Guidelines for

Thunderstorm & Lightning

2021

Gujarat State Disaster Management Authority (GSDMA)
Block No.11, 5th Floor, Udyog Bhavan, Gandhinagar

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Foreword

Thunderstorms have some typical characteristics such as the formation of a squall, strong updraft and downdraft, towering cumulonimbus clouds associated with turbulence andicing, in-cloud electrification and associated lightning, localized strong rain and hailstorm. A dust storm, associated with a thunderstorm and strong winds, generally occurs in arid and semi-arid regions. It lifts loose dust from dry land area.

Experts believe that due to rising global temperature and climate change (IPCC Special Report, 2018 - Global Warming of 1.5 °C), the severity and frequency of thunderstorms/dust storms will rise in the years ahead. Gujarat may also experience an increase in the severity and frequency of these incidents in future. Hence, there is a need for prevention, preparedness and mitigation measures, and to invest in Disaster Risk Reduction (DRR) which will save lives, livestock, property and infrastructure. Accordingly, the Gujarat State Disaster Management Authority (GSDMA) has prepared a Gujarat State Action Plan for Thunderstorm & Lightning-2021 as per the NDMA guidelines 2019 for the Gujarat state. Hope this will help all the stakeholders to take appropriate steps to mitigate ill effects of Thunderstorm & Lightning.

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Foreword

The "Guidelines for preparation of Action Plan – Prevention and Management of Thunderstorm & Lightning/ Squall Dust/Hailstorm and Strong Winds" aim to facilitate and improve the capacity of the State in preparing the Action Plans and respond promptly and effectively to mitigate the adverse effects of these incidents. It will help develop measures for the assessment, forecast, preparedness and mitigation through coordinated efforts with multiple agencies and undertake reconstruction as an opportunity to build disaster-resilient infrastructure.

The guidelines covers Early Warning & Communication, Prevention Mitigation & Preparedness measures & especially the roles & responsibilities of each stakeholders. Thus, the guideline will help to take preventive measures in a better coordinated manner.

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1. Introduction

IMD data (1950-1980[1]) shows that more than 80 thunderstorm days occur per year over the northeastern part of India, some parts of Kerala and Jammu & Kashmir. The eastern and northeasternparts of our country, i.e. Gangetic West Bengal, Jharkhand, Bihar, Odisha, and northeastern States, get affected by severe thunderstorms during the pre-monsoon months of March to May.

According to the report in the plains, lowest occurrence of thunderstorm days is seen over Saurashtra and Kutch (15 days). Thunderstorm activity increases eastwards from western parts of thecountry. Saurashtra and Kutch of Gujarat record less than one thunderstorm occurrence. Pre monsoon and monsoon seasons records the highest frequency of thunderstorms over all parts of the country. Availability of moisture and favourable synoptic features contribute to general increase of thunderstorm activity over all parts of the country outside Kerala. Although western parts of the country continue to be the area of the lowest thunderstorm activity in the country, increase from 2 to 3 days of thunderstorm in the Pre monsoon season to over Gujarat to 10 to 15 days in the monsoon season is quite substantial. During post monsoon thunderstorm occur on less than 2 days over Gujarat.

Thunderstorm & Lightning/Squall/Dust Storm/Hailstorm and Strong Winds have a devastating impact on agriculture and aviation sectors in addition to surface transport, power, communication andother socio-economic sectors. These may also lead to loss of human lives, assets/property/livelihoods, etc. Experts believe that due to rising global temperature and climate change (IPCC Special Report, 2018 - Global Warming of 1.5°C)[2], the severity and frequency of thunderstorms/dust storms will rise in the years ahead.

Thunderstorms have some important characteristics such as the formation of a squall, strong updraft and downdraft, towering cumulonimbus clouds which are associated with turbulence and icing, in-cloud electrification and associated lightning, localized strong rain and hailstorm.

A dust storm associated with a thunderstorm generally carries very little rain in them and the strong winds lift loose dust from dry land in arid and semi-arid regions. Sometimes, heavy rain and hail occur which causes severe damage along with strong winds.

Lightning is yet another weather-related disaster associated with thunderstorms. Lightning occurs due to electrically charged regions in a cloud which is called intra-cloud lightning (IC) or between Cloud-to-Cloud (CC lightning), or between a cloud and the ground (CG lightning). The charged regions in the atmosphere temporarily equalize themselves through this discharge referred toas a flash. A lightning flash becomes a strike if it involves an object on the ground. The flow of electric charges can affect any electrically conductive body. Hence, electrical appliances, if operatedduring a lightning strike, can affect their normal functioning and have a risk of becoming faulty. Similarly, living beings coming in contact with lightning, either directly or indirectly through electrical conductors, can be affected, which may lead to severe burns or even death. Lightning strikesthe Earth 50 to 100 times each second[3].

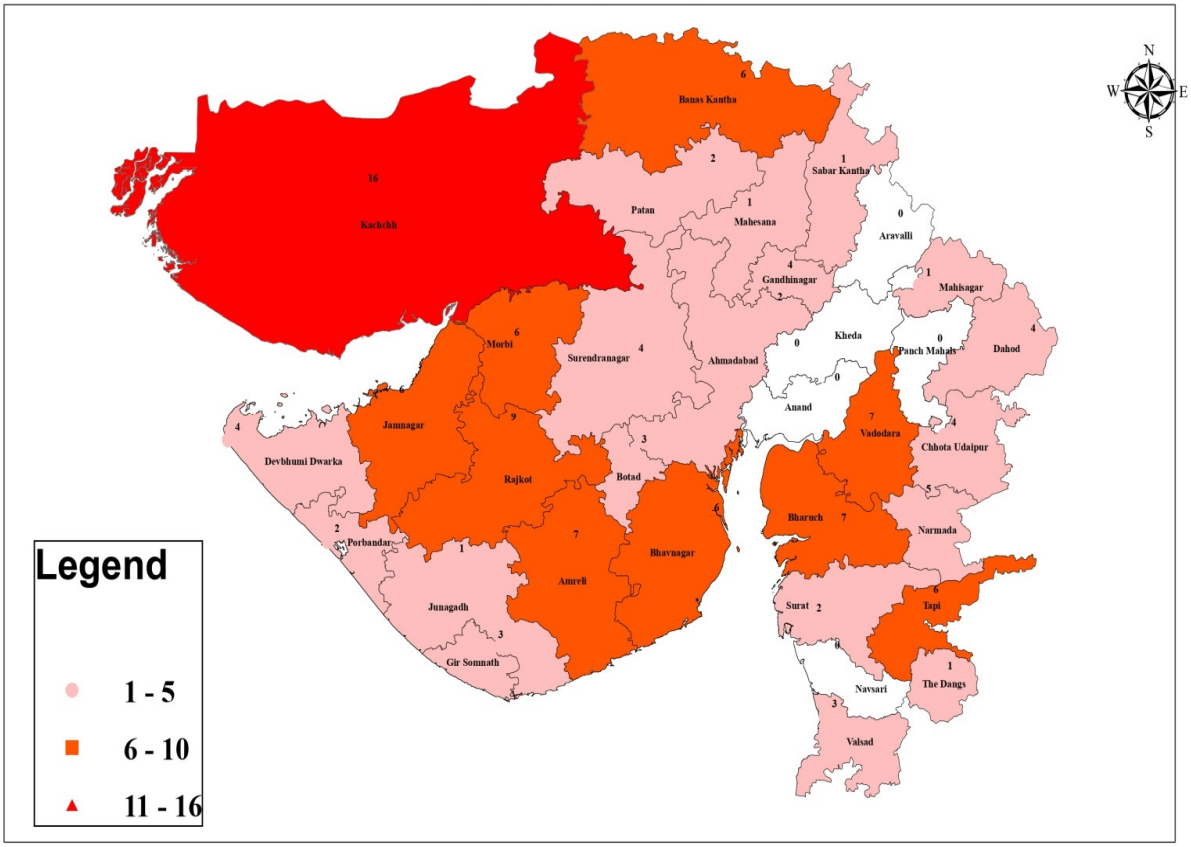
1 Tyagi, A., 2007. Thunderstorm climatology over Indian region. Mausam, 58(2), p.189.

2 IPCC special report on the impacts of global warming of 1.5 °C (Policymakers was formally approved at the First Joint Session of Working Groups III and III and accepted by the 48th Session of the IPCC, Incheon, Republic of Korea, 6 October, 2018.)

3 Dr Sunil D. Pawar, IITM, Pune, and Oliver, JohnE. (2005) National Oceanic and Atmospheric Administration (NOAA),USA.

These Guidelines present salient features of thunderstorms and associated weather phenomena, and guidance for early warning and communication keeping in mind existing gaps, challenges and opportunities. The strategy needs to be followed by all stakeholder agencies with well-defined timelines, roadmaps and Standard Operating Procedures (SOPs).

Lightning Death(2015 - 2020)



1.1 Impact of Thunderstorm/ Lightning, Dust/ Hailstorm, Squall, and Strong Winds in Gujarat, India

During May 2018, severe dust storms, thunderstorms and lightning hit several parts of India, resulting in a large number of deaths and injuries across Rajasthan, Uttar Pradesh, Telangana, Uttarakhand and Punjab. The table below shows the number of deaths from thunderstorm and Lighting in the state of Gujarat from 2011 to 2020. In Gujarat, around 77 deaths are recorded due to thunderstorm and lightning in the year 2020.

Year-wise deaths reported due to Thunderstorm & Lightning

Sr. No	Year	Number of Death
1	2011	33
2	2012	29
3	2013	52
4	2014	60
5	2015	63
6	2016	35
7	2017	55
8	2018	13
9	2019	52
10	2020	77
	Total	**469**

Rural and forest areas are the most vulnerable given the presence of tall trees and water bodies. A majority of the lightning victims are people working in the fields in rural areas. Lightning is also a major cause of electrical power breakdowns and forest fires. It can also damage communication and computer equipment and affect aircraft navigation systems. A moderate thunderstorm can damage thatched huts, Kutch roads, standing crops, orchards, power and communication lines. A severe thunderstorm can cause major damage to thatched houses/ huts. Rooftops may also blow off. Unattached or loosely tied metal sheets mayfly. It can also damage power and communication lines as well as roads, besides flooding of escape routes, breaking of tree branches, uprooting of large trees, etc. Dust storms also lead to breathing problems. Hailstorms may cause injury to human beings, livestock, and can cause damage to standing crops. The probability of occurrence of hailstorms is highest in Maharashtra (91-95%).

Indian Institute of Tropical Meteorology (IITM), Pune, an autonomous institute under the Ministry of Earth Sciences, Government of India, has initiated a project to study the characteristics of lightning by using Lightning Location Network (LLN). This network can accurately detect the location of occurrence of a lightning strike and can help forewarn the public at least 1-2 hours before the occurrence of a thunderstorm. Population density, literacy rate and urbanization along with the density of lightning strikes and the region's topography are the major factors affecting lightning deaths. Maharashtra has established a 20-sensor network with its Central Processing Station at IITM, Pune, on an experimental basis. Each sensor has a coverage of about 200 km. This network is also complemented with a mobile app that not only shows an ongoing lightning event but also sends out warning Short Messaging Services(SMSes) to people. State Governments undertake necessary measures to minimise the impact of these incidents.

1.2 Definitions & Classification of Thunderstorms and associated weather phenomena

A. Thunderstorms:

A thunderstorm is said to have occurred if thunder is heard or lightning is seen. Usually, the thunder can be heard up to a distance of 40 km from the source of origin. Thunderstorms fall in the category of Meso-gamma weather systems with a spatial extent of around 2~20 km and temporal scale of a few hours. Considering their intensity, the thunderstorms in India are categorised as follows:

- **Moderate thunderstorm**: Loud peals of thunder with associated lightning flashes, moderateto heavy rain spells and maximum wind speed of 29 to 74 kmph.
- **Severe thunderstorm**: Continuous thunder and occasional hailstorm, and maximum wind speed exceeding 74kmph.

Thunder storms occur round the year in different parts of the country. However, their frequency and intensity are maximum during summer months(March to June) as the most important factor for the occurrence of thunderstorms is the intense heating up of the atmosphere at the surfacelevel.

B. Squall:

A squall is defined as a sudden increase of wind speed of at least 29 kmph (16 knots) withthe speed rising to 40 kmph (22k nots) or more and lasting for at least one minute. It is of two types:

- **Moderate squall**: If the surface wind speed (in gusts) is up to 74 kmph.
- **Severe squall**: If the surface wind speed (in gusts) is greater than 74 kmph.

The climatology of the spatial distribution of occurrence of a squall is almost the same as that of thunderstorms. The frequency and intensity of squall are maximum over eastern and northeasternStates. Also, its frequency is maximum during the pre-monsoon season with an increasing trend fromMarch to May in different parts of the country. However, there is a secondary maximum in the winterseason over northwest India.

C. Hailstorm:

India, with about 29 hail days of moderate to severe intensity per year, is among those countriesin the world which experience a very high frequency of hail. Hailstorms are mainly observed duringthe winter and pre-monsoon seasons with virtually no events after the onset of the southwest monsoon.

It appears to be associated with a particular cell of convective cloud rather than storm as a whole. Hail occurs in the mature stage, if at all it occurs. Cells in which hails occur have updrafts ofgreater than average intensity, exceeding 15 meters per second. It is of three types:

- **Slight Hailstorm**: If it is sparsely distributed, usually small in size and often mixed with rain.
- **Moderate Hailstorm**: If it is abundant enough to whiten the ground.
- **Strong Hailstorm**: If it includes at least a proportion of large stones.

D. Dust storm:

Northwest India experiences convective dust storms, locally called *"aandhi",* during the pre- monsoon season with maximum frequency and intensity in May. The frequency of dust storms is maximum over Rajasthan followed by Haryana, Punjab and West Uttar Pradesh. It is of three types:

- **Slight dust storm:** If the wind speed is up to 41 kmph and visibility is less than 1,000 metresbut more than 500 meters.
- **Moderate dust storm:** If the wind speed is between 42-74 kmph and visibility is between200 and 500 metres.
- **Severe dust storm:** If the surface wind speed (in gusts) exceeds 74 kmph and visibility isless than 200 metres.

E. Lightning

Lightning is a high-energy luminous electrical discharge accompanied by thunder. It is of threetypes:

1) Thundercloud or Intra-cloud lightning (IC)
2) Cloud-to-cloud or Inter-cloud lightning (CC)
3) Cloud-to-ground lightning (CG)

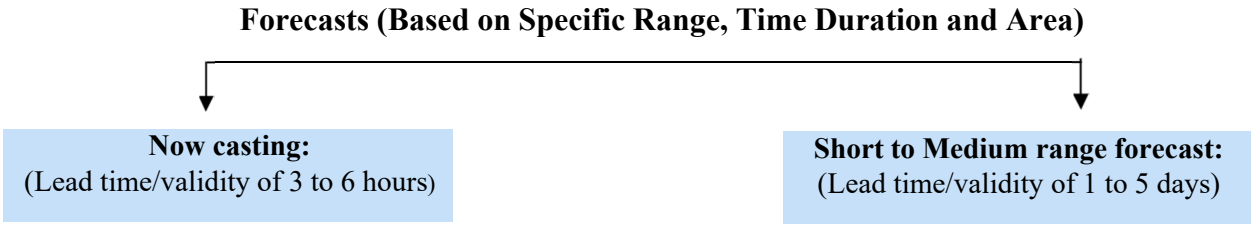
The third type of lightning takes a toll on lives and property, and therefore, is of more concernto us. However, inter-cloud and intra-cloud lightning are also dangerous as they may hit aircrafts. These are also the precursor to cloud-to-ground lightning.

Lightning has a total path length of a few kilometres. Its peak power and total energy are very high, with the peak power discharge in the order of a 100 million watts per meter of the channel andthe peak channel temperature approaching 30,000 °C. Peak currents in a lightning discharge range upto hundreds of kilo amperes (kA) with its typical value being 40 kA. Predicting the precise time andlocation of lightning is very difficult. However, a season or a period of lightning occurrence is knownfor many regions.

2. Early Warning & Communication

2.1 Forecast and Issuance of Alerts/Warning

India Meteorological Department (IMD), Ministry of Earth Sciences, is the nodal agency for providing current weather information and forecast, including warnings for all weather-related hazards. Besides, should establish their own independent early warning and monitoring systems to supplement warnings from the IMD.



While short to medium range forecast provides the potential areas with a probability of occurrence, now casting provides more specific information about the place/time of occurrence.

A thunderstorm is a small-scale phenomenon and has a life cycle of about three hours.It has a dimension of 2 km to 20 km, and therefore, its detection is difficult. Weather monitoring systems such as automatic weather stations (AWS) provide some basic parameterssuch as wind speed, wind direction, relative humidity, temperature, pressure, etc., but do notpredict lightning.

Geostationary Weather Satellite captures images from a height of 36,000 km above theearth. It takes about half an hour to capture the image and another half an hour to process thedata. So, by the time someone sees the satellite imagery on IMD's website, it is already one hour late. Due to the short life cycle of thunderstorms, a satellite cannot capture its initiationunless it is a large-scale thunderstorm activity.

The Doppler Weather Radar, which takes an observation every 10 minutes, can detectthe occurrence of thunderstorms. Therefore, for better monitoring, there is a need for a widernetwork of Doppler Weather Radars in the country.

Lightning incidents can be detected by the ground-based Lightning Detection Networkin real time. There is a need to create a high-density network in regions vulnerable to lightning strikes.

For measuring squall and gusty winds, a meso-network of observation stations are required in the country with anemometers that can measure wind speed up to about 200kmph.Further, one to two high wind speed recorders can be installed in each squall-prone district.

On the day of occurrence of a severe weather incident/thunderstorm, State-level officesof the IMD start now casting. As now casting is valid for the next two to three hours, it gives only a limited lead-time. This now cast, which is at the district level, is provided to Relief Commissioners, State Control Rooms, District Collectors, Disaster Management units, etc. This alert is specific and issued for a district with the time of occurrence and associated wind speed.

In the last decade, there has been a significant improvement in the monitoring and

forecasting of thunderstorms. This can be attributed to a good network of Doppler Weather Radars, a dense AWS network, half-hourly satellite observations from INSAT 3D & 3DR satellites, better analysis tools, and advanced computational and communication capabilities.With these, IMD has started all India now cast services for localized, high impact weather incidents such as thunderstorms, squalls and hailstorms with a lead time of up to 3 hours since2013.

DWR-based observation is the main source of information for now cast of thunderstorms and a DWR-based observation is the main source of information for now cast of thunderstorms and associated weather incidents. In the first phase, 403 cities and towns, which come under the coverage of DWRs, have been included for now casting of convective weather. This coverage would be increased so as to represent all districts by 2020 and all blocks by 2025 through expansion of DWR networks and forecasting systems.

To be effective and complete, an Early Warning System needs to comprise four indicating elements, namely:

(i) Risk knowledge

(ii) Monitoring and warning service

(iii) Dissemination and communication

(iv) Response mechanism and capacity building

Before the preparation of the Action Plan, especially for lightning, it is imperative that the following actions are taken:

1) Mapping of lightning-affected zones on the basis of:
    a. Available data of deaths and injuries (both humans and animals) at different places complete with latitude and longitude points,

b. Data of lightning incidents available with Radar/lightning detection System,
c. Data available from the National Crime Record Bureau.

2) Systemic study of past lightning occurrences by any expert agency or group (to be taken up with State-level knowledge institutions).
3) Sharing of data between different agencies for preparation of mitigation plan.
4) Installation of lightning and thunderstorm detection devices.
5) Generation of a database for future planning.

2.2 Early Warning/Alerts: Dissemination and Communication Strategy

A. Dissemination strategy of Warning Messages

The dissemination strategy should aim at reaching the last person as soon as possible. Thefollowing points should be kept in mind:

a. The warning messages from agencies such as IMD should contain safety directions to befollowed; for e.g.; the now casting messages for severe thunderstorm/dust storm may askthe public to take a safe shelter or move indoors in the wake of an inevitable disaster;
b. The message should be short, clear, in simple language and action-oriented;
c. Greater emphasis must be placed on inter-agency coordination while dissemination ofwarning messages, including public and private media; and
d. The following activities may be considered for ensuring that everyone in the affected areas is warned in time –
    i. Flash messages / tickers / 'breaking news' to be displayed on the local TVnews channels;
    ii. Radio announcements through public and private broadcasters;
    iii. Flash messages / SMSes to the users by the mobile operators in the affectedareas;
    iv. In case of rural areas and small towns, an early warning may be issued bythe local
    v. authorities using loudspeakers, sirens, etc.; and
    vi. Social Media, including group messaging services, should be extensivelyused.

B. Communication Strategy and Drafting of Key Do's and Don'ts

a. The communication strategy should be based on insights of the local populationconsidering the nature of the–

   i. Messages;

   ii. Messenger/Medium/Media; and

   iii. Receiver.

b. The Communication Strategy should aim at promoting a culture of DRR and behaviour change through mass awareness campaigns.

c. The subject matter expert(s) should carefully draft Do's and Don'ts / safety tips or techniques in consultation with the IEC expert(s). For this, IEC expert(s) may use Research Methodology, Rapid Rural Appraisals and Communication Gap Analysis techniques for better understanding of-

   i. Behaviour patterns or tendencies;

   ii. Media consumption;

   iii. Local trends of the vulnerable population; and

   iv. Available facilities like shelter and contact details.

2.3 Public Awareness, Community Outreach and Information Education Communication (IEC)

Awareness campaigns should be carried out based on communication strategy and researchinsights. IEC activities should be planned at State and local levels.

A. State level:

- Carry out mass awareness campaigns in local languages;
- Develop media and communication strategies and plans considering localsocioeconomic and behavioural factors;
- Involve recognised artists of the State, such as folk singers, dancers, and other
- performers for stronger recall value;
- Conduct regular awareness programmes in all districts;
- Conduct regular training programmes for inter-personal communication activities.

B. Local level: The local authorities, due to their proximity to the affected population,are in the best position to ensure the last mile delivery of messages. They may –

- Conduct regular inter-personal communication activities;
- Demonstrate the safety tips to the vulnerable population **in Gujarati local language,**using local customs, cultural aspects and behaviour patterns; Local artists and art forms may be utilized for entertainment-based education programmes; Extensive use of IEC tools and materials (such as flyers, calendars, comic books, etc.) should be made available for people for reference;
- Strengthen and involve local communities such as RWAs, Municipal bodies,NGOs, Panchayati Raj Institutions, *Anganwadis*, *Gram sabhas*, Medical professionals and other local bodies;
- Give special emphasis to dissemination in locations of "closed homogeneousgroups" such as schools, colleges, offices, cinemas, etc.
- Carry out Out-of-Home campaigns using banners, posters, billboards, etc.
- Carry out special awareness programmes for the differently abled.

2.4 Review & Evaluation of the Early Warning System (EWS)

The reliability of EWS and its forecasting performance for natural hazards – in terms of hits, missed incidents and false alarms for different thresholds – has to be evaluated periodically. Its evaluation must include the benefits of risk reduction as well as and the negative consequences of missed incidents and/or false alarms. In addition, the reliability of EWS also depends on the probability of technical failures of system components. Therefore,it is also necessary to evaluate the efficiency of the technical reliability of the system components.

3. Prevention, Mitigation and Preparedness Measures

A. Preventive Measures:

Disaster prevention covers measures aimed at impeding the occurrence of a disaster incident and/or preventing such an occurrence from affecting communities. The occurrence of thunderstorm and squall can't be impeded. However, their harmful effects can be minimized through number of measures.

(a) Hazard and Vulnerability Assessment: Micro-level hazard zoning should be done and vulnerable areas must be clearly marked on a map. The extent of vulnerability (mild, moderateor intensive) and the probable cost of damages to crops due to incidents of varying intensitiesmust be included in the assessment report. With respect to a disaster, risk is specifically described using relative terms such as High Risk, Average Risk and Low Risk to indicate thedegree of probability of the occurrence of the incident. The risk assessment includes an evaluation of all elements that are relevant to the understanding of the existing hazards and their effects on a specific environment. There are several steps in risk assessment based on the related processes of hazard mapping vulnerability analysis. They establish the nature, location and scale of risks to society and its assets. This information can assist decision makersin deciding what can and should be protected and up to which level.

(b) Sensitization of Disaster Managers, Planners and Decision Makers: Sensitization of planners and decision makers can immensely help in minimizing the harmful effects of theseincidents on communities. The first and foremost need is awareness generation among policymakers, administrators, engineers, architects, the general public as well as the farmingcommunity.

(c) Awareness generation among masses: Public awareness and education help in improving the disaster resilience of masses. Information, Education and Communications strategy formas awareness generation has been discussed in detail in section 2.3.

B. Mitigation and Preparedness Measures

The lessons learnt from previous incidents, particularly regarding gaps in rescue and relief works andthe shortcomings experienced in the process, should be dealt with carefully. Disruption of communication and transportation services and undue delays in clearing the fallen trees, electricity poles and hoardings on the roads and/or streets that further delay the immediate transportation of theinjured to nearby hospitals remains a major challenge. The hierarchical structure for execution needsto be formalized so that all efforts are properly coordinated. Coordination for relief distribution is equally important to ensure qualitative and timely delivery; the lack of which may lead to duplicationof efforts at some locations while leaving some others completely starved.

a. **Enhanced understanding of preparedness and mitigation measures:** This will help us minimize the losses due to thunderstorms/squall, etc.

b. **Hazard Resistant Construction:** United Nations Development Programme (UNDP) and NDMA, Ministry of Home Affairs, Government of India, released a "Manual on Hazard Resistant Construction in India" for the non-engineered buildings in July 2008. The popular load-bearing masonry building systems, prevalent in different parts of the country, are covered in the manual. Relevant building codes and guidelines of the Bureau of Indian Standards form the basis for this manual. In addition, the two decades of work carried out bythe authors focusing on the promotion of suitable building technologies in different parts of the country and the on-site training of building artisans and engineers, as well as the post- disaster assessments of damages in various disasters provide the backbone of this manual. Itis hoped that this manual will contribute towards ensuring better structural performance in the face of potentially destructive natural hazards and thus bring safety to the people, rich andpoor alike, in India.

c. **Laying underground electricity cable sand telephone lines:** These are best suited, particularly for congested townships where thunderstorms/squall may cause falling of electricity and telephone poles, and snapping of cables.

d. **Emergency Communication Systems:** Planning, updating and mobilization of existing radio communication resources in emergency situations and acquisition of satellite phones to makethem available at the *tehsil* level to ensure prompt response in the event of occurrence of anydisaster.

e. **Integrating Development schemes with Disaster Management Schemes:** This would enable the creation of disaster-resilient localities by way of recommendations by *patwari/gram pradhan* that quality raw material and technology be used in all infrastructure/construction projects.

f. **Technical, Social, Organizational and Administrative preparedness:** The most urgent need of the hour is to develop a DSS (Decision Support System) for thunderstorm nowcast,which is currently being done using the existing network of observations, radars, satellitesand lightning data. To accomplish this, the DWR and lightning network could be expandedover all thunderstorm prone areas across the country and information thus obtained could bemerged with satellite observation to generate meaningful insights for different regions with alead time of 1-2 hours. The nowcast alerts/warnings should be accompanied with actionableinformation (Do's and Don'ts) and potential impact (expected damage).

Besides SDMAs and DDMAs, tehsil-level Disaster Management Group (TMG) at subdivision/ tehsil level should be formed with representatives of various line departments, including Agriculture, Forest, BSNL and other telecom service providers, Electricity Board,Revenue, P.W.D, Health, Police and Fire Brigade. Village Disaster Management Committees (VDMCs) should also be formed at the village level comprising local villagers. This would certainly strengthen the local response mechanisms to disasters.

g. **Emergency Plan for Hospitals and Health Centres:** Emergency expansion plan for civil hospitals, community health centres, Primary Health Centres (PHCs) and additional PHCs, including schemes for mobile medical teams for a post-disaster situation, should be in place.A list of Army hospitals, Govt. Hospitals (both Centre and State), private hospitals andnursing homes in each district should be prepared. Phone numbers of all these medicalfacilities should be available in the District Control Room as well as in the SEOC. Based onthe hazard assessment, emergency medicines, Operation Theatres and life-saving drugsshould be kept ready. Vacant post of doctors and paramedical staff should be filled in all thegovernment hospitals in order to make available the required number of medical workers atthe time of an emergency. An Action Plan must be considered for training of doctors and paramedical staff on handling patient inflow and treating them in case of a disaster.

h. **Focusing on Research and Establishing a Forecasting Centre for Thunderstorm and Squall to** carry out the hazard zonation and vulnerability analysis for thunderstorm and squallwith State-level knowledge institutions.

i. Making Disaster Risk Reduction (DRR) a part of school and college curriculum: Youth

and children can be taught about extreme weather incidents and the Do's and Don'ts to be followed before, during and after a disaster. They act as agents of change and bring about greater awareness in the neighborhood and society.

C. Structural Mitigation Measures

The most effective structural measures against thunderstorms, lightning, squall and strong winds are meant to protect against the strong, high-speed winds and against the electric discharge due to a lightning strike.

(a) Protection Against Strong Winds

During cyclonic conditions, strong winds are able to reach velocities of more than 200km/hr.The cyclonic winds are also associated with pressure differentials that can cause a huge pressure difference between the outside and the inside of a building resulting in a higher net effect of the windstorm. These high-velocity winds can cause severe damage to light structural and non-structural systems such as claddings. Since the arrival of cyclonic storms is accompanied by suitable warnings,it is expected that people will not be found outdoor during a cyclonic storm. People are, therefore, safe against the most harmful effects of the high wind velocity provided they are inside cyclone shelters or other well-constructed buildings.

During strong winds associated with thunderstorms or squalls, the wind velocity is high but it rarely reaches cyclonic levels. Typical wind speeds during thunderstorms are in the range of 50-80km/hr. During severe thunderstorms, the wind speeds may reach around 100 km/hr. The wind velocity is highest in storms that are associated with extensive lightning activities.

Structures do not require any special protection against storms with wind speeds up to 100km/hr if they are designed and constructed asper approved standards. Buildings that are constructed informally or those which are made using non-engineered materials may not be able to resist the wind forces. These may get damaged even in low wind speed unless special protection mechanisms are adopted. In general, components that provide large areas for the application of windforces are the first to be damaged. They can become loose and pose a threat to humans as flying debris. In buildings that use lightweight sheets for roofing, the panels may collapse on occupants.

Protection against the light weight panels under such wind speeds can be provided by properlysecuring them with their supporting frames. The connection has to ensure that shearing or punchingis avoided. Also, it has to be ensured that the panels themselves have the requisite strength to withstand the wind force. The supporting frames also need to have adequate strength to safely transferthe forces imposed on them.

(b) Protection Against Lightning—Lightning Shields

Installation of lightning arrestors and sound earthing for each building is essential. Lightningshields are the most commonly employed structural protection measure for buildings and other structures. A lightning shield consists of the installation of a lightning conductor at a suitably high location at the top of the structure. The conductor is grounded using a metal strip of suitable conductance. The grounding of the conductor is also specially designed to ensure rapid dissipation of the electrical charge of a lightning strike into the ground.

Lightning shields are not foolproof in their effectiveness. The ability of lightning shields to complete the cloud-to-ground circuit depends on several variables such as the height of the conductor, the shape and size of adjoining structures or natural conductors. The cone of protection is also highlyvariable and the angle of protective cone decreases with the increase in height of the shield's conductor. Very tall buildings may require lightning conductors at intermediate levels of the buildingin addition to the ones at its roof.

Internationally, lightning shields are not used for the protection of open areas such as agricultural fields due to their very high cost and reliability issues. However, they are found to be very effective for the protection of individual structures or groups of structures in an area.

D. Action–Before, During and After

(a) Before Thunderstorm and Lightning

To prepare for a thunderstorm, you should do the following:

a. Do remember that vivid and frequent lightning indicates the probability of a strong thunderstorm.
b. Build an emergency kit and make a family communication plan.
c. Remove dead or rotting trees and branches that could fall and cause injury or damageduring a severe thunderstorm.
d. Postpone outdoor activities.
e. Remember the 30/30 Lightning Safety Rule: Go indoors if, after seeing lightning, youcannot count to 30 before hearing thunder. Stay indoors for 30 minutes after hearing the last clap of thunder.
f. Secure outdoor objects that could blow away or cause damage.
g. Get inside a home, building, or hard top automobile (not a convertible). Although youmay be injured if lightning strikes your car, you are much safer inside a vehicle than outside.

h. Remember, rubber-soled shoes and rubber tyres provide NO protection from lightning.
i. However, the steel frame of a hard-topped vehicle provides increased protection if you
j. are not touching metal.
k. Unplug appliances and other electrical items such as computers and turn off air conditioners. Power surges from lightning can cause serious damage.
l. Shutter windows and secure outside doors. If shutters are not available, close window blinds, shades or curtains.
m. Unplug any electronic equipment well before the storm arrives.

(b) Before/ During a Hailstorm

(i) Farmers are advised to use hail net for orchard crops to protect from mechanical damage.
(ii) Provide support to banana crops, young fruit plants and cropping up in sugarcane crop/stakingof vegetables to prevent the crops from lodging.
(iii) Keep harvested produces at a safe place.
(iv) Keep cattle/goats indoor during a hailstorm.

(c) During Thunderstorms and Lightning

If thunderstorm and lightning are occurring in your area, you should:

a. Use your battery-operated radio/TV for updates from local officials.
b. Avoid contact with corded phones and devices including those plugged for recharging.Cordless and wireless phones not connected to wall outlets are OK to use.
c. Avoid contact with electrical equipment or cords.
d. Avoid contact with plumbing or pipes. Do not wash your hands, do not take a shower, donot wash dishes, and do not do laundry. Plumbing and bathroom fixtures can conduct electricity.
e. Stay away from windows and doors, and stay off porches.
f. Do not lie on concrete floors and do not lean against concrete walls.
g. Avoid natural lightning rods such as a tall, isolated tree in an open area.

h. Avoid hilltops, open fields, the beach or a boat on the water.

i. Take shelter in a sturdy building. Avoid isolated sheds or other small structures in openareas.

j. Avoid contact with anything metal - tractors, farm equipment, motorcycles, golf carts,golf clubs, and bicycles.

k. If you are driving, try to safely exit the roadway and park. Stay in the vehicle and turn onthe emergency flashers until the strong rain ends. Avoid touching metal or other surfaces that conduct electricity in and outside the vehicle.

(d) After lightning strikes a human being

If lightning strikes you or someone you know, call for medical assistance as soon as possible. You should check the following when you attempt to give aid to a victim of lightning:

(i) **Breathing**–If breathing has stopped, begin mouth-to-mouth resuscitation.

(ii) **Heartbeat**–If the heart has stopped, administer Cardiopulmonary Resuscitation (CPR).

(iii) **Pulse**–If the victim has a pulse and is breathing, look for other possible injuries. Check for burns where the lightning entered and left the body. Also be alert for nervous system damage, broken bones and loss of hearing and eyesight.

4. Capacity Building

The **Gujarat State Disaster Management Authority (GSDMA)** will act as a nodal agency to coordinate and monitor activities relating to prevention and mitigation of disasters, including capacity-building.

The GSDMA has been constituted by the Government of Gujarat in the year 2001 to analyseand study the reasons of natural calamities and to suggest the remedies to avoid or minimize the effects of such natural calamities. The composition of state crisis group is headed by Chief Secretaryas chairman and Secretary (Labour) as Member Secretary and other members includes Secretary (Environment), Secretary (Health), Secretary (Industries), Secretary (Public Health Engg.), Chairman of State Pollution Control Board, Secretary/Commissioner (Transport), Director (Industrial Safety)/ Chief Inspector of Factories, Fire Chief, Commissioner of Police and Experts (Industrial Safety & Health). Further, there are 33 District Project Officer (DPO) in each districts of Gujarat.

The Revenue department is primarily responsible for emergency response and relief in the State, while the Gujarat State Disaster Management Authority (GSDMA) is designated as the nodalagency for formulation of policies, long term planning, coordination and monitoring body for mitigation, reduction and preparedness for disasters in the State. The GSDMA organise review meetings with different departments through video conference. Municipal corporations should takeup all measures under the jurisdiction of GSDMA.

The **Gujarat Institute of Disaster Management (GIDM)** is a disaster training institute. GIDM will arranges target based training programs for different stakeholders. The GIDM will also introduce a regular capacity enhancement programme for teachers and professionals on Thunderstorm & Lightning/Squall/Dust Storm/Hailstorm and Strong Winds and identify the gaps,if any.

Target Groups for Capacity Building

Target groups for capacity building include:

- District Project Officer (DPO) – 33 DPOs
- Media professionals
- Urban planners/ development experts/ engineers/ architects/ builders
- NGOs/ social activists/ social scientists/ youth organisations
- Community-based organisations (CBOs)
- School teachers and school children

Capacity Building of Professionals

The Gujarat State Disaster Management Authority (GSDMA) will be in consultation with reputedknowledge institutions like the Indian Institute of Public Health Gandhinagar (IIPHG), and Indian Meteorological Centre, Ahmedabad (IMD), etc., develop comprehensive programmes and a state levelplan for creating a group of mentors from among trained faculty members of engineering and architecture colleges as also from among professionals in the relevant fields.

5. Roles and Responsibility

Risk assessment and scenario projection requires data on the built environment and the lackof which can lead to assumption-based scenarios. The Commission of relief, Gujarat is required todocument data. The documentation will be used for learning lessons from past experiences and factoring improvements into future planning for preventive, preparatory, mitigative, relief and response measures.

GSDMA will support all stakeholders in knowledge sharing regarding Prevention, Mitigation and Preparedness Measures on Thunderstorm & Lightning / Squall / Dust Storm / Hailstorm and Strong Winds. GSDMA will also hold review meetings and support departments on data documentation and compiling in the prescribed manner (Annexure 2). The GSDMA will be in consultation with reputed knowledge institutions of Gandhinagar and Ahmedabad to develop comprehensive programmes and capacity building of differentstakeholders.

Indian Meteorological department (IMD) will provide weather information and forecast, on Thunderstorm and Lighting.

6. Roles and Responsibilities Matrix for Management of Thunderstorm, Lightning, Dust/ Hailstorm, Squall and Strong Winds

S. No.	Tasks/Activities	State Agencies & Their Responsibilities	
		State of Gujarat	**Responsibility**
Understanding Risk			
1	Preparation of policy, guidelines and ActionPlans	Revenue Department/ GSDMA / Commissioner of Relief (COR)	• Prepare State Action Plan and ensure its implementation • Prepare detailed department-wise SOPs
Interagency Coordination			
2	Early Warning and Communication	Revenue Department/ GSDMA/ CoR/ District Admin	• Disseminate information received from the IMD to the public • Promote installation of lightning arresters and Doppler Radars • Create a network of community-based early warning systems • Establish State-level monitoring and warning dissemination system to supplement warning(s) from the IMD[3].
		Revenue Department/CoR/GSDMA I & B Department	• Dissemination of specific information to the public through print/electronic/social and other mass media at the local level
		Revenue Department / COR And concerned dept.	• Ensure push SMS by telecom service operators to all active mobile connections in the affected area.
		Energy & Petrochemical Department/ CoR	• Activate all concerned DISCOM office/officials
		Energy & Petrochemical Department	• To ensure cutting off of power supply[4] and its restoration • Ensure emergency power supply to critical facilities
		Revenue Department / CoR	• Activate the district administrations along with line departments as soon as a specific warning is received
		Revenue Department / CoR / GSDMAs/ Dept. of Agriculture/ Other concerneddepartments	• Follow and quickly implement the instructions of central/State govt.

[3]States should also establish their own Early Warning System in parallel.

Sr. No.	Tasks/Activities	State Agencies and Their Responsibility	
		State	**Responsibility**
3	Relief &Response	**Nodal Agency :** Commissioner of Relief (to coordinate with other concerned Departments/Agencies)	• Designate a nodal officer for emergency response • Coordination among all stakeholder agencies with clearlydefined roles and responsibilities • Rescue and evacuation operations in coordination with the administration, NGOs and volunteers • Emergency medical response Other necessary actions
4	Monitoring and Review of the Guidelines	State Government/ GSDMAs/ DDMAs	• Nodal officer(s) to act as the contact person for eachdept./agency • Monitor State/ District level Plan • Collect updated data / information and give feedback for reviewing/updating the State Action Plan and National Guidelines

[4] In the event of thunderstorm, power supply may further pose additional threats of electrocution

Investing in DRR–Non-structural measures			
5	Prevention, Mitigation and Preparedness measures	**Nodal agency: CoR/GSDMA/ULB/PRIs** (with other concerned Department/ Agencies)	• Inter-agency coordination and implementation of Central/ Statedirections • Implement assessment, preparedness and mitigation measuresand implementing • Review and update precautionary measures andprocedures • Public awareness and education for early warning response • Identify vulnerable places • Follow alerts/ warnings, advisories • Disseminate Do's and Don'ts for general public and enablethem to access safe places • Protect property/infrastructure and environment fromdamage from fire • Ensure strict adherence to fire safety norms • Ensure essential services and facilities at vulnerable places
		Information & Broadcasting Department/ CoR	• Establish public information facilities. • Set up alternative or emergency communicationsystems
		Energy & Petrochemical Department	• Ensure early restoration of electricity supply to essentialservices during emergencies and restoration of electric supply at the earliest • Ensure functional state of all electrical equipment and maintain the service or replace equipment from time to time
		Roads & Building Department	• Ensure quick restoration of road connectivity and access tovulnerable areas

		State/GSDMA/ COR/ Health Department/ District Admin	• Ensure appropriate medical staff and facilities at the placeof incident • Strengthen health centres with a network of paramedicalprofessionals • Ensure stockpiling of life-saving drugs, detoxicants, an aesthesia, and availability of Halogen tablets in vulnerableareas
		COR/ Ag. and AH Department	• Promote crop/animal insurance • Construct thunderstorm safe crop storage shelters for farmers
		Forest Department/UDD	• Ensure adherence to fire safety norms • Protect property/infrastructure and environment fromdamage by afire
6	Record of data and Documentation	**Nodal agency:** State /COR/GSDMA	• Assessment of damage from weather-related incidents • Collect post-disaster data from field and reporting to State/national level

Investing in DRR–Structural measures			
7	Structural Mitigation Measures	**Nodal agency:** Revenue Department /COR /GSDMA / UDD (with other concerned Departments/Agencies) DDMAs/LocalBodies	• Inter-agency coordination, and review and update precautionarymeasures and procedures to be followed • Ensure Building Byelaws are complied with and make it mandatory for all G+2and above buildings to install lightningconductors/ arresters • Promote installation of lightning conductors/arresters in schools,industries, Government and private buildings • Undertaken drives to check the structural strength of hoardingsand old structures
Capacity Development			
8	Capacity Building and Training	**Nodal agency:** State /COR/GSDMA/ GIDM (with respective state training/ DM institutes)	• Conduct training programme for all concernedofficials/volunteers • Conduct training programmes and drills on usage of various fireprotection equipment and preventive systems
9	Mass awareness campaigns and IEC activities	**Nodal agency:** State /COR/GSDMAs and Department of Information and Public Relations	• Extensive IEC campaigns to generate public awareness throughprint, electronic and social media • Ensure Push SMS by various telecom service operators toall active mobile connections

Annexure 1

Thunderstorm & Lightning: Do's and Don'ts

If at home or work

Preparation

- Look for darkening skies and increased wind.
- If you hear thunder, you are close enough to be struck by lightning.
- Keep monitoring local media for updates and warning instructions.
- Stay indoors and avoid travel if possible.
- Close windows and doors, and secure objects outside your home (e.g. furniture, bins, etc.).
- Ensure that children and animals are inside.
- Unplug unnecessary electrical appliances (to isolate them from the main power supply which mayconduct a power surge during a lightning storm).
- Remove tree timber or any other debris that may cause a flying accident.

Response

- Avoid taking a bath or a shower, and stay away from running water. This is because lightning cantravel along metal pipes.
- Keep away from doors, windows, fireplaces, stoves, bathtubs, or any other electrical conductors.
- Avoid using corded phones and other electrical equipment that can conduct lightning.

If Outdoor

Response

- Go to safe shelter immediately – avoid metal structures and constructions with metal sheeting.
- Ideally, find shelter in a low-lying area and make sure that the spot chosen is not likely to flood.
- Crouch down with feet together and head down to make yourself a smaller target.
- Hair standing up on the back of your neck could indicate that lightning is imminent.
- Do not lie flat on the ground; this will make a bigger target.
- Keep away from all utility lines (phone, power, etc.), metal fences, trees, and hilltops.
- Do not take shelter under trees as this conduct electricity.
- Rubber-soled shoes and car tyres do not offer protection from lightning.

If travelling

Response

- Get off bicycles, motorcycles or farm vehicles that may attract lightning.
- Get to a safe shelter.
- If boating or swimming, get to land as quickly as possible and take shelter.
- During a storm, remain in your vehicle until help arrives or the storm has passed (the metal roof willprovide protection if you are not touching metal inside); windows should be up; park away from trees and power lines.

Treatment

- Take the person who is struck by lightning to a hospital.
- If possible, give basic First Aid.
- People struck by lightning carry no electrical charge and can be handled safely.
- Check for broken bones, loss of hearing and eyesight.
- A victim of a lightning strike can suffer varying degrees of burn. Check the impact point and where the electricity left the body for injury marks.

Note: States may customize the contents of the Guidelines for their own use depending on their local experiences and best practices. Further action needs to be undertaken by respective State Governments.

Annexure 2

Format A: For reporting Thunderstorm, Lightning, Squall Dust/ Hailstorm and Strong Winds(District Report to State Government)

Name of the District:……..Period of Reporting:……..

S. N.	Name and address of affected persons(In case of Govt. office – organization name/department and place)	Age /Sex (M, F,TG)	Occupation (Farmer, Labourer, Seller, Student, etc.)	Category (BPL/ APL)	Date and time of Incident	Type(s)of Incident(s) (Thunderstorm, Lightning, Squall, Dust/ Hailstorm and Strongwinds)	Place of Incident (Indoor/ Outdoor /Rooftop /Field)	njured(Severe /Minor)	Deaths	House damaged/destroyed (Kutch a/ Pucca)	Crop loss (in Hect.)	Livelihood losses			Loss to Govt. Infrastructure /Assets	Total estimated cost of losses
												Livestock affected/ deaths	Kiosk /Shop	Others (Ag. Equip/ machinery, etc.)		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
	Total															

Other relevant information (if any):…….

Name:…….....……..Designation:…….....……..Signature with Date:…….....……

Submitted to :.....*.....

Format B: For reporting Thunderstorm, Lightning, Squall Dust/ Hailstorm and Strong Winds

(To be compiled at the State level and sent to the central Government)

Please **Tick** mark the Type(s) of Incident(s) (Thunderstorm, Lightning, Squall Dust/Hailstorm and Strong Wind)

Note: Please fill a separate sheet for each incident/disaster

State:…… Period of Incident (s):…… Date of Compilation:……

S. N.	Name of the district	Total Affected population					Injured			Total Human loss										Livelihood Losses				Private houses damaged/ destroyed(Kutcha/ Pucca)	Loss to Govt. Infrastructure /Assets/ property	Total estimated cost of losses
		Occupations groups					Severe	Minor	**Total**	Sex				Category			Place ofDeaths			Total livestock Loss (In Nos.)	Total CropLoss (In Hect.)	Kiosk /Shop	Others			
		Farmers	Laborers	Hawkers	Others	**Total**				Male	Female	TG	**Total**	BPL	APL	**Total**	Outdoor	Indoor	**Total**							
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
	Total																									

Other relevant information (ifany):…….

Name:…….....……..Designation:…….....……..Signature with Date:…….....……

Submitted to: ----------*----------

Format C: For reporting Thunderstorm, Lightning, Squall Dust/ Hailstorm and Strong Winds

(To be **compiled** by the Central Government)

S. N.	Name of the State	No. of affected Districts	Total Affected population					Injured			Total Human loss										Livelihood Losses				House losses (Kutcha/ Pakka)	Loss to Govt. Infrastructure / Assets/ property	Total estimated cost of losses
			Occupations groups					Severe	Minor	**Total**	Sex				Category			Place of Deaths			Total Animal Loss (in Nos.)	Total Crop Loss (In Hect.)	Kiosk /Shop	Others			
			Farmers	Laborers	Hawkers	Others	**Total**				Male	Female	TG	**Total**	BPL	APL	**Total**	Outdoor	Indoor	**Total**							
1	**2**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**
	Total																										

Name:…….....…….Designation:…….....……..Signature with Date :……..... .....……

Submitted to: ----------*----------

Acknowledgement

GSDMA wish to acknowledge the support of the National Disaster Management Authority for their support and advice, particularly for developing the action plan for Thunderstorm & Lightning/Squall/Dust Storm/Hailstorm and Strong Winds. We sincerely appreciate the valuable contributions by Indian Institute of Public Health (IIPH), Gandhinagar and State IMD for helping in developing the plan for Gujarat.

Government Central Press, Gandhinagar.