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# ADRiMP

*Association for Disaster Risk Management Professionals*

## ADRiMP Webinar Series on DRR

### Webinar on Lightning & Lightning Protection in a Nutshell



**This is an official publication of ADRiMP**

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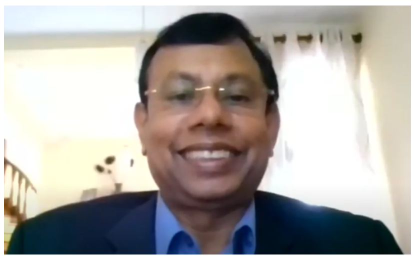
## Greetings and Wishes for a Productive and Resilient New Year 2021 from ADRiMP!

## ADRiMP Webinar Series on DRR: Webinar on Lightning & Lightning Protection in a Nutshell

On the 21st of November 2020, ADRiMP hosted in collaboration with the University of Huddersfield, its first Webinar as part of a series of webinars on DRR. The first Webinar had over 100+ participants, national and international, professionals in the field from countries such as Bangladesh, Nepal, and China, joining the session via Zoom, and more watching the livestream on YouTube.

The event started off with an opening message from Maj. Gen. Sudantha Ranasinghe, Director General - DMC, and proceeded onto the main topics delivered by leading professionals in the field of lightning and lightning protection. This issue of the ADRiMP Newsletter will feature a short summary of the important points that were discussed during the Webinar.



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# Summary of the Webinar on Lightning & Lightning Protection in a Nutshell

**Lightning Climatology by Dr. I. M. S. P. Jayawardena**

Thunderstorms are one of the most common and most noticeable weather events containing multiple dangers that can threaten safety, including heavy rain, lightning, strong winds and hail. As one of the most deadly weather related phenomena, lightning has a very wide spatial and temporal distribution. Lightning causes a number of fatalities in Sri Lanka each year, as well as significant economic losses. At least 50 persons in Sri Lanka are being killed by lightning each year. Consequently, understanding lightning climatology and their spatial and temporal variability provides important information for the general public, decision makers in disaster management, for improvement in nowcasting of lightning hazards, and for identifying and planning for lightning hazard mitigation.

The lightning density is defined as the number of lightning, including cloud-to-ground and intra-cloud lightning, over a unit area in unit time, to describe lightning activity. Annual average lightning density is calculated from GLD360 data from 2015 to 2018 (as shown in Figures 1.1 and 1.2) shows remarkable spatial variation, ranging from less than 20 strokes km-2 year-1 along the coastal areas except western and southwestern coastal areas, Jaffna Peninsular, and high elevation areas of central hills to more than 150 st km-2 yr-1 in the inland areas of western parts of the country. There are enhanced lightning densities along the western and southwestern foothills suggesting a link to the sea breeze and orographic lifting. The three hotspots of high lightning densities, indicated by rectangles in Figure 1.3, are found in north-central province (A), along western foothills of central hills exceeding 100 st km-2 yr-1 (B), southeastern foothills (C). The highest LD of more than 200 st km-2 yr-1 was observed in a small area of the western part of the island, Ruwanwella divisional secretariat division in Kegalle district. It is worthy to mention that higher lightning activity in the region depicted by A, is a major paddy cultivation region where people often work outside, and are involved in agriculture activities during day time and the possibility of becoming victims of lightning fatalities is high.

On average, 3,064,647 lightning counts per year were reported from 2015 to 2018 over Sri Lanka. Annual lighting occurrence is dominated by the First Inter-monsoon Season (March to April) contributing to 50%, and then followed by 25% from the Second Inter-monsoon Season (October to November) to annual lightning occurrence. Least lightning activity is found during the Northeast Monsoon (December to February). During the inter-monsoon period, as there is no predominant wind flow over Sri Lanka, prevailing variable light winds and convective activity associated with the formation of mesoscale circulations due to differential heating caused by horizontal variations in land surface characteristics, together with orographic lifting, contributed to account for ¾ of annual lightning activity in Sri Lanka. Peak lightning activity occurs between 15:30 to 17:30 local time (Figure 1.4) which is a common global feature. Lightning maxima in late afternoon indicates that most convective activity in Sri Lanka is associated with the land surface heating.

Through raising community awareness among people living in high lightning activity areas and taking proper measures, Sri Lanka will be able to mitigate the adverse effects of lightning-related hazards in the near future. Communities themselves must take some initiatives to reduce the damage caused by lightning. Further establishment of lightning detection systems for monitoring and early warning are essential to enhance disaster risk reduction in Sri Lanka.

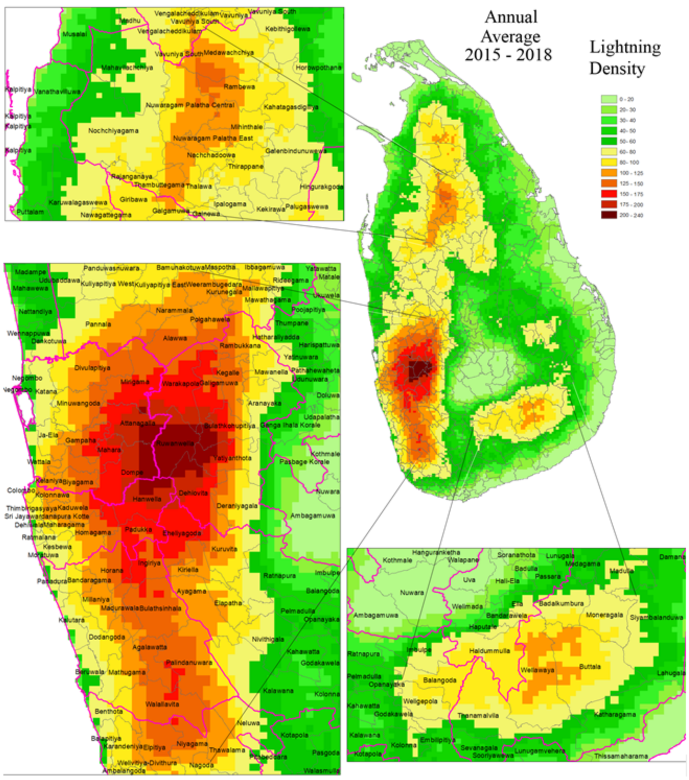



**Figure 1.1 Spatial Distribution of Annual Average (2015-2018) Lightning Density (st km-2 yr-1)**

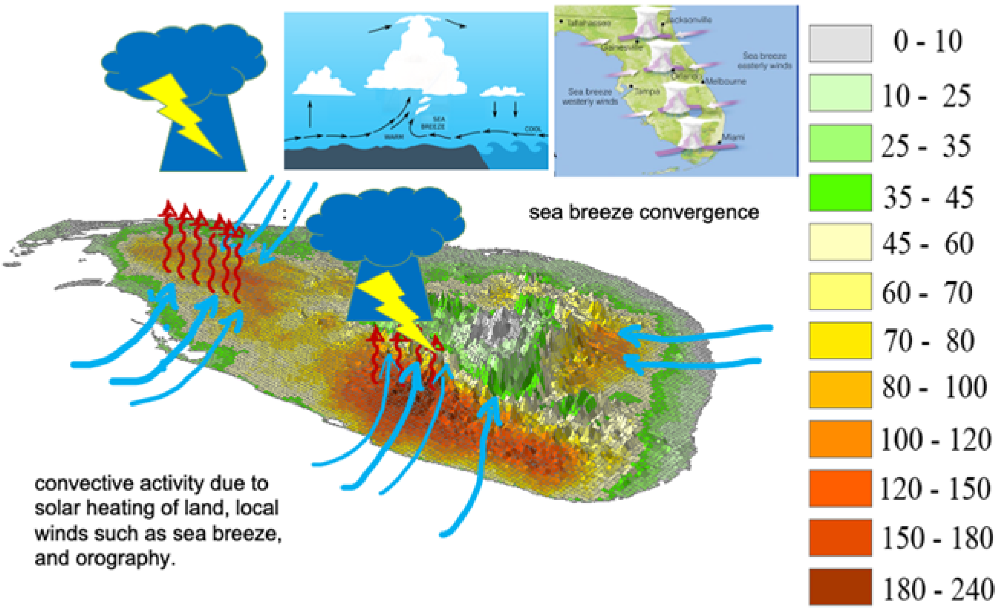



**Figure 1.2 Spatial Distribution of Annual Average (2015-2018)**

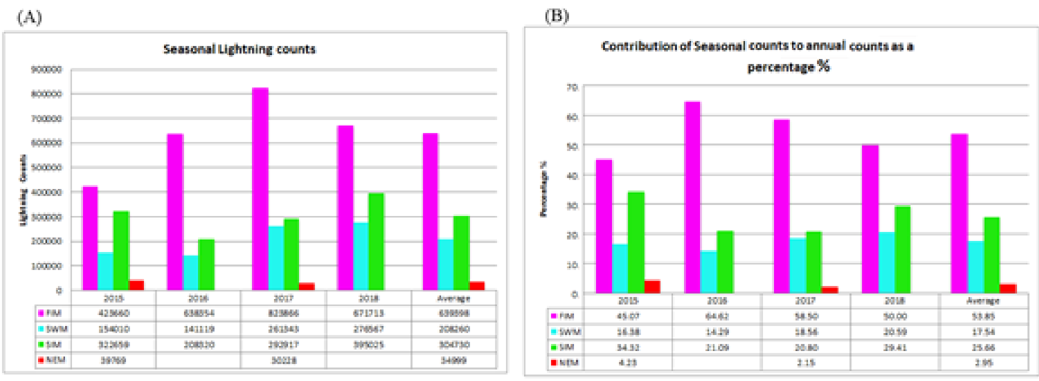



**Figure 1.3 Seasonal Lightning Counts (A) and Contribution of Seasonal Lightning Counts to Annual Total Lightning Count as a Percentage (B) from 2015-2018**

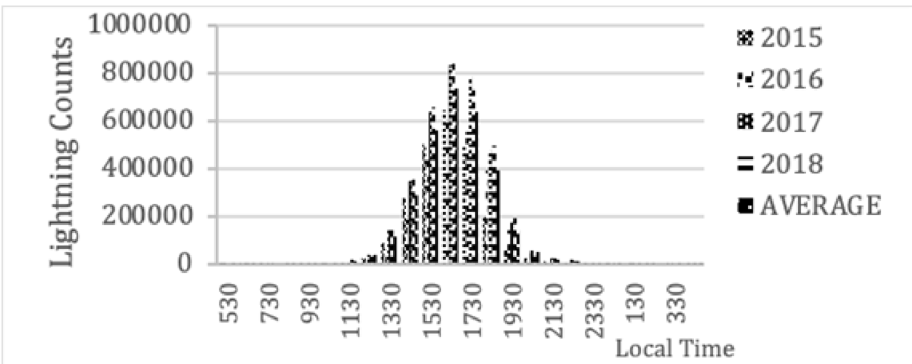



**Figure 1.4 Hourly Lightning Counts from 2015 to 2015 over Sri Lanka**

**Lightning Experience in Sri Lanka by Mr. K. R. Abhayasingha**

Lightning is essentially a giant spark of static electricity. It is known that lightning occurs in thunderstorms when there is a separation of electrical charge within the storm clouds, which can cause cloud-to-cloud lightning, the majority of lightning that occurs in a storm. A charge separation can also form between thunderstorm clouds and the ground, leading to classic cloud-to-ground lightning.

Most of the global lightning flashes are generated by Cumulonimbus (Cb) clouds which are charged during their development. With the influence of negative electrostatic charges at the bottom of Cb clouds, positive electrostatic charges are induced over earth's surface below Cb clouds. When the necessary physical conditions are fulfilled, electrostatic discharge (or lightning) takes place. Depending on locations of charge centers, lightning discharges are mainly categorized into three types. They are cloud flash, ground flash and air flash. The magnitude of electric current associated with a ground lightning flash could range from 3,000 – 200,000 amperes with an average of about 25,000 amperes (25,000 A or 25 kA) and the potential difference between a charged cloud and the earth is about 100 million volts (108 V). The energy of a lightning flash bringing 5 coulombs to the ground is about 500 million joules. It is this sudden discharge of an extremely large current and the voltages it induces that cause the damage from lightning.

**Natural Disasters Caused by Lightning:**

Since a lightning flash carries a huge electric current under large potentials, the significantly large amount of energy can cause destruction if the discharge is grounded through any object, human or animal. Final result of such an event may end up with property damage, wounds or death. A lightning flash can reach a point mainly in five ways. As a direct hit, or a side flash or a contact potential or a step voltage or as a surge transfer. Like rainfall, lightning activity in an area is significantly variable with the time and seasons. Therefore you cannot expect the activity, strength and intensity of thunderstorms to have similar characteristics all the time and every year. Development of thunderclouds, frequency and intensity of lightning etc. depend on a number of meteorological parameters and geographical parameters of a location. A lightning flash, after travelling a distance of about half a kilometer from clouds selects the closest conducting path to go to earth before getting neutralized. Therefore the tallest objects of a location are the best supporters for a lightning flash on its way to the ground. In a natural environment, tall trees are the lightning-attracters.

Otherwise conducting (metal) structures or objects (like communication towers, telephone and power supply lines and TV antennas) will attract close by lightning flashes. In absence of such objects, the buildings in the location are vulnerable to direct hit of thunderbolts. Weather experienced during a 12 month period in Sri Lanka can be categorized into 4 seasons as follow:

1. First Inter Monsoon Season: March - April
2. South West Monsoon Season: May - September
3. Second Inter Monsoon Season: October - November
4. North East Monsoon Season: December - February

Lightning activity over Sri Lanka shows peaks during two inter-monsoon seasons, March - April and October - November (Figure 1.5). During these periods convective clouds (Cumulonimbus) develop over most parts of the island mostly during the afternoon or evening. Since thunderstorms develop under any atmospheric conditions that are capable of developing convective clouds. We should be on alert and take precautionary steps to reduce lightning hazards during all seasons.

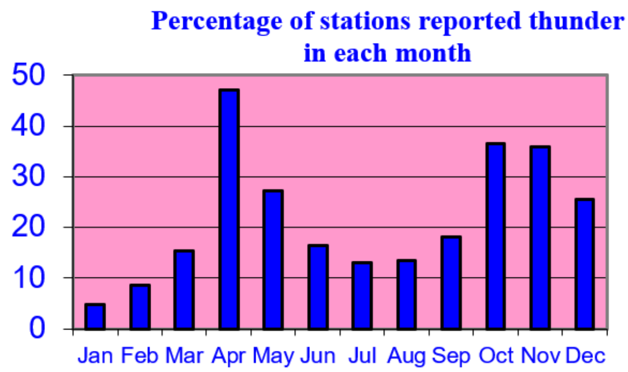



**Figure 1.5 Percentage of Stations Reported Thunder in Each Month**

**Precautionary Steps to Mitigate Lightning-related Disasters:**

If thunderstorms are forecasted, find shelter in a safe place to avoid exposing yourself to the open air. If the time interval between a lightning flash and hearing thunder is less than 15 seconds, move quickly to a protected location, as there is immediate danger of a there being a lightning strike nearby.

In environments with thunderstorms:
(a). Keep electrical instruments disconnected from the main power supply.
(b). Television antennas should be disconnected from the television sets and the antenna socket should be placed close to the earth outside the house.
(c). As far as possible, avoid handling/touching electrical instruments like refrigerators, electric irons, metal frames, TV, and radio.
(d). Avoid touching or standing close to tall metal structures, wire fences and metal clothes lines.
(e). Limit the use of (cable) telephones when a thunderstorm is overhead. Best advice is not to touch the telephone in such instances.

In environments with thunderstorms:
(i). Try to avoid loitering in open areas like paddy fields, tea estates or play grounds. Specially avoid working in open air, holding metal tools like knife and iron rods. If this cannot be avoided, crouch down, singly, with feet together. Footwear or a layer of any non-absorbing material, such as plastic sheet, will offer some protection against ground currents.
(ii). Do not seek shelter under or near isolated tall trees and in high grounds. If the vicinity of a tree cannot be avoided, seek a position just beyond the spread of the foliage.
(iii). By sitting down or lying down, reduce the effective height of the body
(iv). If in an open boat, keep a low profile. Additional protection is gained by anchoring under relatively high objects such as jetties and bridges, provided that no direct contact is made with them.
(v) Avoid riding horses or bicycles, or riding in any open vehicle such as a tractor.
(vi). Avoid swimming or wading.

## Lightning Protection Systems by Eng. Nuwan Kumarasinghe

### Introduction

Lightning is an electrical discharge caused by imbalances between storm clouds and the ground, or within the clouds themselves. Most lightning occurs within the clouds. Lightning is a leading cause of injury and death from weather-related hazards. Although most lightning victims survive, people struck by lightning often report a variety of long-term, debilitating symptoms. A lightning strike can exceed 100 million Volt Amps. Any grounded object that provides a path to earth will emit upwards 'positive streamers' or fingers of electrical charge. These create a channel of plasma air for the huge downward currents of a lightning strike. The high voltage currents from a lightning strike will always take the path of least resistance to ground. A lightning protection system (LPS) can protect a structure from damage caused by being struck by lightning by providing a low-resistance path to ground for the lightning to follow and disperse the huge lightning energy to the earth. In the absence of an LPS, a lightning strike may use any conductor of a structure as a path to reach ground, which could include metal parts of the building including reinforced iron if any, power and phone cables or other metallic parts of the structure. The main idea of a LPS is to be used as a safety tool for the occupants and the property of the building.

### Standards Used in Structural LPS

There are different lightning protection standards used in the world, in the past BS 6651, AS 1768, UL 96A , NFPA were the popular standards used in many countries but after the introduction of comprehensive International Electro-Technical Commission (IEC) standards, IEC 62305 or equivalent national or regional standards became the widely used lightning protection standards in the world. Standards used for structural lightning protection in different countries is give in the following table.

**Table 1.1 Different Structural Lightning Protection Standards**

| Country/Organization | Standard |
|---|---|
| **International Standards** - International Electro-technical Commission-IEC (95% of countries follow this standard or adopted versions of IEC) | **IEC 62305 1-4** |
| **Sri Lanka** (adopted from IEC 62305) | **SLS 1472 1-4** |
| **UK** | **BS EN 62305** |
| **India** (adopted from IEC 62305) | **IS IEC 62305, NBC 2015** |
| **Europe** | **EN 62305** |
| **Japan** (Building Standard Law of Japan and The Fire Fighting Law of Japan ) | **JIS A 4201 also use IEC 62305** |
| **USA** | **NFPA 780, IEC 62305** |
| **Australia** | **AS1768-2007 and IEC 62305** |
| **France** | **NF C 17-102** |
| **Spain** (adopted from NFC 17-102) | **UNE 21186** |
| **Bangladesh** | **BNBC , IEC 62305 also use NFC 17-102** |

It is advisable to follow IEC 62305 standards or its derivative national standards such as SLS 1472 standards for structural lightning protection systems.

**Lightning Protection Systems**
Lightning protection systems (LPS) comprises of:

a. Structural LPS
b. Earthing system
c. Equi-potential bonding system and surge protection system

Structural LPS is used to capture the lightning current by its air termination system whereas the down conductor system facilitates huge lightning energy to transfer to the earth through grounding or earthing systems. Separation distance has been calculated and kept in accordance with the standards. Surge protection system is used for equipotential bonding and to disperse surge current in to the earth. This is demonstrated in the figure below.

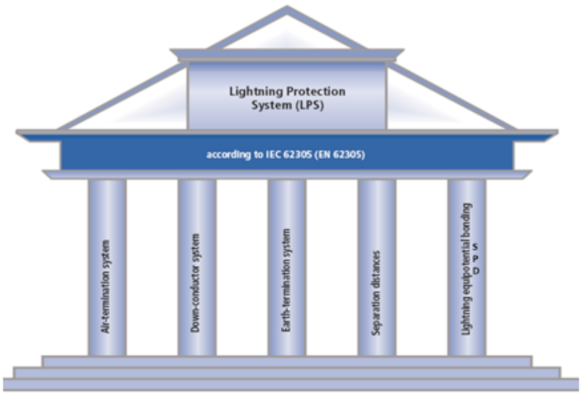



**Figure 1.6 Components of Structural LPS**

**Structural LPS**
Detailed risk assessment has to be done prior to the design of a LPS. Lightning flash density of the location, construction material type of the structure (e.g. concrete, bricks, steel framework etc.), number of occupants, importance of the building (e.g. mission critical location such as a TV or radio studio) are the main factors to consider for the risk assessment. Previous or historically reported lightning incidents, service line types (e.g. overhead or underground power lines) are also considered. A number of equations are used in IEC 62305 standards for the risk assessment calculations, therefore software tools are used at present to save time. Once the probability of lightning occurrence in the premises is more than the permitted value, LPS has to be installed depending on the protection zone or level. The zones are areas characterized according to the threat of direct or indirect lightning flashes and full or partial electromagnetic field (Figure 1.7).

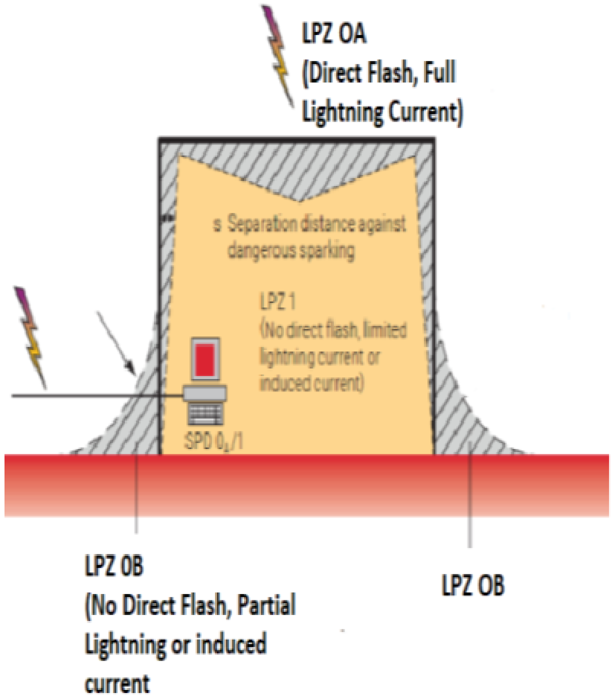



**Figure 1.7 Lightning Protection Zones**

Conventional air terminals are used as per the IEC 62305 standards. Normally copper, aluminium or G.I. type air terminals are used. An example of a vertical air terminal is given in Figure 1.8. The placement of the air terminals has been done using three techniques namely:

1. Rolling sphere method
2. Protection angle method
3. Mesh method

Respective radius (in case of rolling sphere), angle or mesh size depends on the class or protection applied to the structure. Air terminals can be vertical or horizontal and their main duty is the intercepting of lightning current. Air terminals are placed mainly on more vulnerable points of a building.

**Figure 1.8 Air Terminal**

**Down Conductor System**
Down conductor is connected from the air terminal to the earth terminal. Distance between each down conductor depends on the class of protection given.

**Earthing System**
Earthing system is used mainly to protect people and equipment from fault current. There are two main earthing systems used in LPS, as per the IEC 62305 standards:

1. Vertical or horizontal or combination of both
2. Ring earth or foundation earth

Natural components of the structure are used for earthing and it is advisable to pay attention at the foundation stage on earthing of the structure prior to construction. Structure with structural lightning protection system is shown in Figure 1.9.

**Surge Protection System**
Surge protective devices or SPDs are used to minimize damages due to transient overvoltage mainly due to lightning surge current or switching of large inductive loads as motors or nearby operations of welding plants where power fluctuates constantly, which cause damages to electrical or sophisticated ICT equipment. Transient surge voltages are short-term voltages, rises which last for microseconds, and which may reach several times the nominal system voltage. The best lightning and surge protection concepts will be ineffective unless it embraces every incoming electrical and metal service line entering the building. It is advisable to follow IEC 61643 or SLS 1473 standards for SPDs for all service lines. SPDs shall be applied in accordance with withstand capability values in a coordinated manner. This can be shown in Figure 1.10.

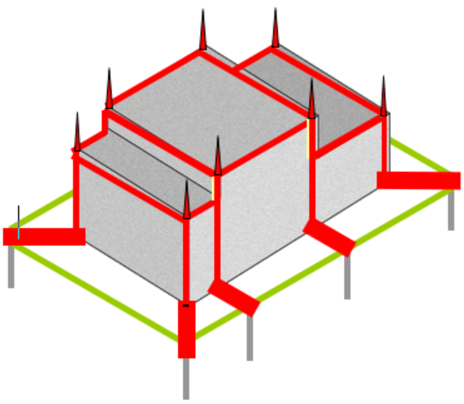


**Figure 1.9 Structural LPS**

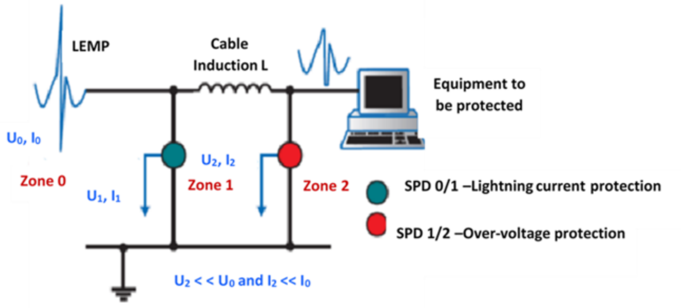


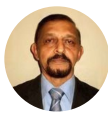

**Figure 1.10 Coordinated Surge Protection System**

SPDs shall be introduced to power, data or network, land phone lines, control and Radio Frequency (RF) cables such as antennas. When you install a SPD, it should be done in accordance with standards such as IEC 61643, SLS 1473, ITU-T (specially for communication lines). All installations should be done by a qualified professional who follows necessary standards.

## Webinar Speakers

**Opening Remarks by Maj. Gen. (Rtd.) Sudantha Ranasinghe** - Director General, Disaster Management Centre (DMC)

**Lightning Climatology by Dr. I. M. S. P. Jayawardena** - Director (Weather Forecasting), Department of Meteorology



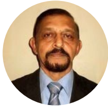
**Lightning Experience in Sri Lanka by Mr. K. R. Abhayasinghe** - Visiting Lecturer, Post Graduate Institute of Science (PGIS), University of Peradeniya, Former Director, Department of Meteorology

**Lightning Protection Systems by Mr. Nuwan Kumarasinghe** - ICT Consultant World Bank Project, Executive Committee Member of South Asian Lightning Network (SALNET), Former Chief Electrical Engineer, Department of Meteorology

## Programme Moderator

**Dr. Ananda Mallawatantri** - Country Representative, International Union for Conservation of Nature (IUCN), Sri Lanka, President of the Association for Disaster Risk Management Professionals (ADRiMP)

## Panel Discussants



**Mr. K. R. Abhayasinghe** - Former Director, Department of Meteorology

**Mr. K. H. M. S. Premalal** - Former Director General, Department of Meteorology

**Dr. I. M. S. P. Jayawardena** - Director (Weather Forecasting), Department of Meteorology

**Mr. Nuwan Kumarasimghe** - Former Chief Electrical Engineer, Department of Meteorology

**Mr. L. S. B. Karunaratne** - Deputy General manager, Sri Lanka Telecom

Thanks to all the participants who joined the Webinar, and special thanks goes out to all the resource persons, without whom this would not have been possible.

Stay tuned for more upcoming webinars organized by ADRiMP as part of ADRiMP's Webinar Series on DRR!

In case you missed the Webinar you can watch it on YouTube using the link below:

Link: https://youtu.be/hQ6PDIPui7Q

# Comprehensive Preparedness for a Community at Extreme Flood Risk: A Case Study from Sri Lanka

**by Dr. Buddhi Weerasinghe & Ms. Ganga Samarawickrama**

### Introduction

This paper describes an action research project undertaken to build comprehensive community preparedness for a worst-case flood emergency scenario. It recognizes comprehensive preparedness as community specific risk perception for a defined geographic boundary to achieve a desired level of safety through decisive action arrived at through an inclusive and participatory process involving stakeholders. The focus on biological hazards in Sri Lanka during flood impact is usually on water borne diseases and on Dengue. The Covid-19 outbreak demands a 'new normal'. Therefore, the authors consider that a comprehensive preparedness approach should be inclusive of safety measures to face such epidemics due to the likelihood of such outbreaks becoming more frequent (Global Risk Report 2019). Covid-19 belongs to the Corona family of viruses. Studies on co-infection with Dengue and Corona virus are sparse (Lorenz et al 2020). Difficulty in diagnosing and discriminating between symptoms of Dengue and Covid-19 has been reported (Chen et al 2020). This may lead to wrong diagnosis leading to the possibility of a Covid-19 spread (Yan et al 2020). Therefore, this paper is augmented with a brief description of Covid-19 'new normal' guidelines formulated to adhere to during shelter provision in flood emergencies with the threat of Covid-19 to ensure comprehensive preparedness.

### Materials and Methods

The process followed in implementation of the action research was aligned to the process advocated by the ISO 22320 of 2018 for emergency management.

### Situation Analysis

Devolved nature of Disaster Risk Management (DRM) in Sri Lanka follows its administrative hierarchy. The country is divided into nine provinces, constituted by 25 districts. Each district is sub-divided into several divisional secretariats, which are in turn divided into several Grama Niladhari (GN) divisions. The Ministry of Disaster Management has two national focal points, the Disaster Management Center (DMC) and the National Disaster Relief Services Center (NDRSC). The DMC has a 24 x 7 Emergency Operation Center (EOC) and a 24 x 7 Call Center 117. The DMC operates a District Disaster Management Coordination Unit (DDMCU) at each district secretariat which functions under the District Secretary. It coordinates activities within the district by linking with Divisional Secretaries (DS) of the relevant divisional secretariats and GN divisions. Officers of the NDRSC are positioned at the district and divisional secretariats. Each GN division is expected to form its GN level disaster management committee for ground level interventions.

Selection of the action research site was guided by the necessity to limit the intervention to a limited geographical area to reduce constraints of logistical arrangements within the project duration of six months.

Based on flood history and consensus of the DMC, DDMCU and NDRSC, a highly vulnerable GN Division was selected after consultation with the relevant District and Divisional Secretaries. Community consultation was carried out after selection of the research site. Convening the community was facilitated by the GN at the request of the DDMCU. Traditionally, such gatherings have taken place at the Buddhist temple and this was selected as the venue. The first consultation was represented by Buddhist priests, a local government representative, community leaders, members of flood affected households and youth. The consultation disclosed the need perception of the community.

A committee of volunteers was formed at the consultation, as there was no GN level disaster management committee. Community-based GIS database development of demography, vulnerability, capacity and flood risk of the Paragoda West GN division was carried out by training a group of youth who volunteered during the community consultation. Based on a detailed questionnaire and house to house visits, collated data were compiled into a database and validated at a later community consultation. Divisional secretariat level consultation was held to present the findings of community need perceptions and the GIS database findings for validation at the divisional secretariat with the participation of all relevant stakeholders. It was chaired by the DS. Consensus on possible interventions and responsibilities were arrived at during the consultation.

## Concept of Operations (CONOPS), for Working Together

CONOPS was adopted from FEMA 1996. The needs for preparedness to face potential consequences of the worst-case scenario were analyzed based on need perception, consultation outcomes and database findings. The adopted CONOPS followed the format depicted in Table 1.1. These were then used to identify operations (key actions) and the responsible stakeholders for their performance. Where relevant, details for the operation of identified activities were compiled as annexes. The rationale for this was to keep the CONOPS as a brief snapshot which is easily understood while providing a holistic image of the operational process to be undertaken. For key stakeholders, standard operating procedures (SOPs) were formulated. Implementation of identified activities followed the CONOPS.

**Situation Analysis**

⬇

**Preparedness Operations**

| Preparedness needs | Key Actions | Responsibility |
|---|---|---|
| Preparedness need 1 | Action 1– Details in Annex | Who does it |
| Other | | |

⬇

**Response Operations**

| Response Needs | Key Actions | Who Does It |
|---|---|---|
| Response need 1 | Action 1– Details in Annex | Who does it |
| Other | | |

⬇

**Recovery Operations**

| Recovery needs | Key Actions | Who Does It |
|---|---|---|
| Recovery Need 1 | Action 1– Details in Annex | Who does it |
| Other | | |

**Table 2.1 Structure of the CONOPS**

## Findings

The GIS database compiled data categories for demography, building and housing, utilities, income, livelihoods, agriculture, Small and Medium Scale Enterprises (SMEs), disaster history, affected housings, and impact on crops.

**Demography:** The project area covered 4.14 sq. km. The total population was 1133 persons with 49.9% males and 50.1% females. The age group of below 15 years was 21.4% with 11.4% male and 10.1% female. Age group from 15 – 60 years was 61.9% with 32% male and 29.9% female. Above 65 years age group was 16.7% with 6.5% male and 10.2% female. The life expectancy of females appeared higher. This is a national trend (World Bank 2018a). The age-dependency ratio was above 60% and was higher than the national value of 53.07% for 2018 (World Bank 2018b). The higher the ratio, higher is the vulnerability because of the higher number of people dependent on those in the working age group.

**Housing:** Out of a total of 315 households, 291 were single story and 24 were double story. 303 houses were built with permanent construction material. 97% of the houses had electricity supply. There was no pipe borne water from the Water Board.

**Educational Achievements of the Community:** 21.45% of the population were school children. 12.9% had up to primary level schooling, 15.98% up to 8th grade, 30.7%. The major segment of the population had undergone schooling up to grade 11 (30.10%), followed by grade 8 achievers (15.98%) and primary attendees (12.89%) in that order. There appeared to be more women participation beyond grade 11. University graduates were only a few. The small segment of vocational trainees was dominated by males.

**Livelihoods:** Unemployment was high (44.3%) with more women in that category. Providing labour appeared to be the major livelihood option (27.2%), followed by private sector employment (15.06%), government employment (3.67%) and self employment (4.3%) in that order. This pattern of livelihoods may be related to the educational achievements of the community. There were seven small scale groceries. Small holder farming of tea, rubber and paddy was limited to land owners. Income of 71.6% of households were below the national poverty line of $3.20 per day for lower middle-income countries. Of the 315 households, 101 households were beneficiaries of the government poverty alleviation program.

**Climate, Topography and Hydrology:** The area receives rain from two monsoons: south-west monsoons during May-July, the north-east monsoons during November-January. Inter-monsoonal rain is also received. Average annual rainfall varies between 3000-6000 mm without a distinct dry period. Locals believe that it rains 300 days of the year. The Kukule River, which is a major mid-basin tributary of the Kalu River runs along the border of Paragoda West. The river originates at an elevation of 2000 m above mean sea level (AMSL). The catchment area is characterized by undulating topography with medium steep ridges and valleys. The upstream Kukule Ganga Dam is a 110 m run-of-river-type gravity dam built across it. The dam feeds an underground hydroelectric power station. River flow is monitored by the Millakanda river gauging station operated by the Irrigation Department downstream of Paragoda West.

**Hazard Profile, Vulnerability and Risk:** Community consultations revealed historical hazard impact. 65.7% of the houses had been impacted by floods, 3.5% by landslides and 0.3% by high winds respectively. There were no records of post-flood epidemics. Flooding was a major concern. Significant flooding has been observed after 2002. The study area is at an elevation less than 10 m MSL and there is a natural flood vulnerability in the area in the event of intense precipitation on the upper catchment (EMAC 2015). The community believed that dam construction in 2002 has increased flood vulnerability of the area, a view that was denied by the reservoir management. The community perception was that opening sluice gates during increased waterflow from the upper catchment causes inundation. There was anger that no early warning is given prior to opening of sluice gates. An Environmental Impact Assessment (EIA) for a second mini hydropower plant upstream of Paragoda West had studied potential emergency discharges from Existing Kukule Ganga Dam and had suggested that if all the sluice gates of the Kukule Reservoir are opened at High Flood Level (HFL), an artificial flood of more than 100 years would be created downstream (EMAC 2015). The construction of this second mini hydro plant had been abandoned due to protests of resident communities downstream based on the fear of further increase in flood vulnerability. The situation analysis could only infer that although sudden releases from the dam without warning could lead to increased flood vulnerability, intense rainfall on the upper catchments of Kukule River appeared to be the root cause.

**A Worst-case Scenario**

On 25th May 2017, the upper catchment of Kukule Ganga received nearly 553 mm rain in about 24 hours, nearly 1/6th of the average annual rainfall. After nightfall, an extreme volume of water rushed downstream across the open sluice gates of the Kukule reservoir and inundated the downstream area. The flood level at Paragoda West rose above the street lamp posts. 174 of the 315 houses were fully inundated. The village school and a few houses located on higher elevations harbored the community members rescued by village responders. It was revealed that villagers refused to vacate homes for fear of looting. This caused many to be marooned after flooding. There was also a hesitancy to come to the school shelter due to minimal conveniences available. Many sought refuges in neighboring houses causing mutual discomfort. Inundation of roads made the GN division inaccessible for ten days with no relief distribution. The Navy boats that were deployed were unable to navigate as the lamp posts and vegetation were under water. Boats that attempted to access the village, got entangled with tree canopies and Navy officers having to chop the inundated canopies to free them. Others' boats had hit inundated roofs. Food, water and Non-Food Items (NFIs) were scarce. Despite these odds, there was a feeling of pride in the community that it was able to prevent any deaths. There was animosity that no early warning was given before opening the sluice gates of the dam.

When the water receded, all crops were found to be covered by the sediments except Rubber. Efforts to recover the crops were unsuccessful.

**Outputs**

## CONOPS

CONOPS depicts the process and strategy involved in preparing for, responding to, and recovering of the Paragoda West community from flood impact. The CONOPS framework is given below in Table 1.2.

**Table 2.2 Formulated CONOPS**

| Preparedness Operations | | |
|---|---|---|
| **Community Preparedness needs** | **Key Actions** | **Responsibility** |
| Comprehensive data for response and recovery by DS | Compilation of a GIS Database (Details of process were given in an Annex). | Project +<br>the community |
| Enhanced Early Warning for<br>River Overflow and Sluice gate opening of dam | Establishment of a mechanism to reinforce early warning received from Emergency Operations Center (EOC), Colombo, with communication from Kukule Dam and Millakanda River Gauge Station. (Details of process were given in an Annex). | DDMCU + DS |
| Real-time communication by Divisional Secretary (DS) | Establishment of a VPN network with nodal points, GN and selected community leaders. | DS |
| Early warning reach for all households | Establishment of a mechanism for community-based early warning (Details of process were given in an Annex). | GN +<br>GN division Disaster Management Committee |
| Upgraded School to serve as a self-contained Evacuation Center | Obtain approval from Ministry of Education to upgrade school facility.<br>Positioning of store room and kitchen space.<br>Positioning of NFIs. | DMC<br>Project<br>Project + NDRSC |
| Positioning of Dry Food for community cooking, prior to Inundation | Reach agreement with Cooperative Stores to provide stocks of dry-food with flexibility to return unused items.<br>Cost reimbursement using daily allowance for displaced persons. | DS<br>NDRSC |
| Agreement to position a motor boat at the school for search and rescue<br>Position a mechanism for boat navigation during extreme inundation | Provide boat at the shelter point prior to road inundation.<br>Hoist flag poles with luminescent flags on street lampposts | DS + DDMCU<br>Project +<br>Electricity Board |
| Provide alternative energy source to the shelter point. | Position electricity generator at the school | NDRSC + DS |
| Position river flow gauge in the river near the village for community awareness | Fix river flow gauge near village | DMC + Department of Irrigation |

| | | |
|---|---|---|
| Awareness creation, provision of relevant training & capacity building | Provide training:<br>On the use and updating of GIS Database for Divisional Secretariat staff and community youth.<br>First Aid.<br>Camp Management.<br>Conduct mock drill for evacuation and camp management. | Project<br><br>Project + Red Cross<br>Project + NDRSC<br>Project + DMC + NDRSC |
| Facilitating Household Preparedness Business continuity | Prepare guidelines for household and business continuity preparedness. (Details were given in an Annex).<br>Explore feasibility of a floating store house to safeguard assets (Details were given in an Annex).<br>Facilitate loan scheme to build an upstairs floor for single story houses. | Project + NDRSC<br><br>Project + private sector sponsorship<br><br>GN + DS |
| | ⬇ | |
| | **Response Operations** | |
| **Community Response Needs** | **Key Actions** | **Who Does It** |
| Carrying out end-end Early Warning | Reinforce early warning received from EOC, Colombo, with communication from Kukule Dam and Millakanda River Gauge Station. (SOP given in Annex)<br>Dispatch early warning via VPN to Local Government nodal point, GN and selected community leaders<br>Convene Divisional Disaster Management Committee<br>Operationalize dry food stocking at shelter point<br>Position boat at shelter point<br>Implement community-based early warning (SOP given in Annex).<br>Convene Paragoda West Disaster Management Committee to implement camp management<br>Monitor river flow gauge and inform GN | DDMCU / DS<br><br>DS<br><br>DS<br><br>DS + GN + Camp management sub committee<br>DS + DDMCU + Camp management sub committee<br>GN + Camp management sub committee<br>GN<br><br>Community |

| | | |
|---|---|---|
| Evacuation | Dispatch evacuation order received to GN and community leaders (SOP given in Annex)<br>Disseminate Evacuation order to Households (SOP given in Annex)<br>Mobilize volunteers to assist Navy boats<br>Roll out evacuation<br>Operationalize camp management arrangements | DS<br><br>Grama Niladhari + Community Disaster Management Committee |
| Response and Search & Rescue | Provide relief material to households not evacuating<br>Rescue persons marooned in flood areas | Navy boats + volunteers |
| | ⬇ | |
| | **Recovery Operations** | |
| **Community Recovery needs** | **Key Actions** | **Who Does It** |
| Rapid Need Analysis | Within 3 days of the flood disaster carry out a Rapid Need Analysis (RNA) using the RNA template to be forwarded to DS | NDRSC |
| Rehabilitation of households | Cleaning households & wells. | Community + NGO |
| Compensation for Loss & Damage | Compensation for Damaged houses, crops and micro enterprises (Details in Annex) | NDRSC / DS / GN |

### Status of Achieving Operations

The GIS Database was compiled, validated at a community meeting and handed over to the NDRSC officer at the Divisional Secretariat. GIS training of 3-days duration was provided for nominated officers of the Divisional Secretariat, selected community youth and representatives of NGOs. Early Warning was reinforced when the Divisional Secretary integrated Paragoda West community leaders into an existing VPN used to communicate Early Warning. This also integrated the Engineer in charge of Dam operations, the Millaknda river flow station and the DDMCU to ensure Early Warning with prior notice of sluice gate opening. A community based Early Warning mechanism was tested out using a loudspeaker mounted on a three-wheeler triggered by the GN on receipt of communication from the DS. River gauge positioning is under the jurisdiction of the Irrigation Department, and DMC is pursuing its materialization. Upgrading of the school as a displaced camp was carried out by positioning a store room and a kitchen using converted containers provided by a private company on a no-profit basis. This was facilitated by the Ceylon Chamber of Commerce. The school compound was enlarged by cutting away slopes and using the soil for filling and levelling the compound. Part of the NFIs for the store room, were provided by the NDRSC. These included mosquito nets for protection against mosquitos. The rest were procured by the project including mosquito coils for day use.

Water and sanitation improvement were undertaken by the NDRSC. Positioning of dry rations for community cooking was agreed to by the Divisional Secretary and the stocking of food rations is to take place prior to floods under the supervision of the GN. Negotiations would be done to return the unused rations. The payment would be taken over by the NDRSC from the daily food allowance of Rs. 300.00 per displaced person (NDRSC 2020). Transport arrangements would be put in place by the DS and DDMCU through the positioning of a boat at the school after Early Warning. Several community members previously trained by the Navy for boat handling volunteered to be available for operation of the boat. Flag poles to be hoisted on lamp posts for navigation of boats were prepared but their hoisting had to be done by the electricity board. Although the engineer in charge agreed in principle to facilitate it, the task appeared to be beyond their work mandate and the hoisting is pending. Energy supply was put in place with the help of a electricity generator provided by the NDRSC. Awareness, capacity building and training was carried out in First Aid, camp management and evacuation.

First Aid training was conducted to volunteered community members. There was higher participation by women. Camp management training was conducted to staff of the Divisional Secretariat, community members and participants from NGOs. A brainstorming session was held with camp management sub-committees and written guideline were given on the expected roles they were to play. Evacuation training was provided through a mock drill. Staff of the DDMCU and community volunteers carried out house by house visits to explain to households what to do after Early Warning. An evacuation drill was conducted with community based Early Warning. Community cooking was undertaken. The sub-committees for camp management were active and visible to the evacuees during the drill.

SOPs for emergency management were formulated for DS, DDMCU and GN and validated with stakeholders. Household preparedness and business continuity preparedness was discussed at a community gathering and written guidelines were provided. Floating store house – The community wanted to try out a floating store house for protection of household and movable business assets during flooding. This was done by building a floating platform using wooden structure positioned on empty plastic barrels. A private sector organization donated the barrels. Lightweight materials were used to construct the storehouse. The store house can be dismantled during non-flood times and stored to open up the space occupied. The store was to float up guided by 4 pillars. However, the projects funds could not be used for construction and the completion of the pillars is pending sponsorship.

A possible loan-scheme to build an upper story for single story houses mooted at the consultation with the Divisional Secretary was agreed to in principle but may take a long period of time for the scheme to materialize. A Rapid Need Analysis (RNA) template has been drafted by NDRSC and the project team participated in the discussion that followed to amend and finalize it. Rehabilitation of inundated households is already practiced by the community and it includes cleaning of inundated wells. No project intervention was directed for this. Risk insurance for disaster losses is implemented through the National Insurance Trust Fund (NITF), since 01/04/2016. Community awareness was lacking. The insurance cover lives and properties, specifically all households and small business establishments (any business of which annual turnover does not exceed LKR 10 M) up to 2.5 million rupees each in respect of damages (per event) caused to their property and contents due to Cyclones, Storm, Flood, Landslide, Tsunami and any other similar natural perils, excluding Drought. Death compensation amounts to Rs.250,000.00 (NDRSC 2020).

The Agriculture Insurance Board covers registered farmers affected by natural hazards for selected crops (The Report: Sri Lanka 2020). Awareness was created on these risk transfer mechanisms and the usefulness of the compiled GIS Database positioned with the Divisional Secretariat to validate losses to award compensation.

## Conclusion

The project has brought all stakeholders together for disaster preparedness of Paragoda West GN Division and put in place a self-contained shelter facility and capacity to face consequences of a flood event of the magnitude of the worst-case scenario. It had gone beyond the formulation only of a plan and established a tangible systems approach for the flood safety of the community. Project work of this nature involving government entities need a longer time period than six months due to slow administrative processes to obtain approval. Carrying out any work within a school premise had to be authorized by the Zonal Director and the Provincial Director of Education. Continued motivation of the community demanded quick visible results. The slowness of putting visible project interventions on the ground, resulted in a noticeable waning of interest in the community.

On a positive note, the project created a team of champions of men, women and youth in the community, who continue to seek completion of the pending operations. Women were more active both in participation for training and camp management sub-committees. This may be due to time availability of many unemployed women. The floating store aroused much interest, and appeared to be a viable solution for the post Covid-19 era (where the virus is projected to become endemic), to face extreme events of a similar nature to the worst-case scenario. It would be a desirable area for future interventions.

## Post-Covid-19 Enhancement

The 'new normal' after the Covid-19 pandemic demands enhancement of the processes put in place by the project. The process of consultation must follow the recommended social distancing guidelines. This may require venues with sufficient space and appropriate seating arrangements. It may also require a reduction of participants to allow this. Covid-19 belongs to the Corona family of viruses. Dengue infections escalate with the monsoons. Studies on co-infection with Dengue and Corona virus are sparse (Lorenz et al 2020). It is important to note that difficulty in diagnosing and discriminating between symptoms of Dengue and Covid-19 has been reported (Chen et al 2020). This may lead to wrong diagnosis leading to the possibility of Covid-19 spread (Yan et al 2020). Therefore, shelter points need to have quarantine space and a mechanism for urgent screening of suspected patients. The need to maintain social distancing and the necessity to have a quarantine space to separate any suspected persons of infection may limit the space available in the school and may become inadequate.

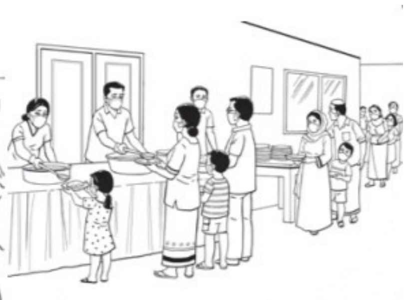
Sheltering evacuees in host houses may not be judicious as it may put both the hosts and evacuees at risk of infection. Therefore, alternate shelter points need to be identified and families made aware of where to evacuate. The shelter points may need more time to reach. Therefore, evacuation must take place immediately with early warning and this may need enforcement of compulsory evacuation. The existing practice of evacuation at the last moment has to be discarded. To ensure safety and protection of women and children and to ensure social distancing, families must be advised to evacuate as family clusters keeping distance between family clusters. Advocacy to carry personal cup, plate and towel for personal use with other recommended items is desirable during evacuation. Screening of evacuees as advised by the health authorities must take place at registration before entering the shelter. Camp management sub-teams must wear protective equipment until the screening is over. Occupation inside the shelter must be as family clusters to maintain social distancing and to ensure safety of women and children. Food and relief distribution must avoid crowding and must be orderly maintaining social distancing.

Evacuees must avoid crowding near toilets. Formation of an orderly queue is desirable. It must be emphasized to wash hands before and after toilet use. The virus can spread through fecal matter. Advocate the careful disposal of children's' feces. Inform to avoid spitting within the premises. Virus can be transmitted through spit. It is necessary to make evacuees aware of the prevention and mitigation measures advocated by the WHO (2020).Perform hand hygiene frequently with an alcohol-based hand rub if your hands are not visibly dirty or with soap and water if hands are dirty; avoid touching your eyes, nose, and mouth; practice respiratory hygiene by coughing or sneezing into a bent elbow or tissue and then immediately disposing of the tissue; wear a medical mask and perform hand hygiene after disposing of the mask; maintaining social distance (a minimum of 1 meter) from persons with respiratory symptoms.

**Screening Evacuees at Shelter Point Registration**

**Evacuation as Family Clusters**

**Family Clusters Inside**



**During Food Distribution**

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