this time, the phenomena of snow interrupting or blocking complex urban functions triggered a new aspect in snow disaster.

As snow disaster effects shifted from natural direct threats to existence to economic handicaps, earlier problems with snow never went away, but simply piled up. Snow damage has thus become diversified and complex over time. Contemporary snow damage includes all these factors in stratification.

**Table 2.** Damage due to snowfall events.

(Units: persons, houses)

	Area	Period	Deaths/Injured		Housing destruction (total/partial)	Remarks
			Deaths/Missing	Injured		
1961 snowfall event	Hokuriku	From the last ten days of December 1960 to January 1961	119	92	119	
1963 snowfall event	Hokuriku Sanin regions and Yamagata, Shiga, and Gifu	Prefectures January to February 1963	231	56	1,735	Establishment of Headquarters for Measures against Emergency Disasters (Article 8)
1974 snowfall event	Hokuriku	January to February in 1974	26	106	41	Severe disaster (Article 8)
1977 snowfall event	Tohoku, northern Kinki and Hokuriku regions	December 1976 to March 1977	101	834	139	Establishment of Headquarters for Measures against Emergency Disasters (Article 8), dispatch of governmental investigation teams to Niigata- and Aomori Prefectures
1981 snowfall event	Tohoku- and Hokuriku regions	December 1980 to March 1981	152	2,158	466	Establishment of Headquarters for Measures against Emergency Disasters (Articles 6, 8, 11-2), dispatch of governmental investigation teams to Niigata, Toyama, Ishikawa, and Fukui Prefectures
1984 snowfall event	Tohoku- and Hokuriku regions centering on Toyama	Prefecture December 1983 to March, 1984	131	1,368	189	Establishment of Headquarters for Measures against Emergency Disasters (Articles 11-2), dispatch of governmental investigation teams to Niigata, Toyama, Ishikawa, and Fukui Prefectures
1985 snowfall event	Japan Sea coast centering on Hokuriku region	December 1984 to April 1985	90	736	30	Dispatch of governmental investigation teams to Niigata Prefecture
1986 snowfall event	Hokkaido, Hokuriku, and Tohoku regions centering on Aomori	Prefecture From mid ten days of December 1985 to last ten days of March 1986	90	678	27	(Articles 11-2), dispatch of governmental investigation teams to Niigata- and Aomori Prefectures
2001 snowfall event	Tohoku- and Hokuriku regions	From mid ten days of December 2000 to February 2001	55	702	5	
2004 snowfall event	Hokkaido, Tohoku, and Hokuriku regions	From mid ten days of January to last ten days of February 2004	22	265	1	Dispatch of governmental investigation teams to Hokkaido
2005 snowfall event	Hokkaido, Tohoku, and Hokuriku regions	From January to last ten days of February 2005	86	758	60	Liaison conference of authorities, joint field investigation by snow management authorities in Aomori- and Niigata Prefectures
2006 snowfall event	Hokkaido, Tohoku, and Hokuriku regions	From the first ten days of December 2005 to February 2006	151	2,136	44	Liaison conference of authorities, joint field investigation by snow management authorities to Aomori, Niigata, and Nagano Prefectures

Source: Housing damage, Fire Defense Agency of Japan

Note 1: Act on Special Financial Measures for Severe Disasters

- 1) Article 6 ... Special case of assistance in project costs for disaster restoration of joint facilities for agriculture, forestry, and fisheries
- 2) Article 8 ... Special case of provisional measures for funding natural disaster victims working in agriculture, forestry, and fisheries
- 3) Article 11-2 ... Assistance to disaster restoration projects for forests

Society has also changed, together with social attitudes, their conditions with the change of snow disaster. Historical snow damage was dealt with through self-help and mutual aid among individuals, families, communities, and regional entities in which the burden of snow-related work was viewed as destiny. In the context of modern snow disasters, the emphasis moved to technical solutions. In the context of contemporary snow disasters, attempts shifted to making urban and regional facilities and organizations

more snow-resistant and comprehensive measures against snow damage not limited to individual ones are needed.

Before going into contemporary examples of snow damage, we review major snowfall damage during this period (**Table 2**). **Table 2** constitute only a part of such damage, which was also accompanied by many-faceted, extensive damage involving physical loss, industrial damage, and functional interruption of transport and communications. While the features of individual cases of snow-

fall event might be found in these factors, it is an unfortunate fact that no statistics cover them in detail. It is at least certain, however, that the scale of damage is an index of the magnitude of overall snow damage in each case. The death toll due to snow damage marked the highest among all disasters in the four times during the decade from 1996 to 2005 [7]. It is clear that snow damage continues to be typical of disasters endangering human life even in contemporary time.

#### 4. 1963 Snowfall Event

In 1963, the first contemporary snow damage occurred. In January 1963, a high pressure front near Kamchatka and a westward low pressure trough stagnated about for one month as cold-air masses moved south from the North Pole, bring unusually low temperatures and snow falls. So-called "sato-yuki" (snow that falls on plains) fell along the plains and the mountains from Yamagata Prefecture and Chuetsu in Niigata Prefecture to Hokuriku, which consists of Toyama, Ishikawa, and Fukui Prefectures and northern Hyogo and Shimane Prefectures [8].

Following heavy Hokuriku snow in 1961, snow damage to transport hindered industrial production and distribution had become a serious problem. In addition to the interruption of railroads, road transport between and within cities became a problem. At that time in Hokuriku, 90-95% of all freight transport relied on railroads [9], and problems due to road transport already exerted significant social influence. In Nagaoka City, where snowfall was greatest at 318 m since the beginning of recorded observation, traffic within the city was paralyzed and people's lives were totally disrupted. The impact was so great that the Nagaoka City assembly adopted Japan's first declaration of a no-snow city. In addition to inner city traffic disruption, the 1963 snowfall event pointed up problems in transport between cities and regions, especially in the isolation of villages in mountainous areas due to massive road and railroad disruption [10].

"Medical Sheets, Bright Winters," [11] published serially in 1963 by the local Niigata Daily Newspaper, examined problems brought by the heavy snowfall in detail and proposed measures listed under keywords such as railroads, roads, and urban areas. The most space was devoted to the issue on snow and urban areas, treating subjects such as sewage and waste disposal, snow removal, snow dumping sites, and emergency fire fighting. The need for drastic measures went beyond the individual and extended to the development of industrial parks for small to medium enterprises and street improvements based on city planning.

Miyamoto Kenichi, a scholar on public finance, who worked at the Kanazawa University in 1963, took up the 1963 snowfall event as an urban snow disaster, stating that "the basic cause for confusion in people's lives lies in the failure of urbanization in snow country." [12], and maintained that industrialization and urbanization resulted aggravated snow damage as an urban problem caused by

lack of urban facilities. The idea was introduced that aggravation of snow damage was an urban disaster brought by social change, collectively called "snow damage," a term that came into widespread use. Miyamoto referred to transport paralysis and the isolation of suburban apartment complexes, calling for solutions to failures in urban reform and public transport left untreated in city planning. Little was done, however, and the problem repeated itself in the 1981 snowfall event.

As stated, the 1963 snowfall event resulted in the most human damage since observations were first recorded (Table 2), and was the largest snowfall disaster since World War II. More than with other heavy snowfalls, an unusual number of houses collapsed because of unusually heavy snowfall on the outskirts of areas of usually heavy snowfalls Chugoku, where snowfall is low in ordinary years. Housing collapses were aggravated by the heavy accumulations of snow and the poor housing conditions remaining after the war even then.

Japan was just moving from restoration after the war to high economic growth when regionally comprehensive measures against snow changed from snow-related problem in everyday life to snow damage as an actual disaster. In 1956, the Special Measures Act on Road Transport Security in Specific Snowfall event Areas was enacted and 5-year projects against cold and snow were implemented based on this act [10]. This was followed by the Snowfall event Specific Measures Act in 1962, triggered by the Hokuriku snowfall, and measures for regionally promoting areas of heavy snowfall were put on track. During this enactment, snowfall disasters were mentioned in the Basic Disaster Countermeasure Act enacted in 1961, enabling the Disaster Relief Act to apply to snowfall disasters [13].

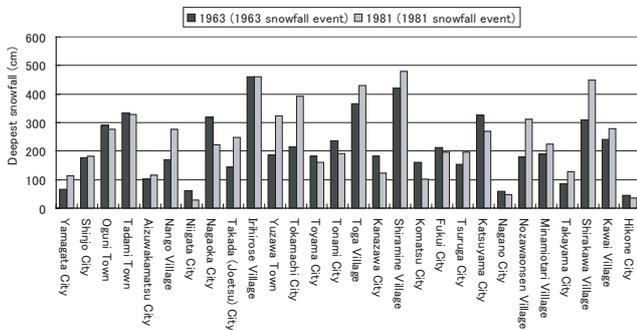
The 1963 snowfall event was the first affected by the acts, giving an opportunity to show the necessity of measures against snow. The goal was set to dealing successfully with snow and making urban areas snow-free in winter. Snow removal on roads increased in importance and advanced rapidly. The total extent of snow removal under Hokuriku Regional Construction Office jurisdiction increased from 94 km in 1958 to 768 km in 1968, for example [9]. Such direct measures against snow were likely to conceal from the public eye the drastic structural measures advocated by, for example, the Niigata Daily Newspaper or Kenichi Miyamoto. The rise in awareness to do something concrete about snow involved administrations and residents in "snow country," making the 1963 snowfall event a good opportunity for changing prevailing views on snow significantly, rather than stressing citizen perseverance.

#### 5. 1981 Snowfall Event

The 1981 snowfall event the 1981 snowfall event that struck Hokuriku 18 years after the 1963 snowfall event is often compared to the 1963 snowfall event, because of similar meteorological conditions, snowfall scale, and pattern. Resulting snow damage, however, mirrored 2

**Table 3.** Comparison of snow removal at Hokuriku Regional Construction Office between 1963 and 1981 snowfall events.

Indices Fiscal year	Expansion of snow removal (km)	Number of business offices	Number of snow removal stations	Number of snow removal machines	Cost of snow removal (million yen)
Fiscal 1962 (1963 snowfall event)	253.1	10	0	27	82
Fiscal 1980 (1981 snowfall event)	978.1	21	32	276	1,819



**Fig. 2.** Comparison of deepest snowfall between 1963 and 1981 snowfall events.

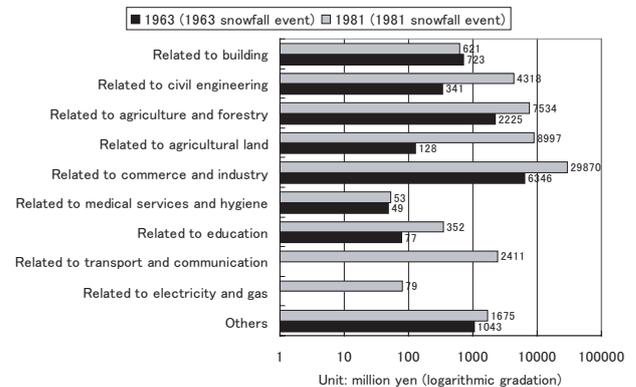


**Fig. 3.** Traffic interference situation in the central area of Fukui city at 1981 snowfall event.

decades of social change.

The atmospheric pressure distribution in the 1981 snowfall event is said to resemble that in the 1963 snowfall event, especially in the early stage, centering on Hokuriku in heavy snowfall. Snowfall in Chugoku was much less than that in 1963. The 1963 snowfall event involved “sato-yuki” (snow that falls on the plains), but the 1981 snowfall event combined sato-yuki and “yama-yuki” (snow that falls in the mountains) [8], and less fell on the plains and more in the mountains in many areas than that in 1963. Even so, the heaviness of the snowfall was no less than that in 1963 (Fig. 2).

A significant feature of damage in the 1981 snowfall event is the increased seriousness of disruption of city and regional functions, despite improved snow removal (Table 3). We went to Fukui City for a field investigation



**Fig. 4.** Amount of damage at 1963 and 1981 snowfall events in Niigata Prefecture.

as researchers of the National Research Center for Disaster Prevention when heavy snowfall peaked. Urban transport was paralyzed and disruptions continued until March (Fig. 3), due in part to the fact that the number of private cars had increased by about 10 times in Hokuriku prefectures compared to 1963. Although quantification of such damage is difficult, we compared 1963 and 1981 snowfall events in terms of damage in Niigata Prefecture as an example (Fig. 4). Compared to 1963, the amount of damage to buildings and medical services and hygiene did not increase, but in civil engineering, agriculture and forestry, commerce and industry, and education grew by over ten times, with transport and communication and electricity and gas functions now included in considerations. Damage does not always represent the real extent of disruption of functions, but damage to commerce and industry, education, transport and communication, and electricity and gas was not limited to physical damage but extended to social disruption of function.

In Fukui City, which was hardest hit [14], transport and communication disruptions included road interruptions 3 times, isolation of districts 5 times, interruption of telephone lines 16 times, and power failures twice during one month. The disruption of everyday urban functions was reflected in the questionnaires we and others distributed in Fukui- and Ono Cities, although limited, in March after the heavy snowfall [15]. Many respondents reported disruptions of waste and sewage disposal and fuel supply, and commuting and parking problems of private car.

Another important feature is the influence of aging on regional society pointed out. Toyoda and others studied

damage in the 1981 snowfall event at medical facilities in Toyama Prefecture, where society had aged about 20 years compared to 1963 [16].

The 1981 snowfall event is the first large-scale snow damage since motorization became widespread. Previous measures against snow succeeded to some extent in the transport between cities by promoting quantitative increases in snow removal from roads [17]. The 1981 snowfall event pinpointed limits of previous measures through expanded urban snow damage and urged a review of urban structures in snow country. This was also the first snow damage reflected the advances in the aging of society.

Drastic were proposed to lessen the influence of snow. The Society for the Study the Measures against Snow Damage in Fukui City examined possible road transport network at the city-level, taking an example in Fukui City. It proposed that a beltway route be constructed, that “park-and-ride” lots be provided at nodes to promote public transport, and that private cars be regulated based on snow considerations [18]. This is similar to European efforts to restrict the entry of private cars into city centers.

New measures against prefecture-level disruptions began being considered, in Hokuriku after the 1981 snowfall event, leading to the Report on Snow-Resistant City Planning in 1982 by the Fukui Prefecture and the Report on Comprehensive Measures against Snow in 1983 by Toyama Prefecture. Even these efforts, however, were not enough.

## 6. 1996 Snowfall Event

The 1996 snowfall event was not epoch-making in size like those in 1963 or 1981, but is noteworthy on the local scale, which is why it is not included in **Table 2**. It nonetheless is worthy noting because (1) it was the first snowfall event in a decade and provides valuable insight into social change vis a vis snow and (2) the unexpected impact of this unusual local snowfall appears to have been influenced by global warming and impacted on urban functions.

The 1996 snowfall event was characterized by the admixture of heavy and light snowfall areas and intensive short-term snowfall (“doka-yuki” in Japanese) [19]. Much snow fell, for example, in Sapporo, Yamagata, and Nagano Cities but little in Obihiro, Akita, and Fukui-Cities. The intensive short-term snowfall especially around Sapporo triggered great confusion and problems, as detailed below [20].

This snowfall event in metropolitan Sapporo is noteworthy as causing full-scale urban snow disruptions after a long interval without – perhaps for the first time since the 1981 snowfall event. Sapporo, a core metropolitan area in Hokkaido, Japan’s furthestmost northeast city, boasts a population of 1.76 million.

Snow began fall intensively in Sapporo began from December 11, 1995, and continued intermittently until January 11, 1996. In January, it was accompanied by snow-

storms so heavy that snow disposal departments in the city were overwhelmed. Falling, as it did, at the busiest holiday season of New Year, it had an especially harsh impact on transport networks and urban functions [21], disrupting intra- and intercity as airplanes, railroads, highways, buses, and trams, with only the subway system left to be relied on. The intensive short-term snowfall also raised havoc in the dense urban population with its aging human stratum.

In reviewing details of the disaster [21, 22], compared to the 1981 snowfall event, the earlier event involved traffic paralysis, the problem of illegally parked bicycles, disrupted garbage collection, and the incidence of gas explosions.

In the case of Sapporo, new technologies in widely dispersed and diversified fields added tragic new wrinkles to the fabric of the unfolding tragedy. These included, for example, the shortage of blood for transfusions and the disruption of transport lines that kept such blood available for kidney dialysis. Mobile blood donation centers collect fresh blood daily and deliver it to medical facilities under computerized control of convenient stocks in small quantities. The influx of snow changed all this.

Sapporo, with its high housing concentration, has invested in new snow disposal techniques such as “hot” pavements and automatic snow-melting troughs and machinery that takes care of the problem without requiring that people leave their homes. At the time of the 1996 snowfall event, however, this system had not been disseminate thoroughly enough, triggering accidents such as the death of an elderly woman who fell into a snow-melting trough and died. Other innovations, such as smaller snowblowers for household use, led to accidents involving operator error.

In the rapidly advanced aging of snow country populations, concerns grew about accidents among the aged such as those falling from or blown off of roofs while removing snow and dying of injury or freezing to death before they were found. These incidents showed a marked increase in 1996 compared to those in the 1981 snowfall event [22].

In Otaru City, city snow disposal for elderly residents in municipal housing or old residences failed to catch up with local needs, adding the event’s impact.

In short, the 1996 snowfall event showed that problems already pointed out in the 1981 snowfall event were not only not solved, but instead has increased in seriousness against the onslaught of urbanization, social flow, motorization, and aging.

In addition there surfaced the problem of urban system management in snowfalls and the massive burden of snow removal and the difficulty of securing enough space for dumping snow. In Sapporo, the amount of snow removal increased 1.5 times in a decade due to a rapid increase in large suburban supermarkets and the rapid enlargement of population in urban areas. Sites for dumping snow decreased concomitantly and remained insufficient despite the city’s efforts to rent private land for this purpose.

Sufficient thought had also not been given to the possibility of heavy snowfalls exceeding the snow-removal ca-

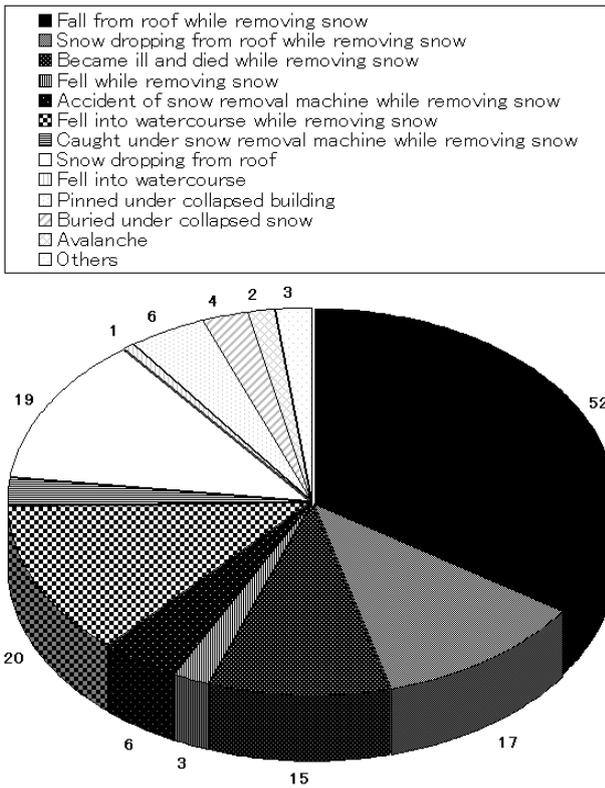


Fig. 5. Breakdown by cause of death in 2006 snowfall event.

capacity of which the city was so proud. When this capacity was exceeded, the city could not move swiftly enough, for example, to provide practical information on snow measures to the public. At one snow removal center, for example, snow removal machines could not move due to unheard-of snowfall and snowstorm activity. Outlying snow removal centers ceased to be able to communicate directly with management hubs, and no system existed to citizens of the situation and to urge them to take action. Residential traffic became locked in snowdrifts, and commuting came to a standstill, aggravating the situation. City authorities realized then that they had not considered snow removal on roads as must-have services and learned through harsh experience that they would have to review this issue from the viewpoint of risk management.

Sapporo’s situation revealed its short-comings beyond all doubt and emphasized the need drastically review the city’s “snow country” image and construct realistic risk management. This is to be noted together with a sharp rise in voluntary snow removal activities centering on Niigata in the same year in ways that differed distinctly from the situation involving the 1981 snowfall event.

## 7. 2006 Snowfall Event

Meteorologically speaking, the circumstances involving snowfall in the winter of 2005-2006 were not dissimilar to the 1963 snowfall event. The storms in December 2005 were stronger than those of 1963 and rivaled any oc-

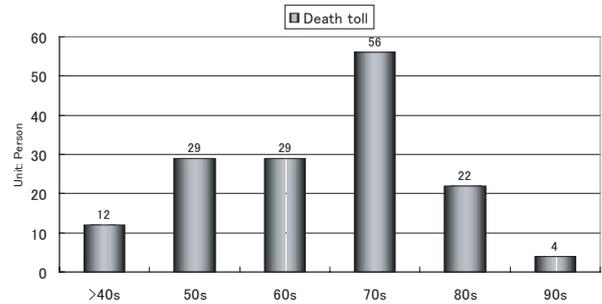


Fig. 6. Breakdown by age of death in 2006 snowfall event.

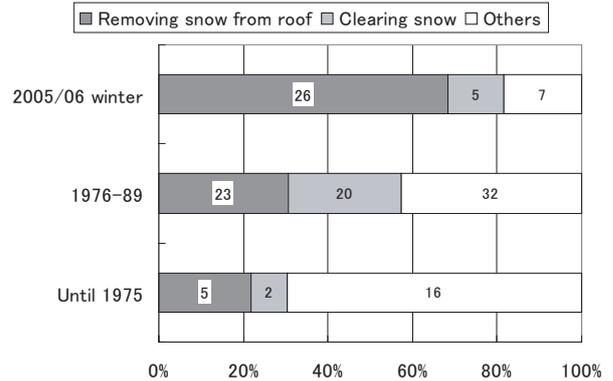


Fig. 7. Transition in conditions at accidents due to snow falling from roof (Yamagata Prefecture).

curing in the last half-century. Overall, the scale of the cold-air mass moving southward was the second largest after the 1963 snowfall event [23].

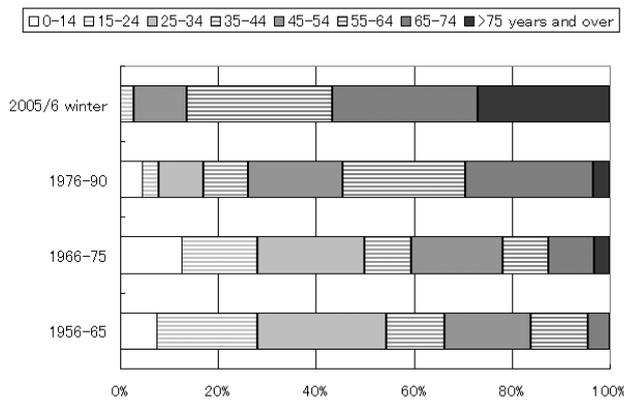
Snowfalls greatly exceeded annual averages nationwide except for Hokkaido, with total amounts west of Niigata Prefecture exceeding by 160 cm that of the average year [24]. The snow came early – in December, as mentioned above – and it came heavily in the form of disruptive “yama-yuki” drifts.

It became the first full-scale snowfall event since 1981, leaving behind it 161 disastrous avalanches, a death toll of 16, and 42 injured [25].

The 2006 snowfall event data is insufficient to compare it quantifiably to 1963 or 1981, although we can confirm, for example, that the number of totally and partially destroyed houses is much lower than in the past [26]. This is attributable to advances in capital investment in lifeline infrastructures and disaster prevention.

The panic observed in Nagaoka- and Kanazawa Cities in 1963, in Fukui City in 1981, and in Sapporo in 1996 did not occur beyond, the attention of the mass media to the isolation of mountainous districts in Tsunan Town in Niigata Prefecture.

The human toll – 152 fatalities – was, however, the third highest after World War after the 1963 and 1981 snowfall events. The 2006 snowfall event features markedly high numbers of accidents during snow disposal (Fig. 5) and among the elderly (Fig. 6) – two closely-related factors that have only become more obvious as time has passed (Figs. 7 and 8).



**Fig. 8.** Transition in mortality due to snow damage by age in Akita and Yamagata Prefectures.

One more feature worth noting about the 2006 snow event is the fact that damage in mountainous areas increased more than that in urban areas, compared to past snowfall events. About 70% of deaths occurred in mountainous area [29], possibly due to the “yama-yuki” properties. In our view, however, the problem lies in the increasing inability to prevent disasters in mountainous areas due to depopulation and aging.

To mention some supporting factors [30] – The elderly population is growing and aging faster in mountainous areas, but until around 1985, the low percentage of elderly people in households compensated for this trend. Especially important is the fact that before 1985, households had a higher proportion of younger members who could, for example, dispose of snow efficiently enough that fewer of the elderly faced this arduous exercise, resulting in a high safety potential. Once this trend reversed, however, and the proportion of elderly in households rose in snow country, the safety net in the form of a viable younger population on which the aged relied began rapidly unraveling.

Hayashi and others analyzed the circumstances involving human suffering in the 2006 snowfall event, concluding in part that the sustainability of the social fabric, especially in an elderly and aging population is becoming increasingly questionable. The sustainability of livelihood in mountainous areas involves more the structural form required than support to the individual [31]. Their analyses seem to be suitable, if only we also point out that these changes do not appear suddenly today.

The grassroots growth in snow-disposal volunteers and organization that drew so much attention during the 1996 snowfall event played an ever larger role in 2006. Applicants for the volunteer snow disposal centering Niigata Prefecture Internet sites are nearly doubling each year, and the movement is spreading locally.

Taking the 2006 snowfall event as an opportunity, Japan’s Ministry of Land, Infrastructure, and Transport established the Social Gathering on Safe Reliable Regional Snow Country Development and examined measures to mitigate damage when heavy snowfalls hit in the foreseeable future. The group proposed improving the

safety net of the aged and ensuring snow disposal centering on mutual aid while viewing ways in basic snow-resistant urban and regional development [29]. In November 2006, under this proposal, the national Basic Plan for Measures in Snow Country was revised after an interval of 7 years, incorporating arrangements to accept volunteers and review improvements in apartment housing for the aged to live in safely.

## 8. Conclusions

We have reviewed examples of snowfall event disasters in 1963, 1981, 1996, and 2006, classifying them into three distinct eras of contemporary snow damage and its effects and noting how this has changed over time.

In the 1963 snowfall event during the high economic growth period, the disruption of urban and regional functions appears for the first time as an issue. Disruption of industrial activity, disruption of urban life, and the isolation of mountainous areas with their elderly, rapidly aging populations, became a serious form of urban damage requiring revisions in snow country city planning. Despite high death tolls due to snow damage since the end of World War II, this issue has attracted little discussion in the media. After the 1963 snowfall event, with the aid of the Snow Country Special Measures Act, movement to correct problems caused by snow advanced more smoothly by, for example, the expansion of snow removal on local roads at the urban and prefectural levels. Drastically needed improvements in urban structures advocated by theories on urban snow damage were not, however, pursued concretely.

The 1981 snowfall event triggered changes in this attitude after full-scale motorization brought residents painfully face to face with the challenge of worsening snow-country weather that snarled intra- and interurban transport despite improved road networks and advances in snow removal. Disruptions in urban and regional functions worsened situations that were already bad at the time of the 1963 snowfall event. The focus of urban snow damage began to shift uncomfortably away from industry and closer to daily private life. The 1981 snowfall event threw the long shadow of an aging and increasingly elderly society little noticed in 1963. Drastic concrete measures attempted, such as snow-resistant urban transport centering on public transportation and comprehensive measures against snow taken by local administrations faded, however, in the face of lighter snowfalls over the years after 1986.

The impact of the 1996 snowfall event, unlike its 3 predecessors, was largely locally, centering on Sapporo, with its sophisticated urban functions, highlighting unexpected, unprecedented glaring failures in urban snow removal at disastrous odds with sophisticated information technology. The 1996 snowfall event triggered drastic measures such as the review of urban risk management, and the reexamination of urban structures in light of the disruptions heavy snowfalls could visit upon an unpre-

pared populace. This was also the time when the serious influence of aging and an increasing rapidly aging of household structures and the unraveling of traditional safety nets attracted increasing public and private concern. This, in turn, triggered a grassroots volunteerism stressing less reliance on administrative urban remedies and more on mutual aid.

The 2006 snowfall event, while less destructive in certain ways than its 3 predecessors, uncovered the inability to prevent disasters in mountainous areas and brought the question of local social sustainability to a head. A greater focus emerged on the vulnerability of an aging local population and the need for active wide-area volunteerism in specialized areas such as snow removal in mountainous areas.

Snow disasters are a complex natural, economic, technical, and social phenomenon that requires equally sophisticated social and economic planning and management. Unless such factors involving snowfall events are treated seriously and in a sustainable way, they will pile up silently like the snow that precedes them – but to whose cost it remains the responsibility of human beings to decide.

Wider-range responses are needed ranging from the maintenance of sophisticated urban functions to the implementation of end-care at peripheral villages in mountainous area. In our view, while snowfall events uncover different problems in the structuring of risk management systems, the central question remains how the social fabric is formed to maintain safe living in snow country in ordinary and extraordinary winter conditions. This involves both software and hardware considerations such as community construction and restructuring. Measures proposed through the occurrence of snow-related disasters such as the 2006 snowfall event will hopefully provide concrete clues to the resolution of such problems.

## References:

- [1] T. Nakamura, "Snow, Snow Disaster and Prevention Techniques against them in Japan," *Technology for Disaster Prevention*, Vol.4, 1980.
- [2] A. H. Barton, "Communities in Disaster: a Sociological Analysis of Collective Stress Situations," Doubleday, 1970.
- [3] Y. Nishikawa, "Nihon-no-saigai (Disasters in Japan)," *Shin-nikkan-tosei-shimbunsha* (New Daily Metropolitan Government Newspaper Company), 1972 (in Japanese).
- [4] N. Numano, "Living in Areas Affected by Snowfall," *YUKIGUNI Snowy Society in Japan*, The Hokuriku Construction Association, pp. 24-29, 2002.
- [5] The Snow Association of Japan, "Nihon-no-setsugai-shi (The Snow Damage History in Japan)," 1981 (in Japanese).
- [6] City and Regional Development Bureau of Ministry of Land, Infrastructure and Transport, "Gosetsu-chitai-taisaku-ni-tsuite (On the Countermeasures for the Snowy Area)," The fiscal year of 2006, 2006 (in Japanese).
- [7] Cabinet Office, Government of Japan, "Bosai-hakusho (White Paper on Disaster Management)," The fiscal year of 2006, Serco Inc., 2006 (in Japanese).
- [8] S. Nakagawa, "56gosetsu-to-38gosetsu (The 1981 Snowfall Event and the 1963 Snowfall Event)," *Gosetsu (Heavy Snowfall)*, Toyama Geographical Society, Kokon-shoin, pp. 72-90, 1982 (in Japanese).
- [9] The Editing Committee for the History of Snow Removing Work Machine, "Josetsu-Kikai-no-Rekisho (the History of Snow Removing Work Machine)," Hokuriku Branch of Japan Construction Mechanization Association, 1991 (in Japanese).
- [10] Regional Development Bureau of National Land Agency, "Gosetsu-chitai-no-genjo-to-taisaku (Present State and Countermeasures of the Snowy Area)," 1985 (in Japanese).
- [11] The Editorial Office of the Niigata Nippo (Niigata Daily Newspaper Company), "Yuki-no-karute (The Medical Sheets for Snow Problems)," Jiji Press Ltd., 1964 (in Japanese).
- [12] K. Miyamoto, "Nihon-no-toshi-mondai (The urban problem of Japan)," *Chikuma-shobo*, 1969 (in Japanese).
- [13] Hirosaki-daigaku-yuki-mondai-hosei-kenkyukai (Legal System Workshop in Hirosaki University for Snow Problem), "Gosetsu-taisaku-kankei-ho-no-hoshakaigakuteki-kenkyu (Study on Laws in Relation to the Countermeasures for Heavy Snowfall from the Viewpoint of Sociology of Law)," The Snow Association of Japan, 1982 (in Japanese).
- [14] National Research Center for Disaster Prevention, Science and Technology Agency, "Showa-56nen-gosetsu-ni-yoru-Hokuriku-chiho-no-saigai-genchi-chosa-hokoku (Survey Report of the Snow Disaster Occurred by the 1981 Snowfall Event)," *Natural Disaster Research Report 17*, 1982 (in Japanese).
- [15] Research Coordination Bureau, Science and Technology Agency, "Showa-56nen-gosetsu-ni-kansuru-tokubetsu-kenkyu-hokokusho (Special Research Report of the 1981 Snowfall Event)," 1983 (in Japanese).
- [16] B. Toyota and Y. Kitabayashi, "koreika-shakai-to-gosetsu (Aged Society and Heavy Snowfall)," *Gosetsu (Heavy Snowfall)*, Toyama Geographical Society, Kokon-shoin, pp. 127-140, 1982 (in Japanese).
- [17] M. Suyama, M. Nakayama, and M. Shindo, "Doro-josetsu-taisei-no-henka (Change of the Road Snow Removing Work System)," *ibid.*, pp. 142-179 (in Japanese).
- [18] Fukui-setsugai-taisaku-kenkyukai (Fukui Snow Damage Countermeasure Workshop), "Gosetsuji-no-kotsu-o-chushin-to-shita-shakaiteki-kino-no-shimyureishon (Simulation of the Social Function Mainly on the Traffic in Heavy Snowfall)," The Snow Association of Japan, 1982 (in Japanese).
- [19] S. Kobayashi, "1996nen-gosetsu-ni-yoru-koiki-seppyo-saigai-no-jittai-chosa-gaiyo (Field Research Outline of the Transregional Snow and Ice Disaster Occurred by the 1996 Snowfall Event)," *Field Research of the Transregional Snow and Ice Disaster Occurred by the 1996 Snowfall Event, Research Report of Integrated Research (A), Grant-in-aids for Scientific Research 07300027*, pp. 1-2, 1996 (in Japanese).
- [20] N. Numano, "96-gosetsu-ni-yoru-setsugai-no-gaiyo (The Outline of the Snow Damage Occurred by the 1996 Snowfall Event)," *Journal of Snow Engineering of Japan*, Vol.12, No.4, pp. 294-298, 1996 (in Japanese).
- [21] E. Akitaya, "1995/96-gosetsu-ni-yoru-sapporo-ken-no-kotsu-setsugai (Traffic Snow Damage of the Sapporo Metropolitan Region Occurred by the 1996 Snowfall Event)," *Research Report of Integrated Research (A), Grant-in-aids for Scientific Research 07300027*, pp. 8-10, 1996 (in Japanese).
- [22] T. Tomabechi, "Hokkaido-ni-okeru-shigaichi-de-hassei-shita-setsugai (The Snow Damage which Arose in Built-up Area in Hokkaido)," *ibid.*, pp. 22-27, 1996 (in Japanese).
- [23] R. Kawamura, "Heisei-18nen-no-gosetsu-o-motarashita-raji-sukeru-no-taiki-junkanba-no-tokucho (Features of the Large Scale Atmospheric Circulation Field which Brought about the 2006 Snowfall Event)," *Research Study on the Transregional Snow and Ice Disaster Occurred by the 2006 Snowfall Event, Research Report of Grant-in-aids for Scientific Research (Special Research Promotion) 17800006*, pp. 1-8, 2006 (in Japanese).
- [24] S. Nakai, T. Kumakura, and K. Rikiishi, "Meso-sukeru-no-kosetsu-bunpu (The Snowfall Distribution of the Mesoscale)," *ibid.*, pp. 20-27 (in Japanese).
- [25] K. Izumi, K. Kawashima, and T. Iyobe, "Heisei-18nen-gosetsu-ni-yoru-nadare-saigai-no-hassei-jokyo-to-tokucho (Generation Status and Features of the Avalanche Disaster Occurred by the 2006 Snowfall Event)," *ibid.*, pp. 75-87 (in Japanese).
- [26] T. Tomabechi and T. Takahashi, "Kenchiku-kanren-no-higai (On the Damage of Buildings)," *ibid.*, pp. 154-160 (in Japanese).
- [27] N. Numano, "Tohoku-chiho-no-seikatsu-kanren-higai (The Life-related Damage of Tohoku District –Limited to the Human Body Damage–)," *ibid.*, pp. 119-128 (in Japanese).
- [28] A. Sato, "Soron (General Remarks)," *ibid.*, pp. 113-114 (in Japanese).
- [29] Gosetsu-chitai-ni-okeru-anzen-anshin-na-chiiki-zukuri-ni-kansuru-kondankai (Conversation about the Development of Region Relieved at Safety in the Snowy Area), "About the Development of Region Relieved at Safety in the Snowy Area: Proposal," City and Regional Development Bureau of Ministry of Land, Infrastructure and Transport, 2006 (in Japanese).
- [30] City and Regional Development Bureau of Ministry of Land, Infrastructure and Transport, "Gosetsu-chitai-no-genjo-to-taisaku (Present State and Countermeasures of the Snowy Area)," 2001 (in Japanese).

- [31] H. Hayashi and K. Tamura, "Heisei-18nen-gosetsu-ni-okeru-hazado-shakai-taio-karamita-jinteki-higai-no-hassei (Occurrence of the Human Damage Judged from Hazard and Social Correspondence under the 2006 Snowfall Event)," Research Study on the Transregional Snow and Ice Disaster Occurred by the 2006 Snowfall Event, Research Report of Grant-in-aids for Scientific Research (Special Research Promotion) 17800006, pp. 188-197, 2006 (in Japanese).



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- "Yukiguni-gaku (Sociology of Snow Country)," Gendai-Tosho, 2006 (in Japanese).

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