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VIDURAVA

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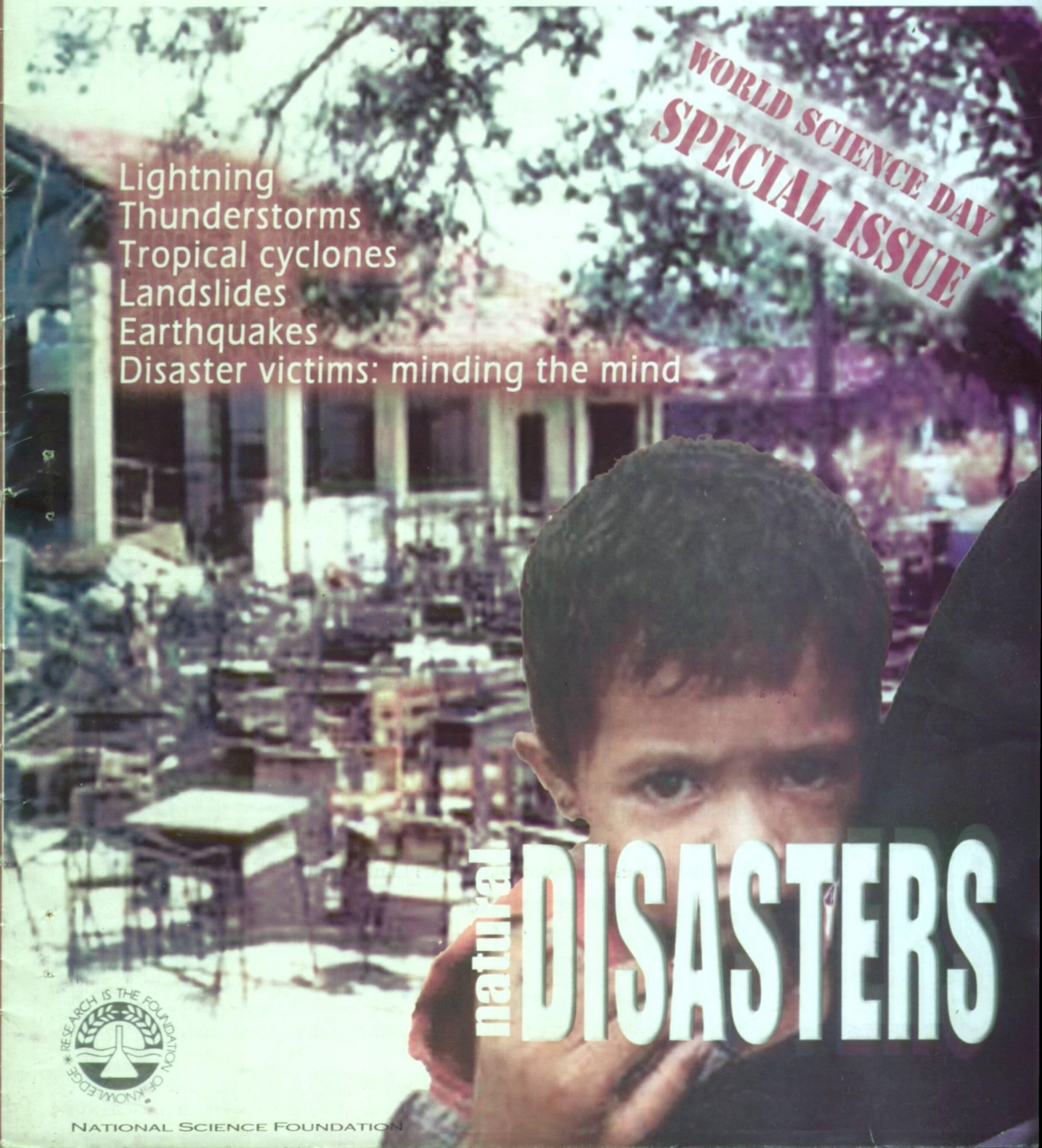

WORLD SCIENCE DAY SPECIAL ISSUE

Lightning
Thunderstorms
Tropical cyclones
Landslides
Earthquakes
Disaster victims: minding the mind

natural DISASTERS

RESEARCH IS THE FOUNDATION OF KNOWLEDGE

NATIONAL SCIENCE FOUNDATION

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VIDURAVA

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Editorial

November 10th

At the 31st Annual Session of the united Nations Educational Scientific and Cultural Organization, popularly known as UNESCO, held in Budapest, Hungary in 1999, a significant, far reaching proposal was brought forward. The outcome was to announce 10th of November as the World Science Day for Peace and Development.

UNESCO endorsed this proposal for a reason. They recognized that science has a special role to play in sustaining peace and development in the world. The proposal to assign November 10th, as the World Science Day was in keeping with the UNESCO charter to promote peaceful and sustainable development in member countries.

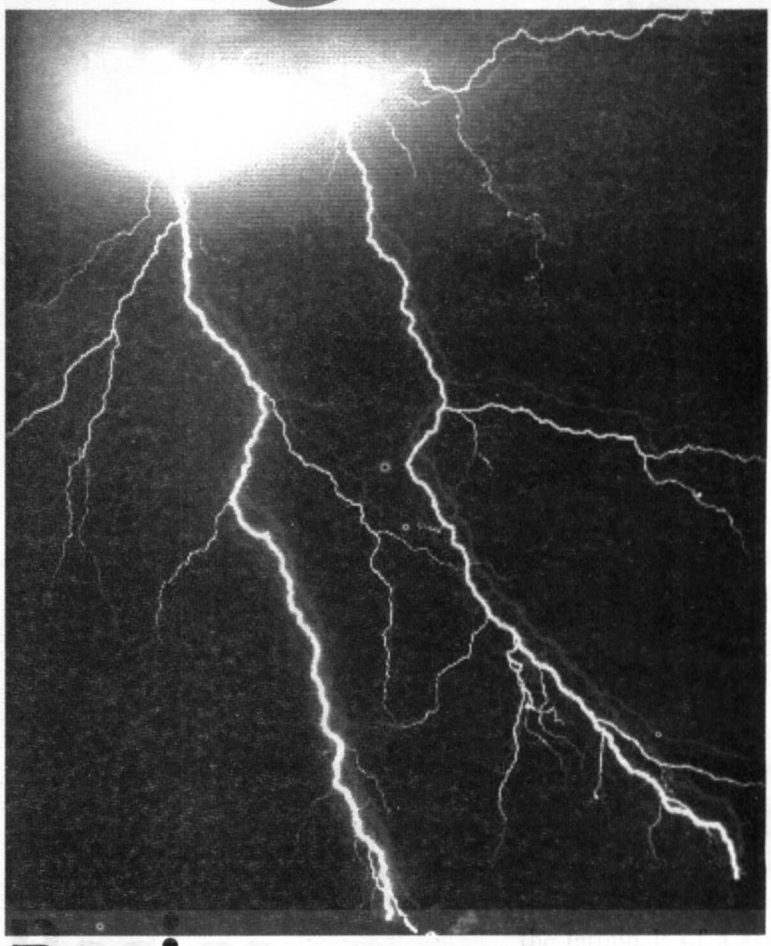
The main aim of the world Science Day for Peace and Development is to renew the national and international efforts to utilize science for peace, development and general welfare of the society and to do so with great sense of responsibility. In the words of the UN charter, it reaffirms *'the crucial contribution of science to the promotion of social progress and better standards of life in larger freedom, including freedom from the scourge of war and conflict.'* Raising the awareness of the general public on the importance of science in every day life and narrowing the gap between the society and science were some of other aims.

For a developing country like ours, these goals are timely and appropriate. We have never had the capability to face wide scale natural disasters, apart from small scale floods, landslides and droughts. We went about with the nation that we are immune from such disasters! That is why, as a nation, we were in turmoil when the tsunami hit us on that fateful day of December 26, 2004. We still look at natural disasters with shock and deep sadness. Yet, we cannot escape them. We need to arm ourselves with scientific knowledge about natural and other disasters. We need to inculcate into us, knowledge and skills based on science, ways of saving lives and minimizing the damage from these disasters. Knowing how natural disasters occur alone is not going to save lives or property.

The challenge faced by our scientist and associations engaged in popularizing and propagating science today, is to instill in to the public not only the knowledge, but also the skills and attitudes required to face natural disasters effectively.

This effort by the 'Vidurava' and the National Science Foundation is giving priority to this need of the hour.

Lightning



Basics, Safety, and Protection

The glazing momentary brightness followed by the monstrous bellowing that occurs naturally in the atmosphere is termed lightning and thunder. It was treated as a powerful divine deity by the people of many civilisations for thousands of years. For an example, ancient Greeks believed that a Cretan called Lasios was struck by lightning hurled by zeus for attempting to ravish Demeter, the goddess of Com. According to the Vedic mythology of India, Indra, the god of earth, conquered innumerable human and demon enemies, and killed the dragon Virtra, who had prevented the monsoon from breaking, by means of the power of lightning and thunder.

It is apparent that people of these ancient civilisations knew that lightning possesses a massive power that is beyond their comprehension. The lightning and thunder gods still continues in the popular beliefs of Eastern Europeans as St. Elijah, of Latin Americans as Santiago and of Nigerian Yoruba tribe as Shango, the thrower of thunderbolts. In Sri Lanka too, there are many beliefs and folk stories related to lightning although our people do not worship lightning in the capacity of a god. The ways that people look at lightning as a phenomenon are sometimes beneficial for them to have protection from lightning while in some cases they are extremely hazardous.

As a number of persons have been killed and millions of Rupees worth properties including very expensive electronic equipment were destroyed during the last few years in Sri Lanka due to lightning, now it is a good time for us to look at the basic concepts and safety of lightning.

What is lightning ?

A lightning flash originates inside a cloud, several kilometers above the ground level. Except for ball lightning, which is a very rare phenomenon that we will discuss later, lightning is simply an electric spark between a cloud and ground, between two clouds or between two parts of a cloud. The spark that jumps between the ends of two wires, which are connected to the terminals of a car battery, is a very basic form of lightning.

Lightning has been reported to occur in various types of clouds, in smoke emission of volcanic eruptions, in sandstorms, in the dust-mushroom created by nuclear explosions etc. Howèver, in tropics lightning is basically associated with a special type of cloud named Cumulonimbus cloud is given in Figure 1. A large source of positive charge is located towards the top of the cloud while a similar negative charge source is located at the lower part. At the cery bottom a small positive charge pocket is located.

When the breakdown stress between the negative charge source and the positive charge pocket exceeds a certain

limit a sparking takes place between the negative charge centre and the positive pocket, thus forming a conducting

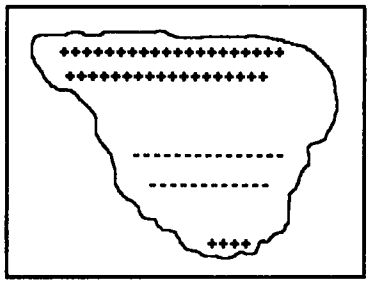


Figure 1: A simple charge structure of a Cumulonimbus Cloud. A large positive charge source at the top; Similar negative charge towards the lower part and a small positive charge pocket at the bottom.

channel. Sometimes when the negative charge source is sufficiently large the so about 10^5 m/s. This channel is termed the stepped leader. When the stepped leader is about 50 - 100 meters above, earthbound objects in the vicinity (eg. trees, buildings, human beings, animals etc.) start sending upward channels of opposite charge to meet the downward channel from the cloud. One of these upward channels succeeds in meeting the downward channel first. Subsequently a large current will flow through the object, which takes the earth potential to cloud (bringing negative charge into ground) is termed the return stroke is followed by several leaders that come along the already formed channel, without stepping, They are termed dart leaders and each of them is number of times. This gives the flickering effect of a lightning flash, The combination of the stepped leader, return stroke, dart leaders and subsequent strokes is termed a lightning flash. A lightning flash lasts for about 0.5 seconds. The above description is diagrammatically shown in Figure 2. In the first return stroke the current drained into ground has a typical peak current of 30 kA, however extreme values of over 250 kA have also been recorded. The inrush of this large current along the channel raise the atmospheric temperature up to about 40,000 K, which is almost 8 times greater that the temperature of the surface of the sun.

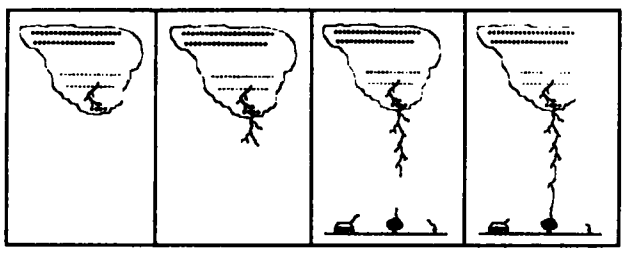


Figure 2 : The breakdown initiated inside the cloud sends a negative stepped leader which will be followed by a return stroke.

The lightning described above is called a negative ground flash as it brings negative charge to ground. Sometimes the channel may come from the upper positive charge centre which is termed a positive ground flash (Figure 3). They drive larger currents into earth than their negative counter part. Records reveal that the peak current of a positive lightning may be as high as 500 kA. They contains long continuing currents which have values over 1 kA flowing for a long period (Several hundreds of milliseconds). These long lasting currents may cause forest fires and severe explosions. Fortunately the percentage of positive lightning in tropics is only about 5% of the total ground flashes.

Except in the cases of aviation industry and high altitude in installations nobody paid attention to the protection against cloud flashes, until the development of digital communication. Cloud flashes generate bursts of pulses which are very similar in temporal characteristics to that used in date line communication. Therefore, they can

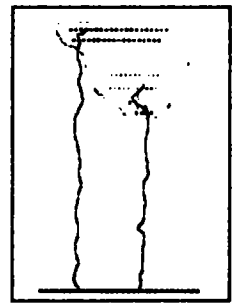


Figure 3 A positive lightning that emerges from the upper positive charge source and a negative lightning that comes from the negative charge source.

generate wrong information in such systems. Cloud flashes may occur within the cloud (intra-cloud flashes), between two clouds (inter-cloud flashes) or from cloud to air (cloud-to-air discharges). The Figure 4 depicts the three types.

If the number of branches at the ground termination is large then the lightning is termed "Fork Lightning". A recent study in Florida reveals that more than 60% of the ground flashes have multi-point ground terminations.

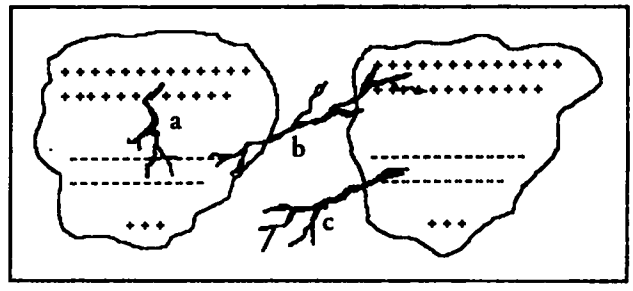


Figure 4 : There types of cloud flashes
a. Intra-cloud flash
b. Inter-cloud flash and
c. cloud to air discharge

How does lightning cause damages ?

Lightning may cause damages to people, buildings and equipment in three ways. If a person or a building is a tall protrusion in a certain landscape, it may be the object that sends the first upward channel that meets the downward stream of charge from the cloud. When a building attracts a downward lightning leader (direct strike) or attract a part of a lightning flash that hit another structure in the near proximity (side flash), it will get the maximum damage (Figure 5). The enormous current involved with the lightning flash may destroy the entire power and communication networks in a building including all the equipment connected to the networks. The high temperature resulted by both the current that flows in the lines and the sparks that jump in between different parts of the building may trigger fires that will completely burn out the installation. Direct lightning (or side flashes) cause damages at a very rapid rate so that once a building is lightning struck, it is very unlikely

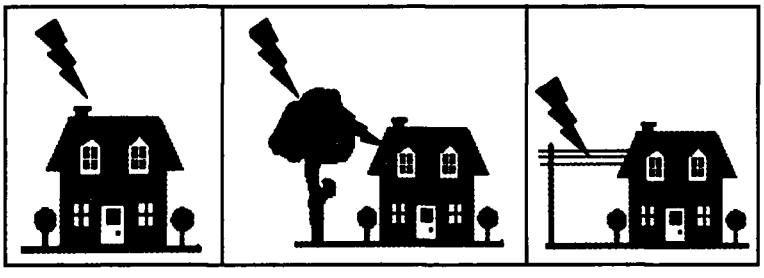


Figure 5 : Ways of lightning current interacting with buildings
a. direct strike
b. Side flash
c. through service lines.

that one can prevent the damages to the equipment and human injuries (still one can prevent the spreading of the fire by acting quickly).

The second mode of getting lightning currents into an installation is through the service lines such as power, communication and cable TV (Figure 5.) Once lightning strikes a service line, fractions of the lightning current enter all the nearby buildings and may destroy all the equipments that are plugged into the system. The lightning current may also injure the users of equipments connected to service lines. This mode of intrusion of the lightning current causes less damages than a direct strike, yet service lines are subjected to lightning strikes much more frequently than buildings themselves.

The lightning current that flows from cloud - to ground is a good emitter of electromagnetic radiations. Thus once a lightning hit a nearby object (e.g. about 500 m) even your building is exposed to a strong dose of electromagnetic radiation. When this radiation passes through electronic equipments such as computers, medical equipments, security and defence etc. The sophisticated parts of them can be destroyed. This may happen even when the equipments are unplugged from service lines. However, the chances of ordinary electrical equipments getting damaged due to such radiation is very slim.

Lightning protection

The above three modes of lightning threats can be eliminated by three types of lightning protection systems. A person who seeks lightning protection should clearly understand this difference.

Building Protection

In the commercial language a building protection system is referred to a network that is meant to protect a building from direct lightning strikes and side flashes. An ordinary building protection system consists of one or several sharp pointed rods (or a mesh of metal strips/wires) installed at the roof of the building (called air termination), several metal stripes or metal wires from roof to base (down conductors) and one or several conducting rods buried in the ground (earth conductors). The down conductors) and one or several conducting rods buried in the ground (earth conductors). The down conductor system connects the air termination to the earth conductors. When a downward channel comes from a cloud, the air termination sends an upward channel much faster than the other parts of the building thus the lightning is attracted to one of the rods (or to the metallic mesh). Then the lightning current is safely passed in to earth through the rest of the system. Thus, instead of repelling a lightning channel, a lightning protection system attracts that. However, as the lightning current is safely driven into earth the building will not be damaged. The above system is called the "Franklin Rod System", named after Benjamin Franklin who first proposed lightning rods in 1749.

It should be clearly understood that the protection of high-risk structures needs special designs in contrast to low-risk structures irrespective of the type of protection system selected. High-risk structures include explosive industries, industries of toxic chemicals, military bases with ammunition and explosive stores, high voltage lines and power plants, oil refineries, nuclear plants etc. Typically for these high-risk structures, tall masts or overhead grounded shield wires located above the structure to be protected are designed. Here, the idea is to collect the lightning above the structure, not directly on it so that any risk of interaction of the lightning current

with the risky areas of the structure or with dangerous substances is completely excluded.

With the above-described system your building is protected only from direct strikes and probably from side flashes. Still your building can be penetrated by lightning currents that propagate along service lines (power, telecommunication etc.) There are special devices (surge diverters or surge suppressors), which prevent these current impulses from entering your building. A surge diverter is connected at the entrance of the service line to the installation. At high level of protection they are connected at the power socket of each electrical or electronic equipments as well. Under normal operation the surge diverter does not interfere with the line signals. In the case of a lightning invasion it provides a convenient path for the lightning current to divert into the earth without permitting it entering into the building or the equipment (Figure 6). Surge suppressors, which have to be connected to protect power lines, communication lines and data lines, are different from one another. Make sure that you go for a reputed brand of surge suppressors, as

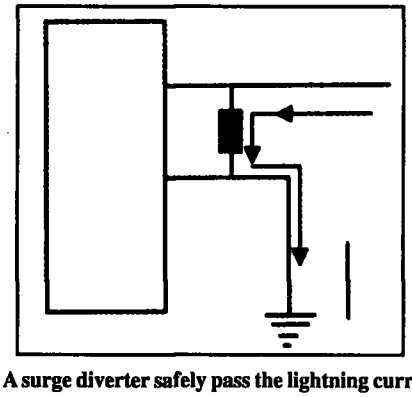


Figure 6 : A surge diverter safely pass the lightning current to earth. Thus the equipment to the left is protected from large current surge.

the performance of such a device is difficult to be predicted unless it has a proven laboratory test report.

The sophisticated electronics in a building can also be damaged by radiation, which will be emitted from the lightning flash. Electromagnetic radiation propagates in free space. This radiation can be prevented from entering the building by taking suitable protection measures. The typical method of radiation prevention is to screen the building with a conductive material so that the building becomes a "Faraday Cage". As it is very costly and unnecessary to screen the whole building it is recommended to take safety measures only to compartments of the building where sophisticated electronics are installed (such as computer rooms, medical theatres and scanning rooms, control chambers of power plants, airports, military bases, and communication bases etc.) Design and implementation of protection systems that prevent the intrusion of undesired electromagnetic impulses through both radiation and conduction is termed Electromagnetic Compatibility (EMC). This newly emerged concept of electromagnetic protection is a huge business in many developed countries but rather unheard to the Sri Lankans. Hence for and interested entrepreneur a tremendous opportunity is opened in the industry of EMC in Sri Lanka.

It is dangerous to be the tallest protrusion of a landscape during thunderstorm conditions. If you are a tall protrusion in a certain landscape your body may be the object that sends the first upward channel that meets the downward stream of charge from the cloud. Thus in thunderstorm conditions it is advisable to avoid standing in playgrounds, seashore, paddy fields, open boats on rivers or sea, roads with no structures beside or swimming in open waters etc. One should also refrain from hiking, working on roofs, on the top of buildings under construction, on telecommunication, radio and television towers (even if the structures are lightning protected) etc.

With all these system still nobody can guarantee you 100% protection from lightning. The company, which provides lightning protection, will give a certain level of protection (by a percentage) related to the system you buy. The cost of the system depends on the level of protection. For an example a nuclear power plant or a store of explosives and ammunitions may need a level of protection of about 99.99% (a highly expensive system) while that of 75% may be acceptable for an ordinary house.

Fire balls our of the sky

Sometimes people have observed balls of fire emerging from the sky in overcast conditions. They are now termed ball lightning. These fireballs are reported as having a size varying from that of a peanut to greater than that of a football. Their colour varies from pale yellow to glittering red. It has been seen that ball lightning moves at walking passes over some one's body the flesh and skin along the path will be burnt to ash while the person get no feeling of heat. Despite all these observations, still the scientists have failed to come up with a concrete explanation for a ball lightning. There are several theories put forward in this respect. At present, those are being discussed and reviewed by the scientific community. Nobody has yet succeeded in giving ball-lightning protection at any level.

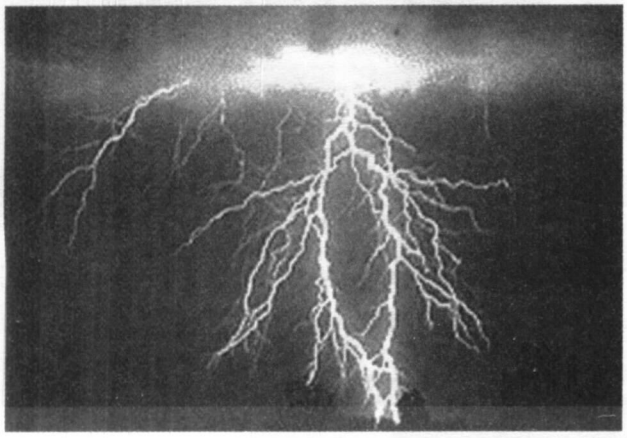
Lightning safety of human beings and animals

It is dangerous to be the tallest protrusion of a landscape during thunderstorm conditions. If you are a tall protrusion in a certain landscape your body may be the object that sends the first upward channel that meets the downward stream of charge from the cloud. Thus in thunderstorm conditions it is advisable to avoid standing in playgrounds, seashore, paddy fields, open boats on rivers or sea, roads with no structures beside or swimming in open waters etc. One should also refrain from hiking, working on roofs, on the top of buildings under construction, on telecommunication, radio and television towers (even if the structures are lightning protected) etc.

A single lightning may kill more than one. In 1998, 11 players of a football team in the Africa state of Congo were killed by a single lightning strike. Also, when there are several people under a tree, several side flashes may leap out of the tree (once the tree is lightning struck) either killing or injuring all of them. Even in Sri Lanka, a few years ago, a single lightning a killed five people on the same place in Moneragala as those people were getting shelter from a thin drizzle, under a tree.

If you are caught up outdoors in and intense thunderstorm never get shelter under a tree. The large current that flows along the trunk of a tree as a result of a lightning strike may decide to jump into your head and reach the ground through your body when you stand nearby. This is termed a side flash. A majority of lightning victims have been struck while getting shelter under trees. Thus, the number one rule of lightning protection of living beings is not to get shelter under trees or any other tall structures when lightning strikes around.

Caught up outdoors in an lightning storm one should not lie down flat. If you lay down flat in a thunderstorm a lightning that strikes ground nearby may send a current through the soil, which may enter your body from head and leave from the feet thus damaging many of the vital internal organs. Thus, the international standards recommend that the best position to be in such a condition is to squat down on your feet and to rest the head on the knees.



Some people believe that a person with wet clothes is safe from being hit by lightning. There is no scientific base behind this belief. However, if the person is lightning struck then the wet clothes will give him some protection. The lightning current always takes the best conducting (least resistive) path. When a person is wet his external body becomes a good conductor thus if he is lightning struck the current will prefer to flow outside the body instead of flowing internally. Thus the person will escape with some skin burns instead of getting damages to vital organs inside the body. Similarly a person wearing a metal necklace following and external path, then to the lower abdomen and flows into earth, thus avoiding the brain and the heart.

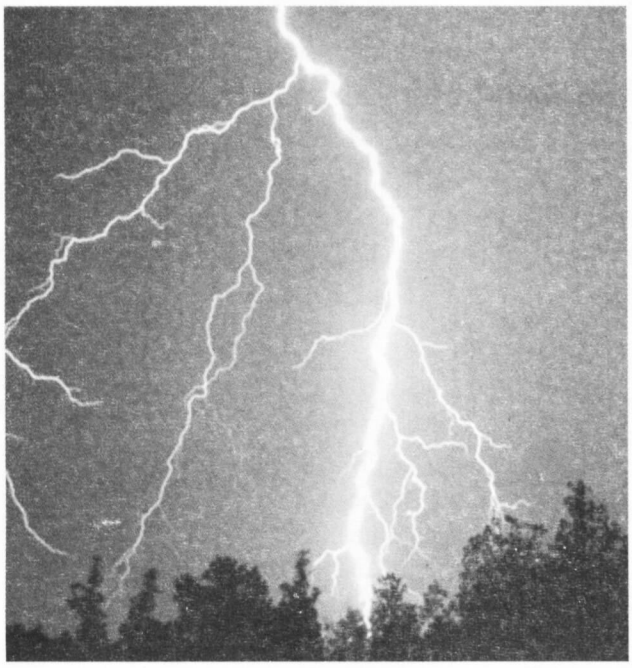
Another wrong belief is that once a person or a structure is struck by lightning her or it will not be struck again. Although it is rare, there are structures and even people who have been lightning struck several times. There is no scientific reason why one should get immunity to lightning once he is struck.

One can not avoid lightning strikes or escape unharmed even when struck by lightning if he wears rubber footwear or plastic raincoats. In contrast to the situation that a person touches a live electric wire, the insulation of rubber, plastic or any fabric cover is not sufficient at all to give you any lightning protection.

A person struck by lightning does not carry a charge in his body for several minutes, so it is not dangerous to touch him immediately after the strike. The electrical charge injected into a person by a lightning current is drained into earth within a fraction of a second. Hence, the lightning victim should be attended immediately and first aid should be given.

A single lightning may kill more than one. In 1998, 11 players of a football team in the Africa state of Congo were killed by a single lightning strike. Also, when there are several people under a tree, several side flashes may leap out of the tree (once the tree is lightning struck) either killing or injuring all of them. Even in Sri Lanka, a few years ago, a single lightning a killed five people on the same place in Moneragala as those people were getting shelter from a thin drizzle, under a tree.

It is a high risk to use the telephone during thunderstorm periods. There is a high chance of lightning striking telephone and power lines which run miles over the open



fields. Once lightning strikes the telephone network, large waves of current will propagate to the nearby subscribes through the lines. A person who uses the telephone during such an instant may be injured or even killed by this large current.

Electrical equipments are not safe if they are only kept switched off during thunderstorm periods. The lightning current, which may propagate through power cables, can easily jump across the open switches and enter the equipment. Thus, it is highly advisable to disconnect your electrical households such as phones, fax machines, computers, TVs etc., from the power line (unplug them) during thunderstorm periods. TV antenna cables should also be disconnected from the telephone network. When you go away for few days during the thunderstorm season it is better to disconnect all the electrical items at home. It is also a high risk to repair electrical networks (house wiring etc.) during thunderstorm periods.

It might be dangerous to use a needle (sewing) during a period when lightning is striking nearby. Sharp and pointed metallic objects attract lightning more than blunt and smooth objects do. Thus if the house is lightning struck, theoretically, there is a chance that the needle would get a side flash from walls, power lines etc. However, we don not know to what extent a tiny needle is capable of attracting a side flash.

Some people in our country throw out a metal rod during a lightning period. One cannot see any scientific reasoning behind this act. However, a metal rod kept close to the wall or especially a power line, metallic drain pipe etc. may attract a side flash if the building is lightning struck. Such a side flash cause fires and explosions. However, in order to get rid of such an accident one has to throw out all the metallic objects our of the house which is not very practical.

According to observations at individual records and damage record of industries and other service providers (bank, mobile phone services etc., there are certain small areas in the country, which receive a high density of lightning compared to the neighbouring areas. Many of these areas are not located in specific geographical conditions that favour high rete of lightning strikes (located at high altitude, isolated hills etc.,) However, we need to conduct a thorough research in order to give reasons for this observation, as our current knowledge does not help to give a reasonable explanation. To name a few of these areas reported are Matugama, Horana, Avissavella, Kalutara, Bulathsinghala, Waliveriya, Gampaha, Nittambuwa and Pilimathalawa.

One may get lightning even in the absence of rain. Rain usually falls from the base of the thundercloud. Sometimes, due to the high wing shear the upper part of the cloud will spread in a large region while the lower part (base) is localised in a comparatively small region. Lightning may emanate from that dispersed upper part, thus the point at which the lightning strikes ground may be tens of kilometers away from the rain. In addition lightning may also emerge from sandstorms, dust clouds of volcanic eruptions and nuclear explosions and forest fire smokes. All these are rainless lightning.

Compared to others, coconut trees are prone to high rate of lightning strikes. There may be few reasons for this observation. Being a tall tree and having leaves with sharp edges and pointed ends a coconut tree may be the object in a certain landscape that send the first channel to meet the down coming channel from the cloud. In addition, being the most abundant tree in the country, coconut trees will obviously have a high probability of getting lightning strikes.

Lightning has a good side as well. Due to the extremely hot conditions imposed by a lightning flash Oxygen and Nitrogen of air combine together to from Nitrous Oxides. These nitrogenous compounds dissolve in rainwater and reach ground to fertilise the soil.

Beyond our knowledge of Science

Most of the ancient temples in Sri Lanka are built either in flat terrain of the dry zone (thus for a large area, the only protrusion of the ground is the Dagaba) or on top of hard rocks. Still there are very few reports on these tall structures struck by lightning. There are similar situations all over the world that can not be explained properly using the current level of scientific knowledge.

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Landslides in Sri Lanka

Of the 65,000 sq km of land extent of Sri Lanka, an area of nearly 20,000 sq km encompassing 10 districts is prone to landslides. It is about 30% of Sri Lanka's land area and spread into several districts, namely, Badulla, Nuwara Eliya, Kegalle, Ratnapura, Kandy, Matale, Kaluthara, Mathara, Galle and Hambantota. Investigations carried out by National Building Research Organisation indicate that haphazard and unplanned land use, inappropriate construction methods and wanton human intervention have lead to an increase in landslide susceptibility (see Figure 1 depicting locations of landslides). To cite the extent of some catastrophic landslide events of recent memory, in 1986, 51 lives were lost with an estimated 10,000 families being displaced. Again, in 1989 and 2003 due to severe landsliding, several lives as well as a sizeable extent of property were lost.

Apart from the damage to life and property, several infrastructural as well as economically important facilities have also been affected, especially water distributory pipes, hydro electricity generating centres, and communication systems. At times, social interests such as educational and health services are also severely disrupted. Moreover, frequent landsliding has threatened the destruction to the environment including the flora and fauna of the areas concerned. Such damage caused to the environment, at times is irreversible and therefore cannot be estimated and perhaps will never be known.

One important factor that is related to landslides but not readily visible is the rising population and the consequent demand for land. This reminds us how important it is to look after usable land when analysing the damage of landslides.

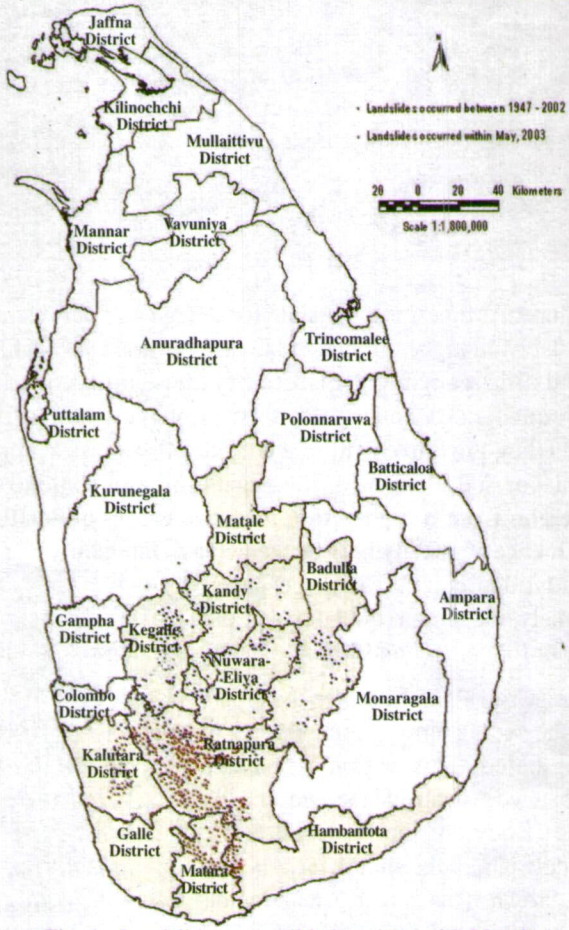

Fig. 1 : Landslide susceptible locations of Sri Lanka

Sudden movement of rock or soil mass are fairly common and are generally termed as landslides. A landslides can be a movement of either a sloping mass or the crest or the foot of a hill or even the cut surface of a slope. Similarly, the materiel that flows down can also vary according to circumstances. It could be a sliding huge soil mass at one time or a giant mudslide at another. It may also be an instance of a falling mixture of rock and soil down a slope. At times, it is possible for a large boulder resting unstably on higher ground to fall down a slope. As such, a landslide can mean differently depending on the circumstances and conditions.

What is a landslide ?

Sudden movement of rock or soil mass are fairly common and are generally termed as landslides. A landslides can be a movement of either a sloping mass or the crest or the foot of a hill or even the cut surface of a slope. Similarly, the materiel tat flows down can also vary according to circumstances. It could be a sliding huge soil mass at one time or a giant mudslide at another. It may also be an instance of a falling mixture of rock and soil down

a slope. At times, it is possible for a large boulder resting unstably on higher ground to fall down a slope. As such, a landslide can mean differently depending on the circumstances and conditions. However, generally speaking, **the movement of a considerable mass of rock and / or soil along with the vegetation and structures thereon from a higher to a lower elevation under the influence of gravity may be termed as a landslide.** These landslides consist of three parts, namely, the crown, the body and the toe or foot of the landslide.

The "Crown" is the upper most part of the sliding terrain from where it is originated. This region is usually subjected to subsidence and cracks. The "Body" of the landslide is the middle part of the sliding mass below the crown. This zone is usually wide and contains most of the sliding matter which collects material and swell causing crack in the lower area of the landslide body. "Toe" is the lowermost part of a slide. When a landslide occurs, the debris that it carries flow down spreading over the lower terrain area with a forward motion of the toe. Often, the toe consists of a moist mixture of soil and strewn stone.

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Types of landslide

Although the various types of mass movement of the terrain are termed as landslides in general, if does not really indicate a clear idea of the actual nature of the event. Therefore, landslides are categorized in the following manner.

* Fall
* Subsidence
* Debris flow
* Toppling
* Lateral displacement

Fall

Here, soil or rock material on a higher elevation falls down freely as a fragments, splinters etc.

Toppling

Generally, rock boulders separated from the bedrock along joint lines of joint systems existing on scarps are subjected to toppling. They may drop directly on to the ground or may roll over along slopes. Usually, rock disintegrates or weather easily along joint lines in the bedrock, especially with seepage of rainwater into the joints, causing rock fragment to fall.

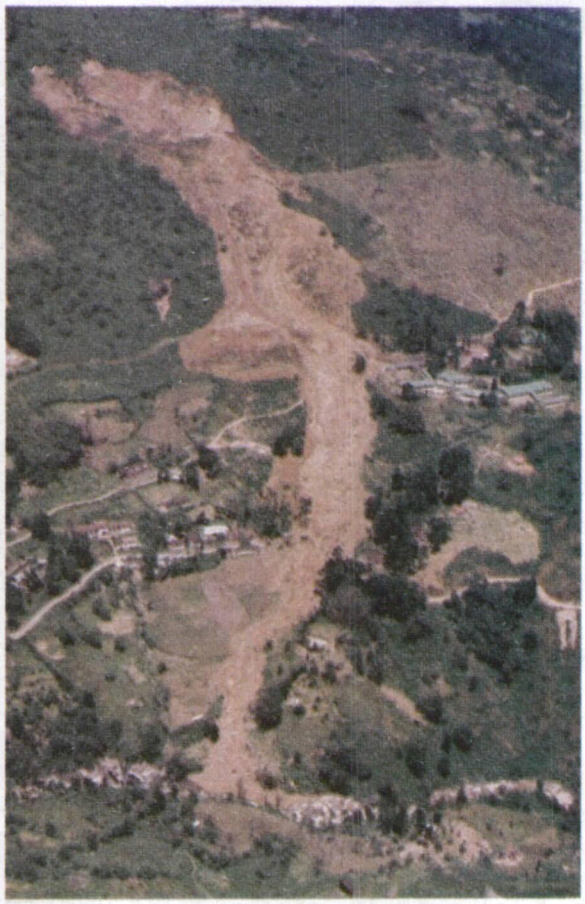
Subsidence

This is a process in which a portion of the terrain subsides or dips from its natural topographic relief level with reference to its surrounding. Soil characteristics and the behavior of different soils with water, internal soil serous and the nature of the bedrock, all of them directly influence the pattern and rate of subsidence.

Lateral displacement

A slow, gentle circular movement of a soil mass laterally or downwards along

the slip surface can be termed as a lateral or downward displacement. The upper region of a such movement is often subjected to tension cracks while down slope can take an irregular form and have the appearance of a disturbed nature and springs and seepages could be observed



Debris flow

This is a downward flow of a muddy water and soil, stone, as well as clay and gravel, They occur mostly on escarpments with a very rapid flow causing much destruction. The speed of such a flow can reach 160 km/h.

Where do landslides occur?

Landslides can occur almost anywhere on the land from sloping terrain, valleys to even plains - even the seabed can be subjected. However, it is usually believed that they commonly occur on hill slopes at an inclination ranging from 15^0 to 45^0 to the horizontal. Although landslides are common at inclinations below 45^0 occurrences at inclinations above 45^0 are seldom for the obvious reason that soil layers will not accumulate on such surfaces for sliding at such angles. Rock falls may occur in such areas instead, but it as been clearly observed that only terrain unduly tampered is subjected to such landslides.

Causes of landslide

Landslides do not occur usually due to a single reason, but it is the nett effect of several, processes and factors, persisting for long periods on the hilly terrain. No single cause can be attributed for the occurrence of a landslide, or rock fall, but it is due to the interaction of a multitude of factors, either natural or man-made.

Natural causes are

* Steepness of hill slope
* Type of rock material
* Deep weathering of rock material and the depth of the weathered rock.
* Density of the joint pattern and the structure of the rock.
* Thickness of colluvium deposits collected down slope due to gravity.
* Poor drainage conditions leading to excessive water seepage in sub strata.
* High intensity of precipitation
* Earthquake as a triggering factor
* Flood and reservoirs in hilly areas

Inclination of hill slopes

It is very seldom for a landslide to occur of on a flat area or a plain, the obvious reason being that there is no space or opportunity for any soil mass in the area to fall or slide any more. However, landslides do occur in such terrain too, but that can only happen due to an excessive weight or pressure placed on top of the hill slope, the tendency for landsliding increases. Slope surfaces with thick soil layers and slope angle between 15^0 and 45^0 have been found to have a greater preponderance for landsliding with maximum tendency of hill slope of angle 26^0 to 35^0 to the horizontal.

Geomorphology and Bedrock characteristics

Generally speaking, soil and rock types having different characteristics or less cohesive properties are the ones mostly subjected to fall or sliding. Various rock characteristics including the structure contribute directly to this looseness of a rock or soil and consequently to such sliding.

Rock is composed of various minerals in different proportions. The rock so formed are subjected to various natural elements such as sunlight, rain, wind, hot and cold temperatures and also to penetration of plant root systems for long periods thus causing disintegration, and weathering.

Also by the impact of various pressures rock materiel can be subjected to splitting, which spreads and in various quantities. The resulting material consisting of soil, clay and the like, have their own characteristics. The above processes finally cause the deposition and settling in various layers or strata on the slopes thus leaving a conductive background for landslides.

Similarly, the action of deferent temperature and pressures on the rock also create fractures in the rock and these fracture systems can be easily lead to separation of the boulders and rock fragments from the parent rock. The separated rock fragment and weathered components can be later transported to lower regions of the slope by erosion and rolling. The increase in the thickness of the overburden deposits (colluvium) so collected can lead to landslides.

Heavy precipitation

Often we hear of a landslide and the consequent damage after heavy precipitation. The background for a landslide to move down a slope is actually created by the action of various environmental factors and undue human activities persisting for long periods is finally triggered by intensive rainfall to a landslide. The heavy rainfall not only causes water penetration into the sub soil layers, thereby loosing the interlayer cohesion but also increases the weight of soil mass. The penetrated water also acts as an easy lubricant flowing down slope. The net effect of these processes is the sliding of the soil mass down the slope as a landslide. According to preliminary investigations carried out, it has been found that if a hill slope receives continuous rainfall of about 200 mm within a period of 3 days, the susceptibility to land sliding in such an area increases. It has been observed that as a result of the current poor, ill-planed land use practices, even a rainfall of 75-100 mm for a 2 day period is sufficient to trigger a landslide.

An earthquakes can influence the occurrence of a landslide directly and indirectly. The vibrations of an earthquake can break up the exciting bond between soil particles and similarly the bond between rock layers can also be weakened considerably. Such tremors can cause an instantaneous earthquake. Sri Lanka has felt some tremors in the recent past and it is necessary to be alert about landslides that could be triggered by earthquakes.

Impact of Earthquakes

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Flood and reservoirs in the hilly terran

Flood and reservoirs in the hill areas can influence the incidence of landslide in several ways. One such instance is the failure of riverbanks scoured by following of swollen rivers after heavy rains. The bottom areas of the banks are eroded by the flowing river water leaving the top areas of the riverbanks without the toe support, which can easily cause the top mass to come down.

Floodwate can also contribute significantly for the collapse of hill slope. The ground water level of the area usually rises after floods and consequently the natural drainage pattern of the area is charged. This cause an increase in the internal water pressure within the slope sub surface while also blocking water from upper soil layers along sub-soil passages resulting in accumulation of water in the slope. As a result of the additional weight due to the water mass and the slope. The recent landslides in Rathnapura are tangible examples of those initiated by such a deluge .

A similar reaction takes place in large water reservoirs with huge dams built on hilly terrain, which happened when impounding and emptying of water in Kothmale Tank. That is what precisely happened with fluctuating ground water levels, the hill slopes abutting the bound slid down in the case of Kothmale reservoir.

Undue human intervention strongly influences the incidence of landslides

Example of some wanton land use practices:

- Denudation of forest areas exposes the topsoil, which affects the stability of slope. The soil cracks and is eroded with the rains causing lanslide.
* The use of land without proper planning.
* Construction on hilly terrain without due investigation or design.
* Quarrying for metal without due investigation and adherence to norms.
* Obstruction of natural water paths and storage of water on high ground.

Identification of area previously struck by landslides

* Abrupt changes of vegetation cover in landslide stricken area from that of the ambient area.
* Clear, sharp delineating boundaries between areas struck by landslide and the balance stable area (Fig 2).

Fig. 2 : A site previously struck by a landslide.

Identification of areas vulnerable to landslide

* In an area vulnerable to landslide, subsidence of the ground and tension cracks could be seen towards the upper region of the slope. Also tall trees may be seen slanting towards the hill. If such observation can be made in any particular are, it is a strong indication of the land area being prone to landslide. Also if cracks are observed on the wall and floors of houses located down slope, it is a further clue to an impending landslide and if these cracks enlarge progressively, it indicates that the landslide is still active in the area.
* Further, in a vulnerable area, water springs, suddenly begin to appear while at the same time water in the wells in the vicinity can get murky. Small streams or superficial watercourses may also disappear suddenly before the occurrence of a landslide in the area.
* Other facts about landslides that cannot be observed in the above manner can be identified by geotechnical and geological investigations. Moreover, by analysing the landform, pattern, water systems, dips, rock types and their structure in the area, maps can be prepared depicting various zones from high to moderate to low hazard level.

How to prevent/mitigate landslide

Although there can be many suitable ways to prevent or mitigate a landslide, an affected area need not be abandoned. An old, traditional method practised to rehabilitate such land profitably has been by cultivating the land in terraces. The tendency for a landslide to occur is also minimized by this method as it affords the slope to be well drained and thereby ensuring the protection of stability of the slope.

It is necessary to establish a suitable drainage system to drain off the surface water properly.

* Landslide struck land should be reforested to protect the exposed soil layer.

* Erosion should be minimized by planting, suitable vegetation such as Vetiver grass, Gliricidia counter fances.

* The upper region or the crown of the slope area should be cut down to lighten the top. Similarly it is also possible to add weight at the base or foot of the slope which will strengthen the base to withstand the sliding forces.

The above procedures can be to followed by anyone in general. However, in addition to them, more effective modern methods, though more expensive, are now available.

Among them are :-

* Tying of the soil layers tending to slide on the ground with wire mesh at staggered anchor points.
* Erecting of concrete or rubble retaining structures.
* Staggered anchoring of the unstable sloping ground with reinforced concrete posts or timber posts or iron fence posts pile-driven into the bedrock.

Future, refraining from conversion of agricultural lands for other purposes, refraining from unauthorized filling up of lands using dug up soil metrical, limiting of the erection of civil structures and implementing of development works on hill slopes under proper technical guidance can all contribute to minimize the occurrence of landslides.

Acknowledgment

My sincere thanks are due to the National Building Research Organization for permitting me to use data of the institution.

R.M.S. Bandara
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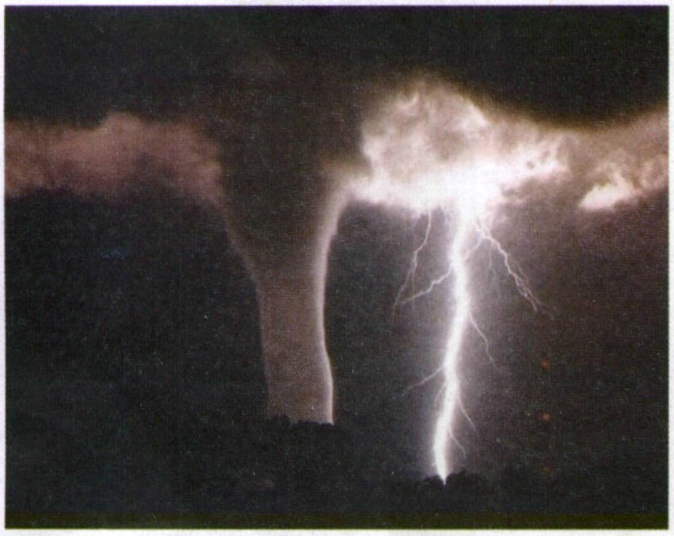
National Building Research Organisation

Tropical Cyclones and Tornadoes



Tropical region is considered as the region between tropic of Capricorn (23^0 South and 23^0 North) of the earth. The weather or climate characterized in this region is called tropical climate. Tropical cyclones are one of the most important tropical weather conditions. They are among the most powerful and destructive natural phenomena of our planet, and they are capable of producing very strong winds, torrential rain and sea water intrusion to the land (storm surge).

They are called as **hurricanes** in the North Atlantic and Northeastern Pacific and as **Typhoons** in the Northwestern pacific. All the other ocean basins namely, in the Indian Ocean and South Pacific Ocean, they are just termed as **tropical cyclones**. There are no evidences of formations of tropical cyclone in the South Atlantic ocean. Approximately 80-100 tropical cyclones occur in a year and they develop over the warm tropical oceans.

In the North Atlantic ocean, North and South pacific oceans and in the south Indian ocean, each cyclone is given a name during its formation. Nations around the north Indian Ocean are currently considering the naming the cyclones developing in the Bay of Bengal and in the Arabian sea. Bangladesh lost more than 300,000 lives within a few hours on 13th November, 1970 due to a tropical cyclone, and in 1992 US economy lost about 26 billion US dollars due to property damage caused by the cyclone (hurricane) Andrew.

Wind and Pressure

Tropical cyclone are low pressure systems in the tropical region. The centre pressure at the surface may be even less than 900 hecto Pascals (1 h Pa = 100 Pascals), where as the surrounding pressure is predominantly a little above 1010 hpa. This large pressure difference drives the winds from the outside to the centre. However, due to the effect of the rotation of the earth, air does not directly moves from the out side to the centre. Instead, it moves towards the centre with counterclockwise whirling in the northern hemisphere and with clockwise rotation in case of southern hemisphere. Closer the centre the pressure change along a radius is larger. Therefore the stronger winds are observed closer to the centre.

Development of Tropical Cyclones

A tropical cyclone starts with a low pressure area where the maximum sustained wind is lower than 17 knots (31 km/h) over the sea. When the surrounding air converge to the low pressure centre, the air rises. As the air is saturated with moisture (over the warm sea), rising motion results in condensation and cloud formation. The condensation of water vapour release very large amount of energy (latent heat of evaporation - nearly 2250 kJoules per kg). If the upper levels (up to about 8 km) of the atmosphere are not dry, further condensation can take place. Some part of energy released in the condensation process further warms up the rising air and the upward motion can continue to a great depth such as, 13 km. Another part of condensation energy, warms the atmosphere directly above the low pressure area if there is not large scale (regional) strong winds (in case of strong winds, the heat is horizontally transported with the wind and does not retain in the same location to warm up). As the warmer air is lighter, the surfaces pressure (centre) decreases further namely deepen further. Therefore, the pressure difference between the centre and the surrounding area increases, strengthening the wind speed. If the maximum sustained wind exceeds 31 km/h, it is said to be a depression. If this process continues, the centre pressure decreases further and the wind speed further increases. The table (1) below gives the classification of the systems related to tropical cyclones used in Sri Lanka (Slightly different classifications are used elsewhere.)

Professor William Gray detailed the necessary conditions for development of cyclones (given below) which is also suggested by the above mechanism.

(1) Warm sea (should be greater than 26 Centigrade from the surface to at least 60 m depth)

(2) Significant influence of the earth rotation (cyclone do not form within the equator and 4 degrees of latitude)

(3). No significant horizontal wind variation between the surface and about 10 km.

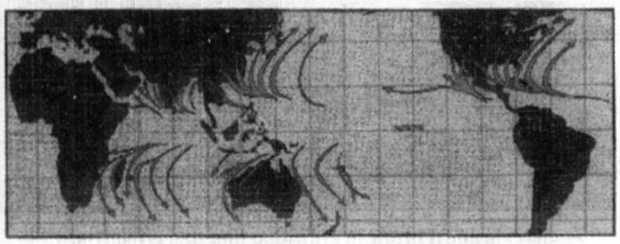
(4). Significant amount of moisture (relative humidity) between 3 and 6 km above the surface,

(5). Having some spin up in the wind field at lower atmosphere.

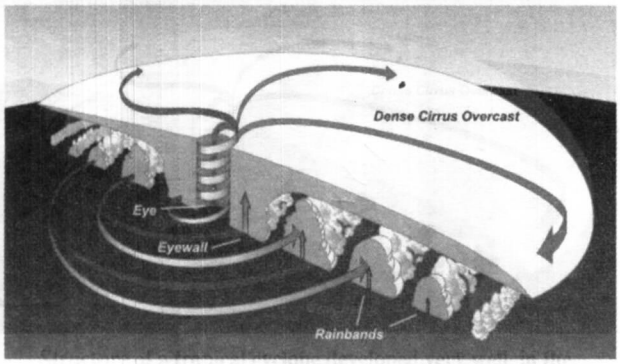
(6). Significant cooling from surface at about 6km height.

Decaying the cyclone

As the major energy source of cyclone is condensation energy, it gets weaken if either oceanic or atmospheric



Starting regions and pathways of world tropical cyclones

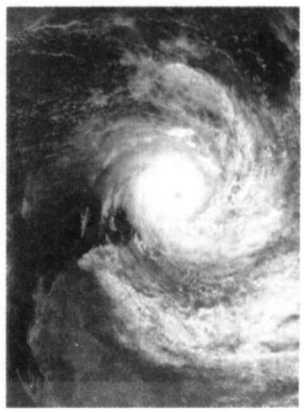


Structure of a tropical cyclone developed very well in the northern hemisphere

conditions are not sufficiently favourable to release enough condensation energy over the cyclone area. Moving over the land or cool ocean, storms fast movement, unfavourable atmospheric conditions for deep convection are some of the reasons for weakening the systems.

Structure of Cyclone

A typical well matured tropical cyclone has vortex (counter-clockwise in the northern hemisphere and clockwise in southern hemisphere) towards it's centre. While the air is whirling it also moves upward. This violent upward spiraling wind result in spiral band of clouds wrapping around the centre. The centre is basically less cloud and calm and, appears as a free of clouds in the satellite imageries. It is called the eye of the storm. The diameter of the eye may be 30-60 km. Clouds those immediately around the eye are called the eye wall clouds. They consist of vertically very tall (may be over 15 km) cumulonimbus clouds (thunder clouds) which produce intense rainfall and violent winds. All the mature cyclones may not have eyes completely by eye wall clouds especially when they are relatively less severe. Instead, partially eye wall clouds with spiral bands may appear. The effect (heavy rain and wind) of tropical cyclone may be felt to the distance even more than 500 km of the centre.



Movement of Cyclones

Tropical cyclones basically do not develop within 4 deg of the equator as the effect of earth's rotation is negligible.

Table 1 - Classifications of cyclone related systems in Sri Lanka

System	Maximum sustained Wind speed		Corresponding Dvorak Classification (T number)
	Knots	km/h	
Low pressure area	less than 17	Less than 31	Less than 1.0
Depression	17-33	31-61	1.0-2.0
Cyclonic storm	34-47	62-85	2.5-3.0
Severe cyclonic storm	48-63	86-117	3.5-4.0
Server cyclonic storm with hurricane force wind or cyclone	Greater than 64	Greater than 118	Greater than 4.5

Once a disturbance from beyond this region, it basically moves towards the west with slight deflection to the poles. Later the pole ward contribution of the motion increases. Finally they move with pole and eastward. Motion of individual cyclones, however, depends upon the large scale wind field, interaction with other neighbouring important systems etc.

Intensity of tropical Cyclone

The intensity of tropical cyclones are indicated by the T-number by Meteorologists. This has been established by vernon Dvorak based on satellite imageries. He has compared large number of satellite imageries with other meteorogical parameters, such as, centre pressure and maximum sustained wind to develop this classification. The corresponding T number for the storms classified in Sri Lanka is given in the table 1.

Forecasting cyclones

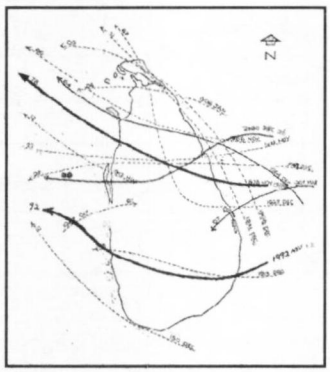
Forecasting the motion of tropical cyclones with its intensity is extremely important to minimize the human loss and property damage. It is done by the interaction between

human being and the modern techniques. Tropical cyclone itself is a devastating phenomena therefore, getting the real observation from the area is extremely difficult. However, using the satellites and modern information technology, meteorologists are in a position to obtain a lot of real time information about cyclones and issue timely warning and fairly accurate forecasts at present.

Cyclones affecting Sri Lanka

Tropical cyclones usually develop during the summer and early winter as the ocean gets warmer due to strong solar heating during the summer. Being the most active region, northwest pacific basin, the cyclone season stretches even longer period. However, in the north Indian Ocean, there are two major periods namely, during the pre-southwest monsoon (April-May) and post southwest monsoon (October-December). The splitting character of the cyclone season is a feature which is a unique only in the north Indian Ocean.

Out of two seasons, the post monsoon period is more active. As Sri Lanka is close to the equator, and in our latitudes, tropical cyclone usually moves in northwest or west wards. Therefore, it is predominantly affected by cyclones those developing in the southern part of Bay of Bengal except in case of Cyclone in October 1967 which struck near Chilaw (west coast). The eastern part of the island is more vulnerable than the western part as during the west-northwestward motion over the land the system get waken. During the period from 1881-2000, 8 and 4 cyclone have crossed in each of March and January. During the months of April and May, Sri Lanka has been badly affected by cyclones passing the vicinity of the island although there are no reports about crossing the island. During the last 50 years, four severe cyclonic storms have crossed Sri Lanka; They are in October 1967, November 1978, November 1992 and December, 2000. The heaviest damage was caused by the one in 1978 which claimed 915 human lives and heavily damaged about 185,000 houses. Technology and the learnt lessons from this event reduced the death toll to less than two digits during the cyclones in 1992 and 2000.



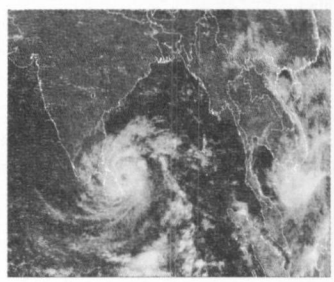
The pathways of cyclones crossed Sri Lanka during 1901 - 2000

Effect of tropical Cyclones and Steps to Minimize the Loss

Tropical cyclones are destructive due to their very strong wind, torrential rain, storm surge (sea water intrusion to the land and to the rivers largely due to strong wind) and very rough seas (due to strong winds). Therefore, forecasting the cyclone are very important for general public as well as for sea and air navigational operations for their safety.

When the cyclone alert is declared, all should be paid more attention on the weather news carefully not to go panic but to do the needful to save their lives and property.

If the area is going to be affected, tight all the unsettle tiles, roofing sheets, repair the door and windows, trim the trees near the house, remove all the valuable document and clothes with polythene and store them at a higher and safer (from strong winds and floods) place, store enough drinking water in an unbreakable vessel. Make sure the perfect working order of battery operated radio tuned to get weather news, pack the essential medicines to be taken away if evacuation is required, keep ready a hurricane lamp with kerosene oil and a lighter, flash light with batteries, some dry food such as biscuits, bread etc., untie cattle and other animal to them to go away and do the other necessary things to save.



The satellite image of the cyclone cantered Trincomalee on 20 - 02 - 2000 evening 4 o'clock.

When the cyclone warning is issued and your place is likely to be affected, you need to evacuate if you are not in a strong and elevated place. If the house is strong (concrete roof and at an elevated place, you may stay but try to get sufficient floods and water for a few days. I f you are required to evacuate, decide where (strong and elevated place) to go and what is the route you need to take, get away from beaches and get extra foods, water, battery operated radio, hurricane lamp or an emergency lamp and essential medicines, special food for kids and, patients etc..

If the centre of the cyclone passes your area, you may feel calm conditions (after strong winds) temporary only. You will experience again strong winds from the opposite direction. Therefore, do not leave your safer place until the safety about your place is announced. Moreover, authorities such as, power supply and irrigation etc., should take appropriate measures to avoid possible destruction due to the damage pf their structures by the cyclone. Once the cyclones passes, heavy rain and flood conditions may contaminate the drinking water. Therefore, it is essential to take hygienically pure drinking water.

Tornadoes

A tornado is a violent storm with strong wind whirling around a small area of extremely low pressure, usually characterized by dark funnel shape clouds causing damage along it's path. The damage is caused by extremely strong winds (may be more than 300 km/h) spinning around the centre and ability of sucking the objects upwards. Violent tornadoes can lift heavy objects, such as, trucks, roofing sheets etc. The tornado is also called "twister" as it has highly rotating nature. Tornadoes often break or fall trees which eventually damage the property near by.

In the central and southern parts of United States, they frequently develop (annually about 1000 tornadoes). Some of the localized severe storms reported from other part of the world may be having tornado type air motion. As the tornadoes are very tiny and short lived, most of them may not have been reported as they do not have frequent and high resolution information techniques as US does.

In Sri Lanka recent damage survey studies of the strong wind affected areas suggests that some of them have shown some features of tornado. During the two inter-monsoon months namely, in the March, April, October and November, deep convection can cause formation of vertically well develop clouds mainly during the afternoon. Almost in every year, there are occasions of reporting strong winds during this period. During the southwest monsoon (May to September) period too damaged due to strong winds are reported Not all, but a few localized strong winds may have been due to formations of tornadoes. However, without proper inspection of the damage area, prior to the alteration of evidences they cannot be confirmed.

A tornado is associated with mostly one or two covective type clouds (cumulus or cumulonimbus). Below the clouds, there is a violently rotating air column including mostly the bottom part of the clouds. This rotation often is seen as a funnel.

The size of tornado is only a few hundred meters but its path may be about one kilometer. Most tornadoes last for only a few minutes; but only a few tornadoes have lived about an hour. Limitation of it's size and the lifespan also limit the affecting area. However, the same reason limits our understanding about it.

Very unstable conditions due to large temperature, humidity, and wind variation are favourable for tornado development. However, the mechanisms of tornados have not been fully understood. In the southeastern sector of United States (Colorado, Oklahoma etc.), where they frequently develop and the frequent satellite and radar techniques give prompt information about the tornado which will allow the people to safer shelter. In addition, the favourable conditions for tornado development are also forecast. However, it is extremely difficult to make accurate forecast about tornado well in advance. Therefore, preventive measures should be taken immediately when the least information indicates the possibility of striking the place.

Waterspout

If tornado type strong sucking effect is experienced over a reservoir or a sea, a narrow column of water is lifted towards the clouds. This is called waterspout which may also move over the land and become a tornado depending on it's energy. On contrary, tornado may become a waterspout if it moves over a water body. As water is lifted, aquatic lives such as fish may also be lifted and drop somewhere. This strange thing is sometime called as 'shower of fish'. In addition, waterspout can harm the boats and ships.

How to protect from Tornado

As tornado cannot be forecast, it is Vital how to identify the environment in case of tornado and take immediate measures if tornado is suspected. A tornado can make roaring sound and funnel shape dark pendant from clouds may be visible. The object may lift and light objects may spin around the center just above the surface. When such thing are felt, running immediately to a strong shelter (under a concrete roof or slab) may save the life. After passing the tornado, main power cables should not be touched as fallen trees may damage the live lines.

Table 2- Comparison between Tropical Cyclones and Tornadoes.

	Tropical Cyclone	Tornadoes
Type	Whirl wind	Whirl wind
Size (Horizontal extent-diameter)	More than 500 kilometers	100s of meters
Covective cells (Cumulonimbus clouds)	Dozens	Mostly one
Life time	Longer than a week	Mostly less than 10 minutes
Favourable Winds for generation	Not much change vertically	Large change vertically
Generation area	Warm sea	Primarily over the land
Horizontal temperature	Not much change	Significant change
Rain	Torrential over a large area	Nil or for a short period
Damage	Floods, landslides, storm surge and wind damages	Only wind damage over the a limited area

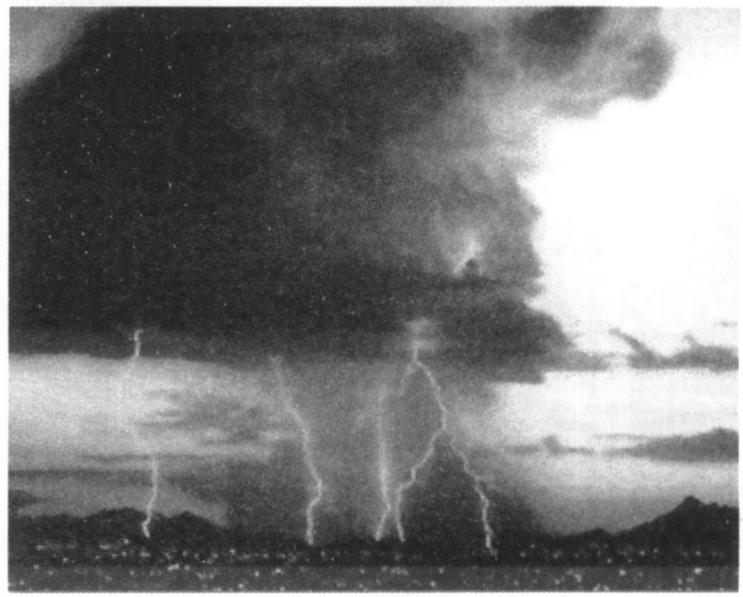
Most wind damage are often referred as cyclones by the public and media. Therefore, it is worth of comparing tornadoes and tropical cyclones (cyclones).

S.H. Kariyawasam,
Deputy Director, Department of Meteorolgy, Colombo 07.

Thunderstorms

What is a thunderstorm?

For a storm to be considered as a thundercloud or a thunderstorm, we require that thunder must be heard. Since this peculiar and intense acoustic disturbance has no other natural source, the presence of lightning is necessarily required. These storms, invariably composed of strongly convective cumulonimbus clouds, are usually accompanied by strong wing gusts, lightning and rain, or sometimes hail or snow. Different weather conditions occur according to the climatic seasons of year.



Climate seasons of Sri Lanka

The climate experienced during a 12 - month period in Sri Lanka can be categorised into four climatic seasons as follows, each season having its typical features.

i. First Inter-monsoon season (FIM) March-April (2 months)
ii. Southwest Monsoon season (SWM) May-September
iii. Second Inter-monsoon season (SIM) October-November (2 months)
iv. Northeast Monsoon season (NEM) December-February

Enhanced convection during inter-monsoon periods produced large bank of cumulus and cumulonimbus clouds and also several layer of altostratus and cirrostratus clouds. They result in frequent thundershowers. If however, convergence occurs only at some distance to the north or south of Sri Lanka, only stratiform, medium and high clouds will be present over the island or part of it. The resulting precipitation over the affected area will then be in the form of occasional light showers. But under certain conditions thunderstorms occur in both main monsoon periods.

Weather systems and Thunderstorms

Since the origin of the earth and our atmosphere, weather has experienced and change in different time and space scales. Weather is the combine behavior of a number of parameters like atmospheric pressure, temperature, wind, moisture content, clouds, rain, sunshine and mist. Therefore, the globe or a particular geographical location is influenced by one or more weather parameters associate to form weather systems. Thunderstorms are very important since they are very common in almost all types of weather systems and climate seasons over many parts of the globe.

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Requirement and Development of a thunderstorm

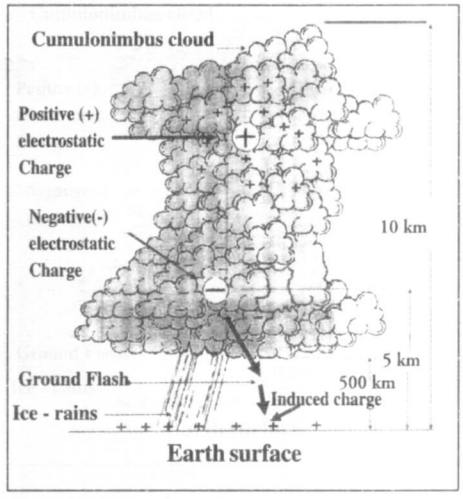
When earth is heated by sunlight, much of the energy goes into warming the air in contact with its surface. At midday, the normal solar input is sufficient to heat a surface layer of air one-meter in thickness by about one degree Celsius per second. As a result of this heating from below, the density of the lower air is decreased and the atmosphere can become unstable for vertical motion.

The lower atmosphere becomes unstable and can be overturned with a release of mechanical energy

whenever the vertical lapse of air temperature becomes more negative than -9.8 degrees Celsius per Kilometer, the adiabatic lapse of temperature with altitude.

Thunderclouds are usually a consequence of atmospheric instability and develop as the warm, moist air near the earth rises and replaces the dense air aloft. This overturn often result in the condensation of atmospheric water vapor forming a visible cloud of water droplets. When this occurs, the heat associated with the phase changes of water acts to speed the overturn: release of heat of vaporization by condensing water vapor enhances the updrafts, while cooling, caused by evaporation of condensed water, can help drive the downdrafts which replace some of the ascending subcloud air.

Atmospheric pressure decreases with altitude so that rising air expands; this effect causes the temperature of rising air to decrease as it exchanges its internal heat energy for geopotential energy of height. If the ascent of a parcel of air continues, its cooling eventually causes some of the water vapor to condense onto dust particles in the air forming small liquid droplets scattered through the volume thus creating a cloud. The cloud droplets grow rapidly hereafter by further condensations of a hundred or more droplets per cubic centimeter.



Characteristics and Effects

Thunderstorms associate a number of weather parameters, Some times hazardous. Some of the products (lightning, thunder, rain, snow and hail) can be observed only with the use of equipment.

Thunderstorms are hazardous because they produce lightning, tornado, waterspout, hailstorms, strong gusty winds and instant rainfalls that result in natural hazards.

During the development stages thunder clouds are charged electro-statistically and the final configuration is so that negative charges concentrate over the lower part of the cloud while the positive charges occupy the upper part. These charges are about 100-200 coulomb and under their influence a positive charge is induced on the earth surface below the cloud. At a certain stage, electrical discharges occur between these charge centers and they are called lightning.

Lightning is a natural phenomenon. It has the potential to cause serious damage to both life and property because the electric current of a ground lightning flash is about 25000 Amperes (25000 A) and the potential difference between a charges clouds and the earth is about 100 million Volts. The resulting energy is about 500 million Watts per flash. Incidents of lightning normally tend to be more frequent in some areas but could occur anywhere.

In Sri Lanka, there have been a number of recorded incidents of death and injury to persons and animals and also to buildings and other structures. On average, the death toll due to lightning is around 50 persons per year.

Hazard of Thunderstorms

Hazard by thunderstorms reach a peak in April every year in Sri Lanka. Statistical values show that the most of hazards occur during the evening, particularly after 3 p.m. with a peak during 4-6 p.m.

Under the normal conditions thunderclouds develop within 500 m and 10 km altitudes. The lower part of a cumulonimbus clouds mostly consists of water particles and drops but the region above about 5 km consists mainly of super-cooled water drops and ice. Since rain starts with the falling ice particles, we sometimes may experience rain with ice (Hailstorms). But fortunately we are living in a tropical country where the low level temperatures are very much above the freezing temperature of water. Therefor, unlike in colder parts of the world, the ice tends to melt before reaching the earth saving us and our property from damages caused by hails (large ice balls).

Vigorous the normal convection leads to development of small-scale cyclone type systems usually called tornado which have a very short lifetime like 10 minutes but they are rich with very strong gusty winds which are capable in resulting considerable damage in a small area in a very short duration. When these systems develop over waterspouts.

Therefore one has to expect hazards caused by a number of parameters like heavy sharp rain, lightning, strong winds and hailstorms in thunderstorms.

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Earthquakes and their geological basis

Very simply explained, earthquake is considered as the sudden release of energy stored in some parts of the crust, and which therefore causes a shaking of the earth. They occur when the plates found on the crust move about relative to each other and when they either collide or are pulled apart. The energy of an earthquake is released in the form of waves. This can be compared to a piece of wood subjected to a strong stress (Fig 1) and which breaks when the application of the stress is continued. The location at which the energy is released in termed the focus and this is within the earth. The location on the surface directly above the focus is termed the 'epicenter' (Fig 2).

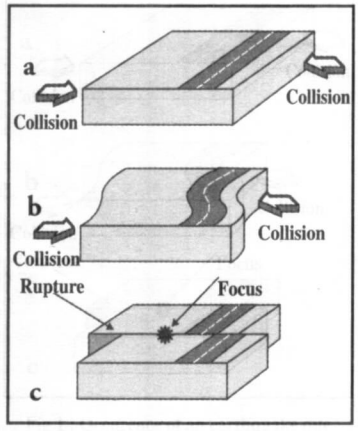

Fig 1 : Occurence of an earthquake due to collision

The earthquake waves so produced travel within the earth as well as on the surface. There are two types of such waves, namely surface waves and body waves. The waves originating from the earthquake and which travel on the surface of the earth are the surface waves while those that travel within are the body waves. The body waves are further classified as primary and secondary waves.

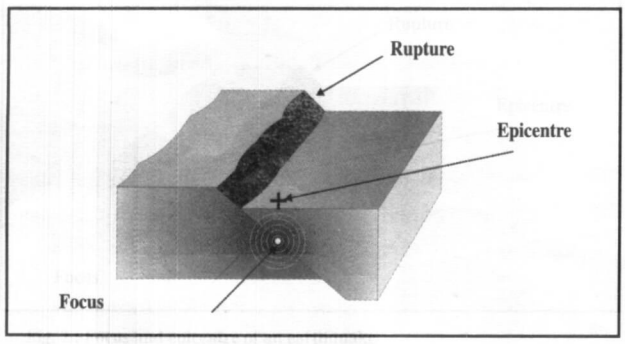

Fig. 2 : Focus and epicentre of an earthquake

As seen in (Fig 3) the vast majority of earthquake occur at margins of the plates. There are 12 major and a few minor plates. These palates move relatively to one another driven by forces originating within the earth. The plates can either collide or one plate can sink under the other. It is the collision of the plates that cause the majority of the earthquakes. In mountain ridges beneath the sea there is a growth of the plates and here too earthquakes are frequent. The theory of plate tectonics can explain the occurrence of volcanoes, High Mountain ranges etc. Countries such as Japan, Philippines, and Indonesia are located near plate margins. The strong forces of the earthquakes can destroy buildings, rupture gas pipes, damage large electrical cables and cause fire. Due to the loosening of the soil, earthquakes in the sea. It is reported that the tsunami that occurred near the Japanese island of Rikyo n 1971 gave rise to waves as high as 85 meters. The destruction that is caused by this to the costal zone is enormous.

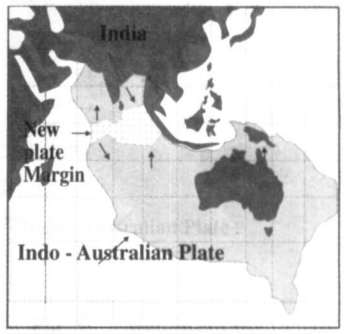

Fig 3: Margins in the Indian Ocean plates

The Magnitude of an Earthquake

When calculating the magnitude and the location of an earthquake, research stations situated on the earth's surface use both surface and body waves. The strength of an earthquake is measured by the 'Richter Scale' first introduced by the American scientist-Charles Richter. According to this scale, earthquakes measuring 7 or more are very destructive while those less than 5 do not cause much damage. According to table 1, the earthquake, which struck the city of kobe, Japan in 1995 had a magnitude of 6.8.

Earthquakes in Sri Lanka

Earth tremors reported in Sri Lanka occasionally. During the last 500 years, about 60 earthquakes felt by man had been listed. From among these, Portuguese records state

that in 1615 April 17 an earthquake that occurred in 1938, 1993, 1999, 2001 and 2004 had been strong enough to be felt. It has been found that many earthquakes not strong enough to be felt, occur in Sri lanka. Even though destructive earthquakes as observed in countries such as Japan, India have not been reported, no one can quite definitely state that such events will not occur in the future.

Up to now, Sri Lanka was considered as a country away from a plate margin. However, according to recent investigations it has been found that there is a new developing plate margin about 480 kms South of Sri Lanka in the Indian Ocean. According to the American and French scientist involved in this study, it has been estimated that this originated about 7.5 million years ago. The gravity change in the Indian Ocean also confirms this view.

Table 1 : Earthquake Severity

Richter Magnitudes	damage
Less than 3.5	Not felt, but recorded
3.5-5.4	Often felt, but not causes damage
5.5-6.0	Slight damage over small regions
6.1-6.9	Can be destructive in areas up to about 100 km
7.0-7.9	Major earthquake, can cause serious damage over large areas
8.0 or greater	Great earthquakes, can cause serious damage in areas several hundred kilometers across

Table 2 : Destructive earthquakes occured in the world

Year	Location	Richter Scale	No. of deaths (approximately)
September 1923	Tokyo, Japan	8.3	140000
May 1935	Pakistan	7.6	60000
January 1970	China		66000
February 1976	Peru	7'8	23000
July 1976	China	8.0	655000
September 1978	Iran	7.8	15000
September 1985	Maxyco	8.1	30000
December 1998	Turkey	7.0	25000
June 1990	Iran	7.7	50000
January 1999	Turkey	7.4	17000
January 2001	India	7.9	13805
December 2004	Sumathra	9.0	200000

It has been recorded that the epicenter of earth tremors felt in Sri Lanka has their locations at this new plate boundary. According to the French geologists who studied this, the fault had shortened by 32-37 km during the last 7 million years. Accordingly, Sri Lanka is moving as a little platelet 6-7 mm/year towards the Southeast.

Some scientists suspect that the earth tremors within Sri Lanka are caused by the large reservoirs. Due to the weight of the large amount of the water there is a stress built up in the rock layer underneath. This stress is expected to cause movement with a resulting earth tremor. Geologists say that earth tremors can occur. However, a study of the earth tremors in Sri Lanka shows that medium sized earth tremors had occurred even before the reservoirs were built.

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Psychosocial care for people affected by disasters

According to the World Health Organization (WHO), only around 5 to 10 percent of the population affected by a disaster will need long term psycho-social interventions. Psychological effects are felt by everyone who is exposed to a disaster. Although, everyone is affected psychologically, majority of a given population exposed to a disaster will be able to cope.

Sports is a very good treatment for poor mental health conditions

Mental health and effects of disasters

Mental health is affected by a disaster due to following main reasons.

a) **Grief and mourning**

This is a Psychological reaction which follows the death of family members, friends and loved ones.

b) **Exposure to a horrific event**

Disasters usually occur suddenly and totally unexpectedly, coming out of the blue with no previous experience. Many had a near death experience where there lives were saved miraculously. Many of them also witnessed their friends and family members getting killed or injured and were helpless and powerless to intervene.

c) **Illness and physical injury**

Exposure to disasters usually can result in physical injury, loss of limbs and vulnerability to various forms of illness due to the adverse environmental factors. Many Tsunami victims were partially drowned resulting in forms of lung and respiratory diseases.

d) **Living in an environment with no community network**

Following a disaster many people have to move out of their homes. Some houses were completely destroyed, other partially affected. Some move out of there homes for fear and safety.

Challenge to the society

The challenge is the delivery of adequate, effective, and appropriate psychosocial care. It should be adequate to cover all who need care. It should be effective so that it provide comfort and relief to those affected. It also needs to be culturally sensitive where religious and traditional beliefs, attitudes and norms are respected.

Psychosocial interventions

The psycho-social interventions provided have to be multi-sectored. This means involvement of medical and non medical mental health professionals, governmental and non-governmental professionals, community volunteers and involvement of the disaster affected population themselves. It should be a multi-disciplinary and a participatory approach.

Service delivery should take place at different levels. Policy and planning can be at central level. The training to be done at provincial and district level. The implementation to take place at the community level.

All psyco-social interventions need to be socially and culturally sensitive and appropriate.

The service providers too would need psycho-social support and provisions to this effect have to be made available.

Reactions to disaster

Reactions to disaster are many and may vary according to the individual and the and the circumstances. Psychological response can be immediate, midterm or long term. Common reactions seen after a disaster are:

a) **Shock, disbelief and denial**

This is a common reaction in the immediate aftermath of a disaster. The person is in a state of shock not knowing how to respond. Disbelief and denial where the individual refuses to accept what has happened is common. This is regarded as a form of a protective mechanism of the mind to shield the individual from the traumatic experience. In the short term this is beneficial but prolonged denial and refusal to accept the reality is harmful.

b) Fear

This is a common reaction. Fear can be felt due to repeated memories of the trauma when the person is awake. It can also occur during sleep as nightmares. Fear due to the possibility of the disaster happening again is common. Rumors and misinformation contribute towards it. People tend to avoid situations and events that remind them of the tragedy.

c) Anger

Anger can be directed outwards at family members, friends, neighbours or close associates. It can sometime be directed at the rescue workers and people coming to their assistance, such as the health care workers. Occasionally anger can be directed at the deceased. Anger can also be directed inwards resulting in self injurious and self destructive behaviour. Suicide may be a tragic outcome of this destructive behavior.

d) Confusion

Mental confusion results due to many reasons. Psychological effects of the trauma, physical exhaustion, inadequate hydration, poor nutrition, exposure to adverse environment, environment, inadequate rest and illness and injury can all contribute to this state.

e) Guilt and shame

This reaction is seen in the immediate and medium term period. Self blame for the tragic event, feeling responsible and accountable for what has happened. Some feel shamed for nor doing enough to help other victims. Some even regret to be alive which is termed psychologically as "Suvivor Guilt".

f) Grief (bereavement)

Grief is define as the psychological reaction to loss. Grief can be normal or abnormal'. Abnormal grief reaction is called "pathological grief."

Normal Grief Reaction

This consists of 3 stages:

Stage one- " It cannot be true " - stage of denial
In this stage there are two psychological processes. Denial - where the person refuses to accept the loss. There is also Numbness-where the person does not feel the emotional pain and distress. This enables the individual to function as needed in the immediate aftermath of a disaster, The first stage lasts between few hours to few days.

Stage two - "I feel miserable" - stage of sadness
In the second stage the person feels the loss of the loved one. The person might direct the anger towards family and friends or people who were with the deceased at the time of the tragedy. There is often sleeplessness. Other psychological symptoms include hearing of the dead person's voice and having visions of the deceased. The person may misidentify the deceased person among a crowd. All these phenomena are normal in grief reactions and the person needs to be reassured these are not signs of insanity. Usually these features come in waves of emotions. The second stage last from few weeks to few months.

Stage three- "It's time to move on" - stage reorganization
During this stage the person comes to term with the loss and starts to readjust his or her life. The individual now begin to think about the future and makes plans accordingly. The memories of the deceased no longer bring out intense emotions. The person is now able to think about the good times spent with the deceased and enjoy the pleasurable memories. The individual resumes his normal day to day activities. The third stage last from few weeks to few months.

Abnormal grief (Pathological grief)
Grief is to be abnormal when the symptoms are:

* more intense than usual
* prolonged beyond six months
* delayed in onset

Abnormal grief reactions are more likely in several circumstances:

* after a death that was sudden and unexpected
* when the bereaved person was very close and dependent on the deseased
* when the survivor is insecure, or has difficulty in expressing feelings, or has suffered a previous mental disorder
* when the survior has to care for dependent children and so cannot show grief easily

All the above reactions except Abnormal grief (Pathological grief) are regarded as ***normal reactions to an abnormal situation.***

Grief counseling
Principles of grief counseling include:

* listening to the person's concerns
* providing information, explanation, and advice regarding the features of grief reaction
* encouraging the expression of emotion
* helping to accept the loss and take part in religious and socio-cultural activities associated with death
* supporting to solve practical problems
* encourage resuming day to day activities and planning for the future

Understanding death

How a person understand that death depends on his age, previous experience, and his religious cultural background is considerd here. An adult's concept of death includes:

* separation
* permanence
* immobility
* irreversibility
* physical causes of death
* universality
* inevitability

Children's understanding of death

Most children develop a "mature" concept of death by the age of 8 to 10 years.

Psychosocial interventions

Aims of psycho-social interventions

a) Normalization of life

The interventions that will help to normalization life include:

* ensuring basic needs are made - water, food, sanitation, shelter, mobility and safety
* reestablishment routine social practices - schooling, recreational activities, household duties, child care, home industries, employment and income generating activities
* re-uniting family tracing
* involving affected communities in the decision making and implementation of relief and rehabilitation

b) Identifying high risk groups

When the whole population of an area is affected it is important to identify and target the psycho-social interventions to these groups. High risk groups include:

* people who have lost all or majority of there immediate family members
* children who have lost both parents
* families with small children, where mother or father has died
* pregnant and lactating women
* disabled people
* elderly
* people vulnerable to harm and exploitation
* people with chronic disorders - epilepsy, diabetes, high blood pressure and mental disorders

c) Provision of specialist care

The following list includes the common mental disorders seen after a disaster:

* Acute stress reaction
* Bereavement disorders
* Adjustment disorders
* Depression
* Anxiety disorders
* Smatoform disorders
* Alcohol and drug abuse
* Post-traumatic stress disorder
* Exacerbation and relapse of pre-existing mental disorders.

These mental disorders require specialist mental health interventions and referral.

d) Capacity building

Developing technical and operational capacities of the governmental and non-governmental personal is an important activity in implementing psycho-social interventions. The activities include:

* preparation of guidelines
* training of selected service providers

Interventions that can be harmful to the victims

When implementing psycho-social interventions it is important to remember there are some activities which can be harmful to victims. Harmful activities include:

* forcing victims to talk about there experiences
* being aggressive or dominant over the victims
* giving sedatives to large numbers of people
* forcing people to do what YOU think is good for them
* 'labeling' people with medical diagnosis
* Promises which cannot be kept

References

* World Health Organization manual for community level workers
* Where there is no psychiatrist - Vikram Patel
* Psychiatry - Oxford Core Text
* Guidelines for health workers in psycho-social care - Ministry of Health

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Consultant Psychiatrist,
Health Education Bureau

What have you learnt ?

Try your hand at MCQs

1. True or false ?

(a) According to the "Richter Scale", earthquakes measuring 7 or more are destructive.

(b) "Richter Scale" was named after the American scientist Charles Richter, who first introduced a scale to measure the intensity of earthquakes.

(c) Earthquakes are not reported in Sri Lanka.

(d) There is a plate margin bout 480 km South of Sri Lanka, which was originated about 7.5 million years ago.

(e) A research station located at the earth surface uses only one category of surface waves or body waves to find the location and the magnitude of an earthquake.

2. True or false ?

(a) Sudden movements of rock or soil mass are generally termed as landslides.

(b) The landslide, which move from higher to a lower elevation under the influence of gravity along with considerable mass of rock and/or soil along with the vegetation and structures consists of three parts namely, the crown, the body and the toe or foot.

(c) A landslide occurs due to a single reason and not due to a net effect of several processes and factors.

(d) Sudden appearance of water springs, becoming water in the wells murky, sudden disappearing of superficial watercourses are characteristics of an area vulnerable to landslides.

(e) Landslides occur due to natural factors and not due to human interactions.

3. True or false ?

(a) A tornado is a violent storm with strong winds whirling around a small area of extremely low pressure.

(b) A cyclone is a low pressure situation in the tropical region.

(c) The intensity of tropical cyclones is indicated by the T-number by Meteorologists. This has been established by Vernon Dvorak.

(d) Water sprout is a situation of lifting of water from a reservoir or a sea towards the clouds due to a tornado type strong sucking effect and experiencing over such a water body.

(e) Cyclone system occurs close to the equator due to having low effect of rotation of the earth.

4. True or false ?

(a) The Southwestern monsoon occurs during May-September while the Northeastern monsoon is during December-February.

(b) Electric current of a lightning flash is about 100 million Amperes and it has a potential energy of 30,000 Volts.

(c) Hazards by thunderstorms reach a peak in April every year and occur during 15.00 -20.00 H of the day.

(d) At midday, the normal solar input is sufficient to heat a surface layer of air one-meter in thickens by about one degree Celsius per second.

(e) There is no great damage due to lightning to human being, animals and to buildings.

5. True of false ?

(a) Psychological reaction which follows the death of a family member, friend or loved one is known as grief and mourning.

(b) Grief can be normal or abnormal. Abnormal grief reaction is called "pathological grief."

(c) A "Mature" concept of death is developed among the children by the age of 8-10 years.

(d) Reactions to disaster are many and may vary according to the individual and the circumstances.

(e) Normal grief reaction consist of three stages namely "it cannot be true", I feel miserable" and "it's time to move on".

1.	(a) True	(b) True	(c) False	(d) True	(e) False
2.	(a) True	(b) True	(c) False	(d) True	(e) False
3.	(a) True	(b) False	(c) True	(d) True	(e) False
4.	(a) True	(b) False	(c) True	(d) True	(e) True
5.	(a) True	(b) True	(c) True	(d) True	(e) True