

Research to develop a strategy to reduce
wind-related disaster risks caused by severe
local storms in Bangladesh

Project Report

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Project Leader: Yuichi Ono
Tohoku University,
International Research Institute of Disaster Science,
2030 Global DRR Agenda Office, Professor

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Executive Summary

The Manikganji Tornado in 1989 killed approximately 1,300 people and became the world's deadliest tornado. However, disaster risk reduction measures against severe local storms, including tornadoes have not been prioritized in Bangladesh in comparison with the ones for river floods and storm surges caused by severe monsoon and cyclones. Ono and Schmidlin (2011) proposed a relatively inexpensive and convenient a household tornado (storm) shelter using local materials. It was expected that this shelter would reduce tornado disaster risk. However, the shelter was not properly used by the owners.

The goal of the current research is to propose a strategy to reduce wind-related disaster risks caused by severe local storms, including tornadoes and downbursts in Bangladesh. This is not a simple survey to investigate feasibility of tornado shelters for Bangladesh, but a unique multidisciplinary research developing a long-term strategy to reduce local severe storm-related disaster risks, including tornadoes and downbursts.

The current research contains three main themes. They are 1) Tornado Shelter, 2) Education, and 3) Early Warning System. Each of the three themes were discussed at the International Forum on Tornado Disaster Risk Reduction for Bangladesh held in 2009 supported by Global COE Program of Tokyo Polytechnic University. In addition, , we conducted a field survey on the assessment of tornado damage investigation. By chance, we were fortunate enough to encounter an actual tornado, and take photos. Precisously speaking, it was a waterspout. The tornado was witnessed at Hakaluki Haor in Sylhet district at 16:00 (local time) on July 24, 2022, and we took photos and a video image for approximately 10 minutes from its occurrence to disappearance.. This waterspout did not cause any human casualties or economic damage. However, if a waterspout make a landfall, it could cause extensive damage, and we reaffirmed the importance of continuing efforts to reduce disaster risks, caused by severe local storms accompanied by strong wind.

In order to reduce those disaster risks, it is essential for various stakeholders to work together. Therefore, a second international workshop was conducted to bring together stakeholders at all levels to come up with a better strategy . In this workshop, the results of the current research project were shared among the stakeholders, and a common understanding of the issues that need to be addressed in the future was captured.

For developing a wind-related disaster reduction efforts in a sustainable manner in the future, it is essential to examine medium- to long-term countermeasure plans, i.e., the formulation of a medium- to a long-term plan. Therefore, based on the results of this project, we developed a roadmap. This clarifies the relationship between each area, and we plan to continue our study based on this roadmap.

1. Background

The tornado that occurred in Manikganji Tornado in 1989 killed approximately 1,300 people and became the world's deadliest tornado. However, disaster risk reduction measures against severe local storms, including tornadoes have not been prioritized in Bangladesh in comparison with the ones for river floods and storm surges caused by severe monsoon and cyclones. This is because the scale the tornadic event is small and it is difficult to predict them well in advance (Mallick and Rahman, 2013). On the other hand, the mortality rates for tornadoes and downbursts have been extremely high. As Bangladesh does not have any safety measures for tornadoes and downbursts, it is a matter of time to see a tornado causing more than one thousand deaths at any time. Despite these situations, most of the current measures and efforts focus on post-recovery measures (Government of the People's Republic of Bangladesh et al., 2009).

In order to discuss disaster risk reduction on severe local storms, including tornadoes in Bangladesh, an International Forum was held in 2009 supported by GCOE Program of Tokyo Polytechnic University. This forum was the first attempt to discuss the matter with agencies from the Government of Bangladesh, World Meteorological Organization, and international experts. In this forum, discussions were held from five aspects to consider concrete measures, including 1. Governance and Policy Making, 2. Public Awareness and Education/Finance and Community Planning, 3. Meteorology and Climatology, 4. Early Warning System in Japan and Bangladesh, and 5. Wind Engineering, Household and Community Storm Shelter, and Risk and Vulnerability.

Ono and Schmidlin (2011) ¹proposed a relatively inexpensive and convenient a household tornado (storm) shelter using local materials. It was expected that this shelter would reduce tornado disaster risk. However, the shelter was not properly used by the owners.

In order to save lives from tornadoes, it is important for local people to take adequate actions. Early warning for tornadoes needs to be provided properly to local people so that they can have enough lead time for evacuation. To develop the system, there is a need to improve communication technologies in addition to build better observation and forecasting capacity.

Only developing the tornado early warning system itself is not enough to save lives, and neither did the tornado shelters. It must be accompanied with increased awareness of tornado risks for local people. Few efforts have been conducted in a comprehensive manner with a specific strategy.

In addition to disseminate warnings for response, it is important to obtain knowledge about tornado and the usage of shelters in normal time. Regarding the construction and

¹ Y. Ono and T.W. Schmidlin, 2011, Design and adoption of household tornado shelters for Bangladesh, *Natural Hazards*, 56, 321-330.

utilization method of the tornado shelter, it is effective in adapting to local culture and practices. However, no concrete review has been conducted on how to utilize the tornado shelter which has been introduced on a trial basis.

Having said this, countermeasures against tornado disasters cover wide range of fields. A key is that these technological developments and research do not make significant progress independently. It requires a unified manner based on strategic plan. A medium to long-term planning is indispensable for developing sustainable tornado countermeasures. It is an urgent task to create a master plan and roadmap that can be the basic policy for tornado disaster risk reduction in Bangladesh.

2. Objectives

Bangladesh has the world's highest tornado disaster risks, with more than 100 annual tornado fatalities. The goal of the research is to propose a strategy to reduce wind-related disaster risks caused by severe local storms, including tornadoes and downbursts in Bangladesh. The comprehensive strategy will be applied by covering various academic disciplines such as meteorology, wind engineering and geography and practical perspectives such as meteorological services and operations, public awareness and education, and other disaster risk reduction measures.

There is academic uniqueness on this research project. No previous research has been conducted on fact-finding surveys on the tornado shelters. There is no research which focuses on tornado shelter which was introduced on a trial basis as a concrete measure against tornado disasters in Bangladesh.

This is not a simple survey to investigate feasibility of tornado shelters for Bangladesh, but a unique multidisciplinary research developing a long-term strategy to reduce local severe storm-related disaster risks, including tornadoes and downbursts. A wide range of renowned researchers such as wind engineering, meteorology, and geography participate in this research from Japan and Bangladesh in collaborate with governmental agencies, including Bangladesh Meteorological Organization, Ministry of Disaster Management and Relief, and NGOs.

3. Schedule

No.	Item	1 st Jul	Oct	Jan	Apr	Jul	30 th Sep
1.	Needs assessment of tornado shelters						
1.1	Research review	←————→					
1.2	Making an interview and a questionnaire sheet			←————→			
1.3	Interview and questionnaire survey to local people				←————→		
2	Understanding the situations for effective public awareness and education						
2.1	Research review	←————→					
2.2	Making a questionnaire sheet			←————→			
2.3	Questionnaire survey to school teachers				←————→		
3.	Interviews with Bangladesh Meteorological Department staff members for developing a tornado early warning system					↔	
4.	Assessment of tornado damage investigation					↔	
5.	Developing a roadmap for medium to long-term measures						←————→
6.	International workshop					↔	
7.	Final report						←————→

4. Activities

4.1 Needs Assessment of Tornado Shelters

It is common practice to take shelter in a solid building as a measure to protect oneself from wind related disaster, as typified by tornadoes. Especially in the U.S., where huge tornadoes occur every year, there are shelters for evacuation in case of a tornado. These shelters are mainly for personal use, with one shelter per household. However, considering the economic situation in Bangladesh, which is considered one of the poorest countries, especially in rural areas where the poverty level is high, it is considered difficult for each household to procure and maintain a shelter for individual households like those introduced in the United States.

Against this background, Ono and Schmidlin (2011) proposed a mini-shelter room that can be installed relatively easily in rural areas of Bangladesh and is designed to protect against wind gust damage. The mini-shelter rooms were installed on a trial basis in two communities in the Tangail district, where tornado damage had occurred in the past, and where there was a high interest in installing mini-shelter rooms.

Since the two shelters installed on a trial basis have not been monitored for post-installation use and maintenance, it is unclear how local people have utilized and maintained the mini-shelter rooms. It is important to verify the effectiveness of these mini-shelter rooms in reducing the damage caused by wind related disaster so that they can be deployed horizontally in vulnerable areas and implemented in society.

(1) Methodology

In order to monitor the use and maintenance of mini-shelter rooms for the purpose of mitigating damage from wind storms, this study conducted interviews mainly with two households in a local community where mini-shelter rooms were installed on a trial basis. In addition, interviews were also conducted with local people of another household in the same community in order to understand not only the utilization and maintenance status of the mini-shelter rooms, but also the community's understanding and perception of the mini-shelter rooms. These interviews were conducted in May 2022, and responses were obtained from a total of six local people (two local people with MSR installed and six neighbors of the local people).

The questions prepared in advance for the interview survey were categorized into six main types: 1) General Information, 2) Reasons not to use MSR, 3) Suggestions for Improvement of MSR, and 4) Ideal Shelter. 5) Evacuation or protection of yourself and 6) Education and/or Awareness, 1) General Information, which included questions to determine the demographics of the respondents, such as age and gender. 2) Reasons not to use MSR, which included questions to determine the respondents' ability to use MSR. 2) "Reasons not to use MSR" questions were designed to find out the reasons why mini-

shelter rooms are not utilized, based on the results of the pre-test conducted prior to this interview survey, which showed that mini-shelter rooms are not utilized appropriately. 3) "Suggestions for Improvement of MSR" questions were designed to find out the reasons why mini-shelter rooms are not utilized. "Suggestions for Improvement of MSR" was a set of questions to identify what is needed to implement mini-shelter rooms in the future. 4) "Ideal Shelter" was a set of questions to explore the needs of local people in order to define the requirements for an ideal shelter. 5) "Evacuation or protection of yourself" was a set of questions to explore the needs of local people in order to define the requirements for an ideal shelter. 5) "Evacuation or protection of yourself" was designed to identify actions to be taken regarding evacuation and protection of oneself. 6) "Education and/or Awareness" questions were designed to identify the knowledge and educational opportunities that local people have at this point in time. The questionnaire was developed as follows.

**RESEARCH TO DEVELOP A STRATEGY TO REDUCE WIND-RELATED
DISASTER RISKS CAUSED BY SEVERE LOCAL STORMS IN BANGLADESH**
Implemented by: BDPC and Supported by: Tohoku University

Component 1: Needs Assessment of Tornado Shelters

Questionnaire

1. General Information

- a) Location: District:
- b) Name:
- c) Age:
- d) Gender:
- e) Cellphone:
- f) Number of Family Member:
- g) Structural types of house:

2. Reasons not to use MSR

a) When was it built?

- i) Were you pleased that it was built in your house?
 if yes, why were you pleased?
- ii) Did you think that it will be useful for you?
 if yes, what were in your mind?

b) Did you ever use the shelter?

- if yes, for what purpose (keeping crockeries, blankets and quilts, suitcase, valuable items, deeds, money etc.)
- for how long?

c) When did you fill it up?

d) Why did you fill it up?

- What went wrong? why?
- What problems or inconveniences?

(supplementary answer-based questions related to size, depth, construction materials, entrance, cover, location in room etc.)

1

Figure. 1 Interview sheet (1/3)

3. Suggestions for Improvement of MSR

If similar types of shelters are constructed, what are your suggestions for improvement?

a) For Construction

- i) Size
- ii) Materials for construction
- iii) Location in the room
- iv) any other

b) For maintenance

- i) What is needed?
- ii) At what intervals?

c) For normal time use

(Please remember that MSR is used for taking shelter in time of tornado in shortest possible notice time. So, it should not be filled up with materials in normal times)

- i) Do you think it should be used in normal time?
 - If so, what it should be used for?

4. Ideal Shelter

a) Any suggestions or idea for ideal shelter in your village

(Please give some idea of shelters used in other countries e.g. USA, Japan etc.)

5. Evacuation or protection of yourself

a) Did you get any early warning/ information about the tornado that hit your village in 1996? - no

- if yes, from whom and how long before the tornado hit?
- if no, did you apprehend anything from the cloud or blowing of wind or rain etc.?

b) Did you feel that your house was not safe for your protection?

- if yes, did you want to be evacuated to any safe place?
- is there any safe place, close to your house, for evacuation?
- if yes, what is that place, how far from your house and why did you think that it was safe?

c) What did you do to protect yourself from the Tornado?

- laid down / went under the wooden bed / ran out of house etc. etc.

Figure. 2 Interview sheet (2/3)

6. Education and/or Awareness

a) Related to MSR:

- If the shelters are constructed, then what awareness is needed before, during and immediately after the construction?
- What long-term follow-up measures are needed after the construction?
- Who should do that follow up and at what intervals?

b) Related to Tornado:

- Did you have any knowledge or wisdom about protection against tornado?
- If yes, from whom? (Parents, schools etc.)
- Do you think that awareness/education is needed?
- If yes, what public awareness programme activities should be conducted in your village? (through Masjids in weekly prayers, through schools etc.)

Figure. 3 Interview sheet (3/3)

(2)Results

After conducting the interviews, the correspondence between each question and the results is as follows.

Table. 1 Answer list of questionnaire on mini shelter room

No.		Question to those who have MSR		1	2	3	4	5	6
Q.1 General Information									
a		Location							
		District	Tangail	Tangail	Tangail	Tangail	Tangail	Tangail	Tangail
		Upazila	Kalihati	Kalihati	Kalihati	Kalihati	Kalihati	Kalihati	Kalihati
		Union	Balla	Balla	Balla	Balla	Balla	Balla	Balla
		Village	Rampur	Rampur	Rampur	Rampur	Rampur	Rampur	Rampur
b		Name	Jobda Khatun	Sulekha	Aysha	Nurul Islam	Wazed Ali	Emdadul Mia	
		MSR	Yes	Yes	No	No	No	No	
c		Age	70	45	40	48	60	65	
d		Gender	Female	Female	Male	Male	Male	Male	
e		Cellphone	N/A	01742 139344	01766 037665	01799 926693	01816 902054	01623 914089	
f		Number of Family Member	6	5	5	4	6	7	
g		Structural types of house	Kutcha	onehouse house was "Kutcha" now shifted in "Pucka" house	Semi-Pucka	Kutcha	Semi-Pucka	Semi-Pucka	
Q.2 Reasons not to use MSR									
a		When was it built?	2012	2012	Yes	Yes	Yes	Yes	
	i	Were you pleased that it was built in your house?	Yes	Yes					
	ii	If yes, why were you pleased?	I thought there will be no change in my room	I thought we can use it in normal time					
	iii	Did you think that it will be useful for you?	Yes	Yes					
	iv	If yes, what was in your mind?	We can use the mini shelter room as storage room	We can keep household things there					
b		Did you ever use the shelter?	Yes	No	Yes	Yes	No	No	
	i	If yes, for what purpose (keeping crockeries, blankets and quilts, suitcase, valuable items, deeds, money etc.)	Keeping blankets and quilts, steel pots and pans	N/A	Keeping blankets and quilts	Keeping blankets and quilts	N/A	N/A	
	ii	for how long?	5-6 days	N/A					
c		When did you fill it up?	around one year ago	No didn't fill it up, we shift in new house	Yes	Yes	No, it was not filled up, the old house was demolished and a new house was built	No, it was not filled up, the old house was demolished and a new house was built	
d		Why did you fill it up?	the wooden door broken and was unsafe for family members (my daughter's husband was injured for that broken door)	N/A	they told us that the wooden door was broken and unsafe for family members	Yes, I heard that the wooden structure decayed	N/A	N/A	
	i	What went wrong? why?	The wooden frame was not durable	It didn't work, I couldn't keep anything due to sweating, small size etc					
	ii	What problems or inconveniences?	Always sweating the wall of MSR	sweating problem due to underground					
Q.3 Suggestions for Improvement of MSR									
If similar types of shelters are constructed, what are your suggestions for improvement?									
a		For Construction							
	i	Size	definitely size should be large, it should be kept all family members	Size should be large	Size should be large, fit for all family members	Size should be large (should be included 5-6 family members)	Size should be large	Size should be large so that neighbors can use it	
	ii	Materials for construction	should be strong particles and durable	should be use hard materials	should be strong steel	should be use strong materials	should be use good quality materials	should be use strong and good quality materials	
	iii	Location in the room	There should be one pukka room for people of 3-4 houses at a close distance on them	it would be better if it was built on the floor with the wall, not underground	beside our room	beside room or in courtyard	Pucka separate room would be better	anywhere	
	iv	any other	N/A	N/A	N/A	N/A	N/A	N/A	
b		For normal time use							
	i	What is needed?	nothing	nothing	Nothing	No idea	Nothing	Nothing	
	ii	At what intervals?	N/A	N/A	N/A	N/A	N/A	N/A	
c		Do you think it should be used in normal time?	Yes	Yes	Yes	No	No	No	
	i	If so, what it should be used for?	can kept our household materials	should be used for keeping some household things	can kept our blankets or unused materials	N/A	N/A	N/A	
Q.4 Ideal Shelter									
a		Any suggestions or idea for ideal shelter in your village	Strong and durable things should be used for ideal shelter	Strong Pucka house needed in our village	strong pukka building/room	strong shelter should be made by Government in every area	Pucka room or building	Initiatives should be taken to make an ideal shelter room in every house	
Q.5 Evacuation or protection of yourself									
a		Did you get any early warning/ information about the tornado that hit your village in 1997?	No	No	No	No	No	No	
	i	If yes, from whom and how long before the tornado hit?	N/A	N/A	N/A	N/A	N/A	N/A	
	ii	If no, did you apprehend anything from the cloud or blowing of wind or rain etc.?	black cloud and strong wind	black cloud	black cloud	black cloud and rain after tornado	black cloud and strong wind	black cloud	
b		Did you feel that your house was not safe for your protection?	Yes	No	Yes	Yes	Yes	Yes	
	i	If yes, do you want to be evacuated to any safe place?	Yes	N/A	Yes	Yes	Yes	Yes	
	ii	is there any safe place, close to your house, for evacuation?	No	No	No	No	Yes	No	
	iii	If yes, what is that place, how far from your house and why did you think that it was safe?	N/A	N/A	N/A	N/A	my brother's house, very near from my house	N/A	
c		What did you do to protect yourself from the Tornado?	laid down	laid down	laid down	laid down	went under the bamboo-made bed	laid down	
Q.6 Education and/or Awareness									
Related to MSR:									
		If the shelters are constructed, then what awareness is needed before, during and immediately after the construction?	No idea	No idea	everyone should know the uses of the shelter during tornado and other disasters	committee should be formed before construction of shelter and committee members should spread awareness during and after construction	No idea	Ensuring local knowledge and participation of local people before and during construction	
		What long-term follow-up measures are needed after the construction?	No	N/A	Yes	Yes	N/A	training programme for local people	
		Who should do that follow up and at what intervals?	N/A	N/A	one designated person should follow it up in every six months	one team or volunteers' group should be followed it up in every month	N/A	make a team for follow-up in every month	
Related to Tornado									
		Did you have any knowledge or wisdom about protection against tornado?	No	No	No	No	No	No	
		If yes, from whom?	N/A	N/A	N/A	N/A	N/A	N/A	
		Do you think that awareness/education is needed?	Yes	Yes	Yes	Yes	Yes	Yes	
		If yes, what public awareness programme activities should be conducted in your village?	through Masjids in weekly prayers	through schools	through schools	through Masjids in weekly prayers and also mixing in the area	through Masjids in weekly prayers	through Masjids in weekly prayers	

(3) Discussion

As a result of this interview survey, it revealed that mini-shelter rooms were rarely used. The reasons for this were that the use of the rooms during normal times was not clear, and those maintenance methods had not been established.

Robust buildings are essential to protect against wind related disasters such as tornadoes. However, considering the conditions in the rural areas of Bangladesh, it would be difficult for all people to evacuate to a safe building after recognizing the occurrence of a wind gust disaster. Therefore, although the mini-shelter room is considered to have a certain role in this project, there is still room for improvement in its implementation and horizontal deployment.

One solution would be to evacuate a certain number of households together to a single shelter, rather than a large shelter such as a cyclone shelter, as this would be more realistic. The following is a summary of the lessons learned and the solutions developed in this study.

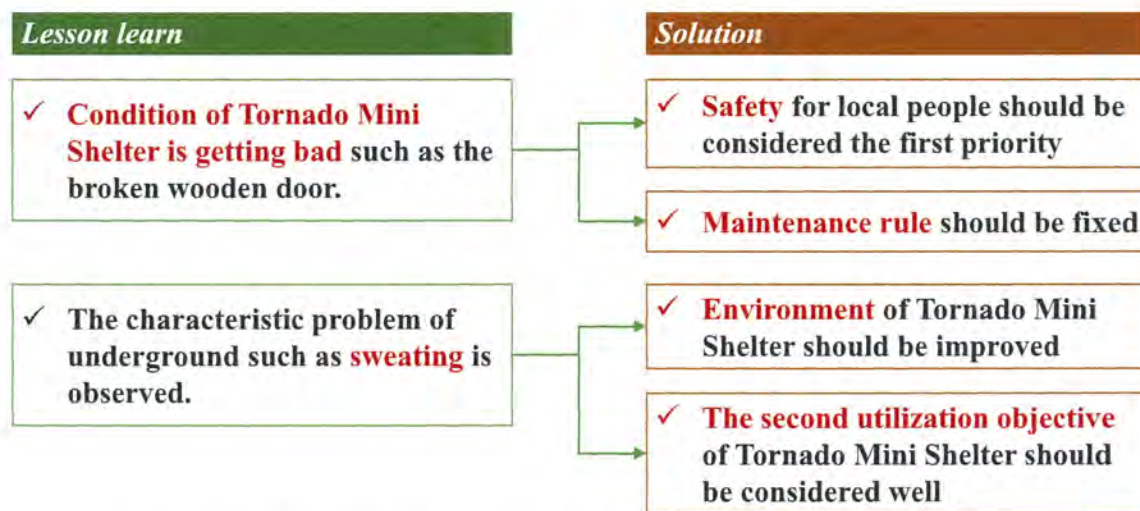


Figure. 4 Lesson learn and solution on needs assessment of tornado shelters

4.2 The Experience of Tornado and Indigenous Knowledges

The frequency and size of tornadoes in Bangladesh are smaller and less frequent than those in the United States. For this reason, there is not much interest among the local people in improving research on tornadoes and their countermeasures in Bangladesh. In other words, when a wind gust disaster occurs in Bangladesh, the lack of experience and social jaywalking will likely result in greater damage. However, to the best of the author's knowledge, there are no studies that have examined the evacuation behavior of local people in past wind gust disasters such as tornadoes.

(1) Methodology

In order to share the wisdom of local people that can contribute to the study of damage mitigation measures based on past experiences of tornado damage, this study conducted a questionnaire survey among local people of the past affected districts. The questionnaire survey was conducted in May 2022, targeting 18 people (male: 9, female: 9) from Manikganj, Tangail, and Feni districts that were affected by past tornadoes.

The questions prepared in advance for the survey were categorized into five main types: 1) General Information, 2) Experience in Tornado Disaster, 3) Other's Information, 4) Indigenous Knowledge, and 5) Suggestion. 1) General Information: Questions were prepared to identify respondents' demographics, such as age and gender. 2) Experience in Tornado Disaster: Questions were prepared to identify respondents' past experiences with tornado damage. 3) Other's Information: Questions were designed to identify not only their own experiences but also how other community members, such as neighbors, protected themselves. 4) Indigenous Knowledge included questions to identify wisdom and lessons learned from people close to them (e.g., parents, elders, etc.). 5) Suggestion questions were designed to identify advice and suggestions on how to protect oneself in the event of a future tornado or other wind gust disaster. The questionnaire was developed as follows.

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DISASTER RISKS CAUSED BY SEVERE LOCAL STORMS IN BANGLADESH**

Implemented by: BDPC and Supported by: Tohoku University

**Component 2: Indigenous Knowledge on Coping Mechanism and Survival
Techniques in Tornado Disasters in Manikganj District**

Questionnaire

1. General Information

- a) Location: District:
- b) Name:
- c) Age:
- d) Gender:
- e) Cellphone:
- f) Number of Family Member:
- g) Structural types of house:

2. Experience in Tornado Disaster

- a) Have you experienced any tornado?
- b) How many tornados have you experienced?
- c) Do you remember the date(s) of the occurrence(s)?
- d) Which was the worst one?
- e) Did you get any warning information or sign of occurrence of any of the tornados you just mentioned? Please explain (e.g. cloud, wind blowing, rain etc.)
- f) If you got the sign, did you take any preparation?
- g) What did you do?
- h) Where did you take shelter? specify the location
- i) How did you position your body?
- j) Did you help other(s) to take shelter? (e.g. children or elderly etc.)

3. Other's Information

Do you know how others saved themselves in this or other tornados?

Figure. 5 Questionnaire sheet (1/2)

4. Indigenous Knowledge

Have you got any wisdom/knowledge from your parents and/or senior members of the family about survival technique and coping mechanisms in case of tornado?

5. Suggestion

Do you have any advice/suggestion about:

- a) What should be done to survive in case of any tornado?
- b) What should be the ideal shelter to save life from tornado?
- c) How the survival techniques and coping mechanisms should be promoted to people?
(through family, school, mosque etc.)

Figure. 6 Questionnaire sheet (2/2)

(2)Results

The survey was conducted, and the correspondence between each question and the results is shown below.

Table. 2 Answer list of questionnaire on indigenous knowledge (1/3)

No.	Question to those who have MSR	1	2	3	4	5	6
Q.1	General Information						
a	Location						
	District	Manikganj	Manikganj	Manikganj	Manikganj	Manikganj	Manikganj
	Upazila	Saturia	Saturia	Saturia	Saturia	Saturia	Saturia
	Union	Saturia	Saturia	Saturia	Saturia	Saturia	Saturia
	Village	Naogaon	Saturia	Saturia	Saturia	Saturia	Saturia
b	Name	Sufia Begum	Shanti Bosak	Padma Bosak	Jomir Uddin	Md. Iqbal Hossain Khosru	Goutom Kormokar
c	Age	95	65	50	55	58	40
d	Gender	Female	Female	Female	Male	Male	Male
e	Cellphone	01827 704416	01721 319231	01739 126294	01726 597108	01712 290549	01726 949749
f	Number of Family Member	7	13	5	4	5	4
g	Structural types of house	Semi-Pucka	Pucka		Kutchha	Pucka	Semi-Pucka
Q.2	Experience in Tornado Disaster						
a	Have you experienced any tornado?	Yes	Yes	Yes	Yes	Yes	Yes
b	How many tornados have you experienced?	1	1	1	1	1	1
c	Do you remember the date(s) of the occurrence(s)?	26-Apr-89	26-Apr-89	26-Apr-89	26-Apr-89	26-Apr-89	26-Apr-89
d	Which was the worst one?	N/A	N/A	N/A	N/A	N/A	N/A
e	Did you get any warning information or sign of occurrence of any of the tornados you just mentioned?	Black darkness descended with a loud noise	Black darkness descended with a loud noise and the sky color was red like fire.	heavy rain and black cloud	Darkness descends, followed by heavy rain	black cloud	No
f	If you got the sign, did you take any preparation?	came inside home after seeing the darkness	I told everyone to come inside home	No	No	No	No
g	What did you do?	was sitting at home with my grand-daughter	ran inside my house	ran into my neighbour's house with my baby on the lap	was sitting in my shop	I was returning from Dhaka	was standing at the courtyard
h	Where did you take shelter? specify the location	In my own house but the tin-shed of the house was blown away. Then I threw my 2 years old grand-daughter under the bamboo platform and I fainted.	In my home	neighbour's house	in my own shop	In a shop	my own house
i	How did you position your body?	laid down	laid down	laid down under the bed with holding my one-year old baby	sat down	sat down	was standing
j	Did you help other(s) to take shelter?	yes, my grand-daughter.	yes, my 4 years old child	yes, my children	No	No	No
Q.3	Other's Information						
	Do you know how others saved themselves in this or other tornados?	Many were in the pucka building	Many were taken shelter in their nearest building	No	many were taken shelter in Pucka building	many were in Pucka building	No
		Many were under the bed of wooden platform				many were under bed or platform	
Q.4	Indigenous Knowledge						
	Have you got any wisdom/knowledge from your parents and/or senior members of the family about survival technique and coping mechanisms in case of tornado?	No	yes, moving to a safe place or shelter	No	No	No	No
Q.4	Suggestion						
	Do you have any advice/suggestion about:						
a	What should be done to survive in case of any tornado?	One should stay in Pucka building without rushing	Should be in the underground	If the sky became bad, stay at home.	Make strong and sturdy wood or bamboo platform for protecting ourselves from tornado	should stay at home under bed or strong table	should go underground shelter
				take shelter under bed, table or strong structure			protect head from moving things of tornado
b	What should be the ideal shelter to save life from tornado?	Strong and sturdy building	Strong one storied building	Strong and sturdy one storied building	Strong and sturdy one or two storied building	strong and sturdy one or two storied building	Strong Pucka building or underground shelter
c	How the survival techniques and coping mechanisms should be promoted to people?	through family and mosque	through family	through family and school	through mosque	through family	through school and mosque

Table. 3 Answer list of questionnaire on indigenous knowledge (2/3)

No.	Question to those who have MISR	7	8	9	10	11	12
Q.1 General Information							
a	Location						
	District	Tangail	Tangail	Tangail	Tangail	Tangail	Tangail
	Upazila	Kalihati	Kalihati	Kalihati	Kalihati	Kalihati	Kalihati
	Union	Balla	Balla	Balla	Balla	Balla	Balla
	Village	Rampur	Rampur	Rampur	Rampur	Rampur	Rampur
b	Name	Abul Hossain	Kalpana Begum	Parul Akter	Farida	Rehana	Lutfor Rahman
c	Age	52	43	45	50	62	48
d	Gender	Male	Female	Female	Female	Female	Male
e	Cellphone	01724 738023	01762 365491	01640 826 805	1814708371	01732 944487	01754 229682
f	Number of Family Member	5	2	5	4	3	3
g	Structural types of house	Semi-Pucka	Kutchha	Semi-Pucka	Kutchha	Semi-Pucka	Semi-Pucka
Q.2 Experience in Tornado Disaster							
a	Have you experienced any tornado?	Yes	Yes	Yes	Yes	Yes	Yes
b	How many tornados have you experienced?	1	1	1	1	1	1
c	Do you remember the date(s) of the occurrence(s)?	13-May-96	13-May-96	13-May-96	1996	1996	13-May-96
d	Which was the worst one?	N/A	N/A	N/A	N/A	N/A	N/A
e	Did you get any warning information or sign of occurrence of any of the tornados you just mentioned?	No	No	heavy rain and black cloud	Black cloud	Black cloud	Black cloud
f	If you got the sign, did you take any preparation?	No	No	No	No	No	No
g	What did you do?	I was standing at my home	sitting in a chair	ran into the house from courtyard	sitting inside house	ran to house from outside	I was in the market
h	Where did you take shelter? specify the location	In my own house	neighbour's house	my house	my house	my own house	in a shop in the market
i	How did you position your body?	Standing up	laid down	I was stand up	sitting down	Stood in front of door	sat down
j	Did you help other(s) to take shelter?	No	yes, 15 years old daughter of my neighbour	No	No	No	No
Q.3 Other's Information							
	Do you know how others saved themselves in this or other tornados?	No	No	No	No	No	No
Q.4 Indigenous Knowledge							
	Have you got any wisdom/knowledge from your parents and/or senior members of the family about survival technique and coping mechanisms in case of tornado?	No	No	No	No	No	No
Q.4 Suggestion							
	Do you have any advice/suggestion about:						
a	What should be done to survive in case of any tornado?	Need a government shelter	should go under bed or strong something	laid down under bed or table	No idea	No idea	should go near pucka building
		Siren should be ringing to inform people about sudden tornado					
b	What should be the ideal shelter to save life from tornado?	Should be strong and pucka	Pucka building	Pucka house	No idea	No idea	Strong pucka building
c	How the survival techniques and coping mechanisms should be promoted to people?	through mosque	through family and school	through family	through family	through family and school	through family, school and mosque

Table. 4 Answer list of questionnaire on indigenous knowledge (3/3)

No.	Question to those who have MSR	13	14	15	16	17	18
Q.1 General Information							
a	Location						
	District	Feni	Feni	Feni	Feni	Feni	Feni
	Upazila	Chagalnaiya	Chagalnaiya	Chagalnaiya	Chagalnaiya	Chagalnaiya	Chagalnaiya
	Union	Pathannagar	Pathannagar	Pathannagar	Pathannagar	Pathannagar	Pathannagar
	Village	Gondhabopur	Pathannagar	Sonapur	Pathannagar	Pathannagar	Pathannagar
b	Name	Rahima Begum	Fatima Khatun	Abul Taleb Mazumder	Abul Taher Majumder	Abul Kashem Majumder	Joydul Abedin
c	Age	63	53	54	68	78	58
d	Gender	Female	Female	Male	Male	Male	Male
e	Cellphone	01826-495344	01840-041389	01820-926306	01867-329787	01813-375656	1815660031
f	Number of Family Member	5	8	4	6	11	4
g	Structural types of house	Pucka	Kutcha	Kutcha	Pucka	Pucka	Pucka
Q.2 Experience in Tornado Disaster							
a	Have you experienced any tornado?	Yes	Yes	Yes	Yes	Yes	Yes
b	How many tornados have you experienced?	1	1	1	2	1	1
c	Do you remember the date(s) of the occurrence(s)?	1981	40 years ago	Apr-81	1962, 12 April 1981	Apr-81	Apr-81
d	Which was the worst one?	N/A	N/A	N/A	12-Apr-81	N/A	N/A
e	Did you get any warning information or sign of occurrence of any of the tornados you just mentioned?	Black darkness and rain	Black cloud	Black cloud	No	No	No
f	If you got the sign, did you take any preparation?	No	No	No	No	No	No
g	What did you do?	I was preparing to cook food	nothing	He was holding the window of Madrasha by a board	he was in a barber shop	I was in a meeting in the market	I was standing in the Cow-house
h	Where did you take shelter? specify the location	In my own house	courtyard	In Madrasha (religious school)	in the barber shop	in a shop in the market	Cow-house
i	How did you position your body?	sat down	sat down	Standing in front of window	sat down	sat down	was standing
j	Did you help other(s) to take shelter?	yes, my sister-in-law, father in law, aunt in law and nephew	No	no, there were no opportunity to help others	No	there was no chance to help others as it was occurred suddenly	No
Q.3 Other's Information							
	Do you know how others saved themselves in this or other tornados?	No	No	No	No	No	No
Q.4 Indigenous Knowledge							
	Have you got any wisdom/knowledge from your parents and/or senior members of the family about survival technique and coping mechanisms in case of tornado?	No	no, only heard the name of cyclone from them	No	No	No	No
Q.4 Suggestion							
	Do you have any advice/suggestion about:						
a	What should be done to survive in case of any tornado?	Should be in a strong house	No idea	Should be under the bed in Pucka house	should go to safe place like pucka building	laid down	laid down by cover the head by hand
		Should lie down				if possible, go to underground hole	survival techniques should be promoted to make people aware
b	What should be the ideal shelter to save life from tornado?	strong Pucka house	No idea	Should be strong	Strong and durable	Every house should have a tunnel-like structure where family members can take shelter in time of tornado	Strong buildings should be built as ideal shelter
c	How the survival techniques and coping mechanisms should be promoted to people?	through mosque	through mosque and school	Miking in the area and through school	through miking in the mosque	through mosque	through miking in the area, mosque etc

(3) Discussion

The results of this survey showed that the majority of respondents to the question of how local people protected themselves at the time of the tornado were those who retreated indoors. The survey did not provide clear answers to the question about experiences and lessons learned from past tornado damage, which was the purpose of this survey. This is thought to be due to a lack of knowledge about tornadoes. In addition, local people indicated that they would take shelter in Pucka, a robust building, as a response action they would take in the event of a tornado or other wind gust disaster in the future. However, Pucka is not numerous in the suburbs of Bangladesh. Therefore, it is not always possible to evacuate to a Pucka.

Thus, it is clear that local people currently possess little wisdom and lessons learned regarding wind gust disasters. Therefore, it is necessary to promote education on windstorm disasters in the future. The following is a summary of the lessons learned and the solutions developed in this study.

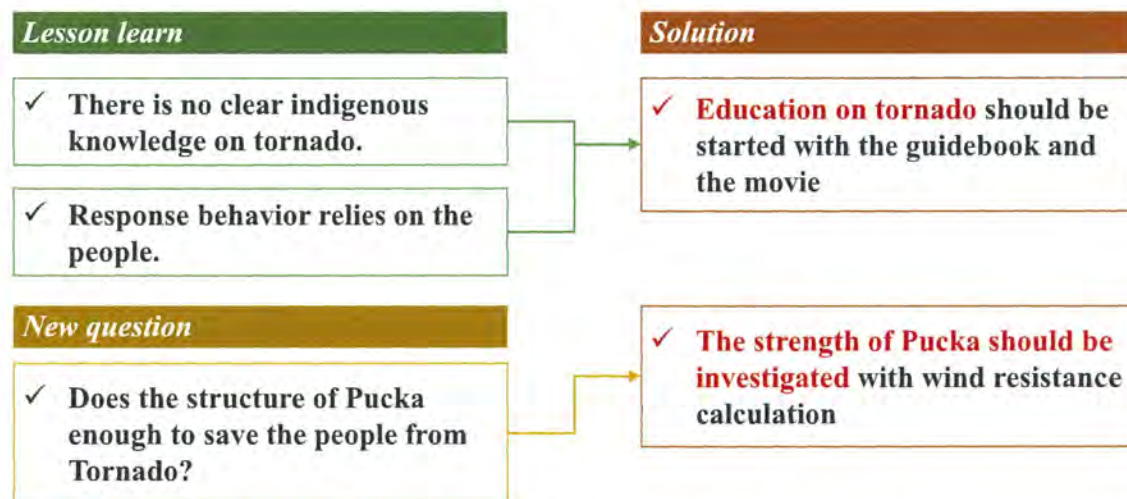


Figure. 7 Lesson learn and solution on the experience of tornado and indigenous knowledges

4.3 Understanding the Situations for Effective Public Awareness and Education

In order to mitigate the damage caused by tornadoes, it is desirable to train students in advance so that they can learn and practice appropriate judgment and actions when faced with a tornado attack, based on a thorough understanding of the nature of tornadoes. It is especially important for countries such as Bangladesh, where it is difficult to mitigate damage through infrastructure development due to economic reasons, to provide such awareness-raising activities in schools as part of their educational activities. In this study, a questionnaire survey on tornado disaster prevention education was conducted among school teachers in order to understand the actual situation of tornado disaster prevention education in schools and to identify issues that need to be solved and the needs of schools in order to improve tornado disaster prevention education in Bangladesh. This section describes the results and discussion of the survey.

(1) Methodology

A questionnaire survey of 16 school teachers was conducted in Kalihati district, Tangail district, a city in central Bangladesh, where a severe tornado that killed more than 700 people occurred on May 12, 1996. Severe local storms caused by cumulonimbus clouds, such as tornadoes, hailstorms, and thunderstorms, are relatively common in Bangladesh. Table 1 shows basic information about the respondents to this survey. The details of the questionnaire items are shown in the Appendix at the end of this section.

Table. 5: Basic information of the respondents (N=16)

Gender	Male:8	Female:8					
Age	20-29:1	30-39:8	40-49:4	50-59:3			
Teaching Career	<5:0	5-9:5	10-14:4	15-19:2	20-24:1	25-29:2	>30:1
		Unknown:1					
Level of school	Primary:8	Secondary:8					
Type of school	Public:8	Private:6	Madrasha (Islamic religious school):2				

**Questionnaire form for the interview survey of current situations of tornado
preparedness in school**

Sex : Male Female

Age : ()

Academic background : ()

Years of your teaching career : ()

Level of school which you are working : () ex. primary level etc

Kinds of school which you are working : () ex. public, private, madrasa
etc

District and upzila of school which you work : ()

#Tornado preparedness means knowledge and skill for reducing damages by tornado.

Q1 Do you have sufficient knowledge about tornado?

very sufficient sufficient insufficient very insufficient no idea

Q2 Do you have sufficient knowledge about tornado preparedness?

very sufficient sufficient insufficient very insufficient no idea

Q3 Which month does tornado occur most frequently in Bangladesh?

()

Q4 Which district does tornado occur most frequently in Bangladesh?

()

Q5 Which time do tornado occur most frequently in Bangladesh?

0-3h 4-7h 8-11h 12-15h 16-19h 20-23h

Q6 Choose correct items in the followings:

A tornado has a spatial range of 1000km and continues during a few days.

A tornado is often associated with a funnel cloud.

A tornado occurs in a tropical sea around the equator, and then lands the coast of
Bangladesh during a few days.

A tornado is formed under a cumulonimbus cloud.

**Q7 Select teacher's appropriate instruction to students for reducing damages when a
tornado attacks your school in the followings.**

When students are in a playground of your school, the teacher should instruct
students to evacuate into the robust buildings.

When students are in a playground and there is no robust building around them,
the teacher should instruct students to keep standing up to pay their attention all over

Figure. 8 Questionnaire form (1/4)

the place.

When students are in a classroom, the teacher should instruct them to open a window shutter and stay near the window to pay their attention outside.

When students are in a small classroom, the teacher should instruct them to move to larger rooms.

The teacher should instruct students to hide under a strong desk with protecting their head.

Q8 Do you have the education class for tornado preparedness in your school?

Yes No

Q9 For persons who answer "Yes" in Q8, why do you start the education class for tornado preparedness in your school?

Because you have the experience of serious damages of tornado in your area in the past.

Because your living area has the possibility of occurrence of tornadoes although any damage has not been occurred until now.

Because teachers of your school begin the education class for tornado preparedness voluntary.

Because the manager and/or the principal of your school call for starting the education class for tornado preparedness.

Because local government calls for starting the education class for tornado preparedness.

Because local people requests your school to start the education class for tornado preparedness.

Others (Please write your answer).

Q10 For a person who answer "Yes" in Q8, which kinds of the education class for tornado preparedness do you have in your school?

Class on mechanism and meteorological characteristics of tornado

Class on tornado damages occurred in the past

Class and drill on evacuation and suitable action for reducing the damages of tornado

Others (Please write your answer)

Figure. 9 Questionnaire form (2/4)

Q11 For a person which answer "Yes" in Q8, what is needed for improvement of the education class for tornado preparedness in your school?

- Educational materials (if possible, please answer which kinds of material you need)
- Equipment (if possible, please answer which kinds of material you need)
- Human resource
- Time
- Curriculum
- Training for teachers
- Support of specialist such as meteorologist and weather forecaster
- Financial support
- Others (Please write your answer)

Q12 For a person which answer "No" in Q8, do you think that you should have the education class for tornado preparedness in your school?

- Yes No

Q13 For a person who answer "Yes" in Q12, why don't you have the education class for tornado preparedness even though you think it necessary?

- No time
- No human resource
- No educational materials
- No equipment
- No idea
- Others (Please write your answer)

Q14 For a person who answer "No" in Q12, what is the reason why you don't think that you should have the education class for tornado preparedness in your school?

- Because there has not been damage of tornado in your area.
- Because a tornado damage is very rare.
- Because you think that the education class for tornado preparedness should be conducted at other place than school.
- Others (Please write your answer)

Q15 Do you think that the early warning system for tornado is needed for tornado disaster prevention in a school?

- Yes No

Q16 For a person who answer "Yes" in Q15, how should the early warning be reported for school?

- TV Radio Internet Others (Please write your answer)

Figure. 10 Questionnaire form (3/4)

Q17 For a person who answer "No" in Q15, why do you think that the early warning is not needed for a school?

- Because early warning system is not reliable.
- Because if you and your students learn the knowledge and skill for tornado preparedness, the early warning system is not needed.
- Because the spending cost for early warning system is wasted as a tornado is very rare.
- Others (please write your answer)

If you have any opinion for education for tornado preparedness in school, please answer freely.

Figure. 11 Questionnaire form (4/4)

(2) Results and Discussion

The responses to the items (Q1 and Q2) regarding the respondents' knowledge and skills in tornadoes and tornado disaster prevention revealed that most of the respondents felt that their knowledge and skills were inadequate. In terms of basic knowledge about tornadoes and tornado preparedness (Q2-Q7), many respondents were accurate about when tornadoes are most common in Bangladesh (March to May), but many were inaccurate or "don't know" about where and when they are most likely to occur. In addition, some respondents seemed to confuse tornadoes and cyclones. Tornadoes and cyclones are different atmospheric phenomena, and the formation process and the temporal and spatial scale of the phenomena are completely different. The authors have developed a tornado damage database based on a survey of newspaper articles reporting tornado damage. In this survey, the confusion between tornadoes and cyclones was often observed in newspaper articles. In Bangladesh, it seems that the correct understanding of the difference between tornadoes and cyclones is not well understood, and appropriate treatment of tornadoes at the early stage of primary and secondary education is required. Regarding item (Q7) asking about appropriate instructions for students when a tornado strikes a school, most of the respondents selected appropriate instructions (evacuate to a sturdy building when outdoors, or hide under a sturdy desk while protecting your head with your hands).

The responses to the questions regarding tornadoes and tornado disaster prevention education at schools (Q8-Q14) indicate that all respondents feel the need for tornado and tornado disaster prevention education, but that it is not being implemented at their schools. The most common reasons for the lack of tornado disaster prevention education were the lack of teaching materials, equipment, and human resources. Lack of government support and guides were also cited as reasons. It would be extremely difficult for schools to start tornado disaster prevention education from scratch under the current circumstances. It is one of the important issues for the future to appeal the importance and necessity of tornado and tornado disaster prevention education at schools to the government departments concerned with education and disaster prevention and to encourage them to enhance the system to establish learning programs and human resource development as part of the national education and disaster prevention policy.

All teachers answered that early warning is necessary for tornadoes (Q15~Q17). A relatively large number of teachers mentioned the use of megaphones, bells, and sirens as a method of early warning communication. This is a method used in Bangladesh to call for evacuation in the event of a cyclone and is recognized as effective in encouraging early evacuation and mitigating damage. Many of the teachers who responded to the survey are thought to have responded based on this method of publicizing evacuation when a cyclone strikes. However, unlike a cyclone, a tornado that occurs suddenly has a

very short lead time (time to prepare for evacuation), so there is a large possibility that people will not be able to evacuate in time if they use megaphones to call out to local people to evacuate. (According to the author's interviews with tornado survivors, some of them testified that they heard a roaring sound when the tornado hit.)) For early warnings for sudden events with a short lead time, such as tornadoes, it may be more effective to use a method that can be reliably transmitted directly to each local people in a short period of time, such as the use of smartphones. This may be due to the lack of understanding of the difference between tornadoes and cyclones as phenomena. In order to determine the most effective method for disseminating warnings to mitigate damage, it is necessary to further examine the actual understanding of tornadoes among teachers and local people and to consider the local information and communication environment in more detail in the future.

(3)Conclusions

In this study, a questionnaire survey of teachers was first conducted to understand the current status of tornado disaster prevention education at schools in order to improve it in the future. Although the number of teachers was not large and limited, this type of survey has never been conducted before, and we believe it is significant as a budding study to understand the current status of tornado disaster prevention education in schools. In the future, we would like to conduct more surveys of teachers in various regions to understand the current status of tornado disaster prevention education in schools in more detail, and based on the results, contribute to the development of a framework for tornadoes and tornado disaster prevention education.

The survey revealed that many of the teachers who responded to the survey feel the importance and necessity of tornado disaster prevention education at their schools, but are currently unable to implement it due to a lack of resources such as necessary teaching materials and human resources. It was also found that teachers' understanding of the atmospheric phenomenon of tornadoes is not sufficient. It is important to develop human resources for tornado disaster prevention education (e.g., by enhancing education at teacher training schools) and to develop teaching materials and learning programs that can be used effectively when such human resources are trained. We would like to contribute to the construction and enhancement of a top-down national infrastructure for tornado and tornado disaster prevention education while clarifying issues and needs through a broad and detailed understanding of the actual situation in the field, and appealing to relevant government departments with proposals and recommendations based on the results of these surveys.

4.4 Interviews with Bangladesh Meteorological Department Staff Members for Developing a Tornado Early Warning System

Describes the current status of meteorological observations for severe local storms such as tornadoes at the Bangladesh Meteorological Department and the future construction of an Early Warning System.

(1) Ground observation

The Bangladesh Meteorological Department conducts observations of ground meteorological elements (wind speed, pressure, temperature, humidity, precipitation, soil temperature, and solar radiation) at 61 regional meteorological stations and weather stations, including the main station in Dhaka, eight times a day, every three hours. The data is then sent to New Delhi, the center of South Asia, via the Global Telecommunication System (GTS) of the World Meteorological Organization (WMO). Some weather stations also conduct continuous observations using pen-written self-recorders. This pen-written self-recorder can capture sudden changes in weather elements when a severe local storm, such as a tornado, passes nearby. In addition, Automatic Weather Stations (AWS) have been introduced in recent years. However, the accuracy of AWSs cannot be guaranteed because the instruments are not sufficiently verified on a regular basis. In addition, the maintenance status of conventional manual instruments is sufficiently assured, but AWSs sometimes stop working or malfunction the instrument.

(2) High-level observation by radiosonde

High-level observations using radiosondes are conducted at four locations: Dhaka, Chittagong, Bogra, and Sylhet. In Dhaka, they are usually conducted once a day at 00 UTC daily, and once every two days at 00 UTC at the other locations. Temporary observations are made when a cyclone is approaching or when heavy rains are expected. The results of these observations are also sent to New Delhi. The results of these observations are extremely important for evaluating atmospheric stability, which is a major condition for the occurrence of severe local storms such as tornadoes. Wind-balloon-only high-level wind observations are being conducted at about 10 other locations.

(3) Observation by meteorological satellites

The image was taken by the Japanese meteorological satellite Himawari. The Himawari is located on the equator at 140 degrees east longitude, and the sky over Bangladesh is the western edge of the satellite image, so the clouds are seen from a very oblique angle. Also, the resolution of the satellite image is not high enough to observe cumulonimbus clouds, which are the parent clouds of tornadoes.

(4) Observation by meteorological radar

Compared to weather satellites, weather radar can observe the movement of cumulonimbus clouds. However, its spatial resolution is not high enough to directly observe tornadoes, but it can monitor the behavior of cumulonimbus clouds that may cause tornadoes. In Bangladesh, five radars have been deployed with Japanese assistance in Dhaka, Longpur Moulvibazar, Khepupara, and Cox's Bazar, covering almost all of Bangladesh.

(5) Discussion

Thus, the current observation system of the Bangladesh Meteorological Department makes it difficult to directly capture severe local storm phenomena such as tornadoes, which are small in time and space. This is a fundamental physical problem in meteorological observation, not only in Bangladesh.

Furthermore, in Bangladesh, the weather radar is operated every three hours for one hour of observation and then suspended for two hours. This is to reduce wear and tear on radar components and to operate for a longer period of time, as well as to conserve electricity. This observation system can cope to some extent with the general observation of weather phenomena such as cyclones and relatively large Spatio-temporal scale phenomena such as typhoons. However, it is not suitable for observing severe local storms such as instantaneous tornadoes, and continuous observation is definitely needed.

All five of these radars were provided by Japan. They work well for a few years after being introduced in Japan, but when equipment malfunctions, repairs are difficult and subsequent operations become almost impossible. The unstable voltage and inadequate power supply in Bangladesh are the causes of the malfunctions. In addition, the fact that there is almost no person who can respond to this contingency with sufficient knowledge and skills in radar when it occurs requires adequate countermeasures to be developed prior to introduction.

For forecasting meso-weather phenomena such as tornadoes, parameters such as wind shear, which indicates the degree of atmospheric instability and dynamic instability, and CAPE, which indicates thermal instability, are used. If we can fully understand the physical meaning of these parameters and use them in our business, we will have a better chance of forecasting outbreaks. However, it is difficult to achieve such accuracy in Japan, as it is said that only 10% of tornadoes actually occur under a tornado warning. In this process, we believe it is important for the newly established Department of Meteorology at the University of Dhaka and the Meteorological Department to cooperate in conducting steady research.

4.5 Assessment of Tornado Damage Investigation

Tornado disasters in Bangladesh are known to occur mostly in April and May and are thought to be caused by the generation of updrafts due to the entry of cold air into the sky. Although many studies on the mechanism of tornadoes have been conducted in the U.S. and other countries, the clear process of their generation is not well understood. The reason for this is thought to be that, as represented by tornadoes, the phenomenon has a small spatiotemporal scale, so there are few cases that capture the entire process from its onset to its disappearance.

In this study, however, we were fortunate to capture a tornado in Bangladesh. The project members were visiting Bangladesh Meteorological Department Sylhet to discuss the development of a meteorological observation network. While the project members were in Bangladesh on the evening of July 23, they received information that a tornado had occurred in the area. The location was Hakaluki Haor in Fenchuganj Upazila, Sylhet district. Since the scale of the tornado and the extent of damage were unknown, we conducted a field survey the next day, July 24, and interviewed local people to obtain more detailed information. As a result, it was determined that the tornado that occurred on July 23 was a waterborne tornado, so a cruise ship was arranged and headed for the location where the tornado occurred.

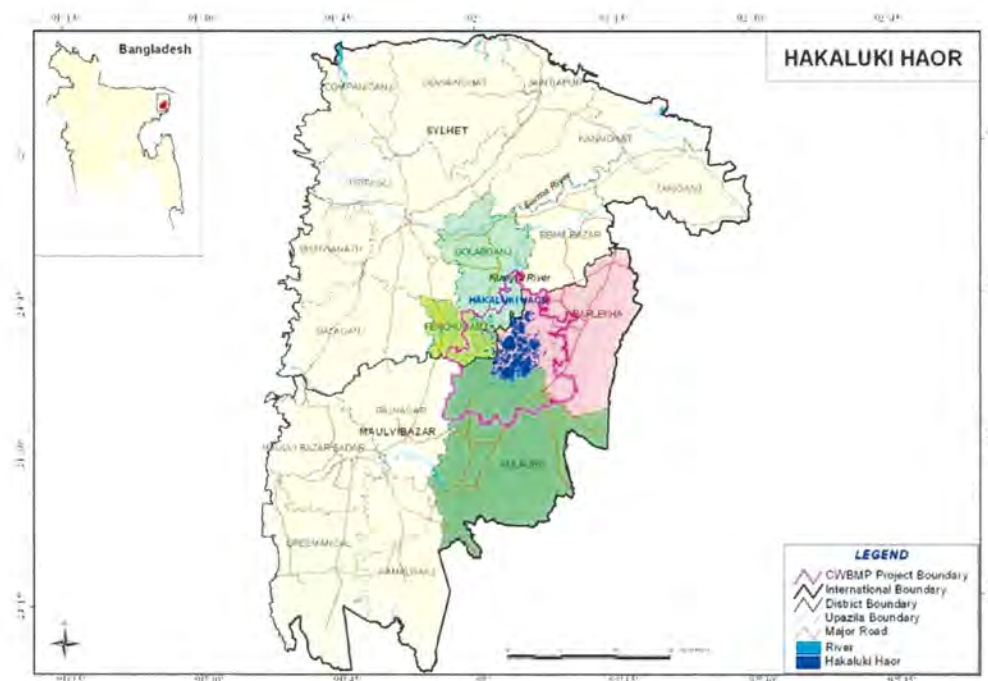


Figure. 12 Location map of Hakaluki Haor²

² Akm Shahidullah, 2016. Community-Based Developmental Entrepreneurship Linking Microfinance with Ecosystem services. DOI:10.13140/RG.2.2.28508.28805

The tornado was witnessed at Hakaluki Haor in Sylhet district at 16:00 (local time) on July 24, 2022, and we took photos and a video image for approximately 10 minutes from its occurrence to disappearance. The photos taken on that day are shown below. The tornado that occurred on that day was also generated and disappeared over the water and was considered to be a water spout. Since the size of the tornado was not so large, it did not cause human casualties or economic damage. However, considering the fact that waterspouts occurred on two consecutive days, we recognized that there is a favorable condition for tornado and waterspout formation in Bangladesh even during the summer monsoon season, which is less unstable in terms of atmospheric instability.



4.6 International Workshop

In order to reduce those disaster risks, it is essential for various stakeholders to work together. However, in Bangladesh, the main disaster hazards are storm surge inundation caused by cyclones and river flooding during the rainy season, and gusty wind disasters, including tornadoes, which have not received much attention. Therefore, a second international workshop was conducted to bring together stakeholders at all levels to come up with a better strategy. In this workshop, the results of the current research project were shared among the stakeholders, and a common understanding of the issues that need to be addressed in the future was captured.

(1) Agenda

International Workshop on "Development of a Strategy to Reduce Tornado and Other Severe Local Storm Related Disaster Risk for Bangladesh"		
Date: 20 July 2022, Wednesday		
Venue: Multi-purpose Hall, Department of Disaster Management		
Programme Schedule		
Time	Event	Presenter
10.30 am	Registration	
11.00 am	Address of Welcome and Setting the Scene	Mr. Muhammad Saidur Rahman Director, BDPC
11.10 am	Inaugural Address	Mr. Md. Atiqul Huq Director General, DDM
11.20 am	Testimony of the People affected by Tornado in Tangail and Manikganj districts	
11.50 am	Online Message	Prof. Yukio Tamura Tokyo Polytechnic University
12.05 noon	Presentation of the Research Report	Mr. Masashi Sakamoto Tohoku University Prof. Taiichi Hayashi Kyoto University
12.45 pm	Questions, Answers and Open Discussions	
01.30 pm	Speech by the Senior Representative of JICA	Ms. Mari Miura JICA
01.40 pm	The Way Forward	Prof. Yuichi Ono Tohoku University
01.55 pm	Closing Remarks by the Moderator	
02.00 pm	Lunch	
02.30 pm	One-hour Technical Discussion on Forecast and Tornado Characteristics in Bangladesh	Small group discussion with participants from BMD, DU, BUET, JICA and BDPC

(2)Participants

**International Workshop
on
“Development of a Strategy to Reduce Tornado and Other Severe Local Storm
Related Disaster Risk for Bangladesh”**

Date: 20 July 2022, Wednesday
Venue: Multipurpose Hall, Department of Disaster Management

List of Participants

Sl#	Name and Designation of Participants	Number	Remarks
Department of Disaster Management		4	
1.	Mr. Md. Atiqul Huq Director General dg@ddm.gov.bd		
2.	Mr. Netai Chandra Dey Sarker Director (MIM) netai@mail.com		
3.	Mr. Probir Kumar Das Programmer programmer1@ddm.gov.bd		
4.	Mr. Syed Ashraf ul Islam Communication Media Specialist cms@ddm.gov.bd		
Cyclone Preparedness Programme (CPP)		2	
5.	Mr. Ahmadul Haque Director (Admin) Mobile: +88-01711241344 ahmad.haq2008@gmail.com		
6.	Mr. Md. Nur Islam Khan Osi Director (Operation) director.ops.cpp@gmail.com		
Bangladesh Meteorological Department (BMD)		2	
7.	Dr. Md. Abdul Mannan Meteorologist Storm Warning Center, BMD, Agargaon, Dhaka-1207 Mobile: +88-01627739445 E-mail: mannan_u2003@yahoo.co.in		
8.	Dr. Muhammad Abul Kalam Mallik Meteorologist Storm Warning Center, BMD, Agargaon, Dhaka-1207 Mobile: +88-01711048157 E-mail: mallikak76@yahoo.com		

Sl#	Name and Designation of Participants	Number	Remarks
International Organizations		9	
9.	Ms. Mari Miura Senior Representative JICA Bangladesh office Bay's Galleria (3rd floor) 57 Gulshan Avenue (CWS-A19) Gulshan Circle 1, Dhaka- 1212 miura.mari@jica.go.jp		
10.	Mr. Daisuke Ito Representative JICA Bangladesh office Ito.Daisuke.3@jica.go.jp		
11.	Mr. Md. Anisuzzaman National staff JICA Bangladesh office MdAnisuzzaman.BD@jica.go.jp		
12.	Mr. Sanjeev Kafley Head of Delegation International Federation of Red Cross and Red Crescent Society sanjeev.kafley@ifrc.org +88 01794581877		
13.	Ms. Dilruba Haider Programme Specialist, DRR, Climate Change and Humanitarian Actions UN Women Mobile: 01777737507 E-mail: dilruba.haider@unwomen.org		Mr. Kausik Das will come
14.	Mr. Kamal Hossain NRP (DDM Part) kamal.hossain@undp.org		
15.	Mr. Towhidul Islam Tarafder Oxfam Bangladesh towhid.office@gmail.com 01715 324846		
16.	Ms. Wahida Bashar Ahmed Mo: +88 01713 012 574 Email: wahidabasharahmed@yahoo.com		
17.	Mr. Md. Rafiqul Alam Executive Director Dwip Unnayan Songstha (DUS) Cellular: +88 01715 475 222 E-mail: dus.eddus@gmail.com		

Sl#	Name and Designation of Participants	Number	Remarks
Academicians		4	
18.	Prof. Towhida Rashid Professor, Dept. of Meteorology Dhaka University towhida_rashid@yahoo.com		
19.	Dr. Fatima Akter Assistant Professor Department of Meteorology Faculty of Earth and Environmental Sciences University of Dhaka fatima.geoenv@du.ac.bd		
20.	Prof. Rafi Uddin Professor of Atmospheric Laboratory, Dept. of Physics, BUET rafiuddin@phy.buet.ac.bd		
21.	Prof. Nasreen Akter Professor of Atmospheric Laboratory, Dept. of Physics, BUET nasreenphysics@gmail.com		
Project Team Members from Japan		3	
22.	Prof. Yuichi Ono Tohoku University		
23.	Prof. Taiichi Hayashi Kyoto University		
24.	Mr. Masashi Sakamoto Tohoku University		
BDPC		3	
25.	Muhammad Saidur Rahman		
26.	Laila Kabir		
27.	Mahmuda Begum		
Local Level Participants		13	
a)	From Tangail		
	Mr. Dilip Kumar Saha, DRRO, Tangail	1	
	Mr. Sehab Uddin, PIO, Kalihati Upazila, Tangail	1	
	Chairman, Balla Union Parishad	1	
	Persons from families where MSR were installed	4	
	Teachers	2	

Sl#	Name and Designation of Participants	Number	Remarks
b)	From Manikganj		
	NGO Representative	1	
	People who were affected by Tornado	3	
	Total Participants	40	

(3) Discussion

1) Presentation

Each project member gave a presentation to share the results of this project. Professor Tamura of Tokyo Polytechnic University presented the results of the previous project as background for this project. He introduced the purpose and construction status of the mini-shelter room construction for mitigating wind gust disaster damage, which was implemented in the previous project.

Mr. Sakamoto, a joint researcher at Tohoku University (seconded from Pacific Consultants Co., Ltd.), reported on the results of this project, including the utilization of mini-shelter rooms and the results of a questionnaire survey of local people in areas where tornado damage occurred.

Professor Hayashi of Kyoto University reported on the status of radar observations and the meteorological service system at the Bangladesh Meteorological Department as a result of this project. In addition, Associate Professor Yamane of Tokiha University reported on the current status and issues in disaster education, for which he is in charge.



2) Speech

Ms. Miura of JICA's Bangladesh office explained the relationship between JICA and the Bangladesh government, as well as the capacity building and support for meteorological services in Bangladesh. She emphasized that Bangladesh and Japan are celebrating 50 years of cooperation and have strengthened their partnership and friendship, and expressed her intention to continue to support the development of meteorological services. She also noted the lack of preparedness for disasters associated with weather phenomena such as tornadoes and lightning compared to storm surges and river flooding caused by cyclones and expressed her belief that all the efforts made by the workshop and key stakeholders would be invaluable in making Bangladesh a resilient and prosperous country. She stated that she believes that all the efforts made by the workshop and key stakeholders are valuable for making Bangladesh a strong and prosperous country.

Professor Ono of Tohoku University mentioned the point that the real voices of not only experts but also of local people provide the energy to create solutions. He also mentioned that the fundamental issue of this project was the large number of fatalities that occurred during the 1996 tornado outbreak, and explained the importance of efforts to mitigate damage from wind gusts. He emphasized the importance of continuing medium- and long-term cooperation and efforts by clarifying the pillars of the project, which include not only the construction of mini-shelter rooms but also the establishment of an early warning system and disaster prevention education.



3)Survivors' experiences and questions and answers

Participants in this workshop included not only academics but also local people who had actually experienced tornado damage in the past. The local people explained the meteorological phenomena at the time the tornado damage occurred and the damage that occurred in their area based on their actual experiences. This enabled the entire audience to share the enormity of the tornado damage.



5. Developing a Roadmap for Short to Long-term Measures

A multidisciplinary approach is important for measures to reduce the risk of wind gust disasters, involving not only academics but also diverse stakeholders, including practitioners and local people. In this project, not only science and engineering approaches such as observation and prediction of meteorological phenomena and early warning, but also social science approaches such as early evacuation, awareness raising, and disaster prevention education are required and need to be considered in a comprehensive manner. For developing a wind-related disaster reduction efforts in a sustainable manner in the future, it is essential to examine medium- to long-term countermeasure plans, i.e., the formulation of a medium- to a long-term plan.

Therefore, based on the results of this project, we developed a roadmap. The roadmap was categorized as short-term and long-term in order to clarify short-term initiatives that can be started immediately and initiatives that will be undertaken from a long-term perspective. This clarifies the relationship between each area, and we plan to continue our study based on this roadmap.

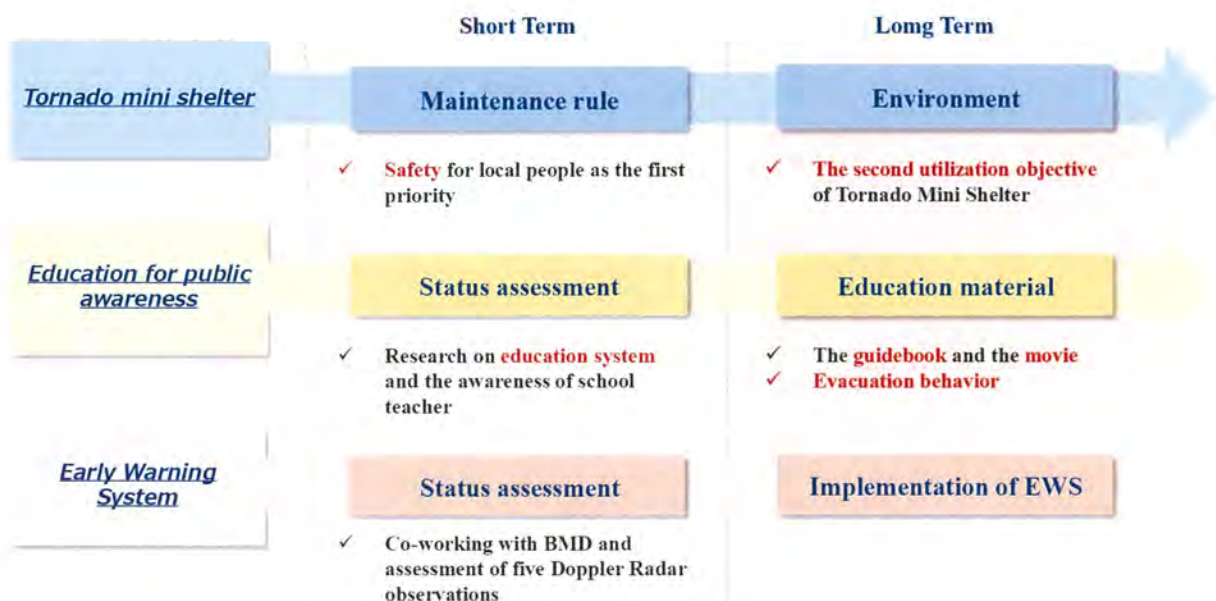


Figure. 13 Roadmap

6. Lesson Learn and Recommendation

This study had mainly three topics: 1) Tornado Shelter, 2) Education and 3) Early Warning System. The comprehensive strategy was applied by covering various academic disciplines such as meteorology, wind engineering and geography and practical perspectives such as meteorological services and operations, public awareness and education, and other disaster risk reduction measures. The followings are the lesson learn and recommendation in each topic.

Regarding the tornado shelter, the interview survey showed that mini-shelter rooms were rarely used. The reasons for this were that the use of the rooms during normal times was not clear, and those maintenance methods had not been established. One solution would be to evacuate a certain number of households together to a single shelter, rather than a large shelter such as a cyclone shelter, as this would be more realistic.

Focusing on the education, the survey revealed that many of the teachers who responded to the survey feel the importance and necessity of tornado disaster prevention education at their schools but are currently unable to implement it due to a lack of resources such as necessary teaching materials and human resources. It was also found that teachers' understanding of the atmospheric phenomenon of tornadoes is not sufficient. It is important to develop human resources for tornado disaster prevention education (e.g., by enhancing education at teacher training schools) and to develop teaching materials and learning programs that can be used effectively when such human resources are trained.

For forecasting meso-weather phenomena such as tornadoes, parameters such as wind shear, which indicates the degree of atmospheric instability and dynamic instability, and CAPE, which indicates thermal instability, are used. If we can fully understand the physical meaning of these parameters and use them in our business, we will have a better chance of forecasting outbreaks. In this process, we believe it is important for the newly established Department of Meteorology at the University of Dhaka and the Meteorological Department to cooperate in conducting steady research.

A multidisciplinary approach is important for measures to reduce the risk of wind gust disasters, involving not only academics but also diverse stakeholders, including practitioners and local people. In this project, not only science and engineering approaches such as observation and prediction of meteorological phenomena and early warning, but also social science approaches such as early evacuation, awareness raising, and disaster prevention education are required and need to be considered in a comprehensive manner. Based on the results of this project, we have organized the issues to be addressed in the future as a roadmap. This clarifies the relationship between each area, and we plan to continue our study based on this roadmap.