

The Landslide Disaster Prevention Handbook

-Prepare Yourself for Landslide Disaster-



November 2014

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1. Aim of this Handbook

This handbook outlines the information people should know about landslide disasters.



What is landslide?

Will landslide disaster occur in my place?

Why landslide occurs?

Any signs before landslide occurs?

Can we build our house in a landslide prone area?

Can we avoid landslide disaster?

What should we do in case of a disaster?

Where to evacuate?

What are the emergency contacts?



Source: NPO Sediment Disaster Prevention Publicity Center (SPC)

2. What is Landslide?



2-1. Definition of landslide

A landslide is a large amount of earth, rock, and other materials that moves down a steep slope. Landslides happen when a layer of earth or rocks separates from the layer below it. The force of gravity pulls the loose layer downward. (Source: Children's Encyclopedia)

Since landslides occur over a massive area, and a large amount of soil mass gets moving slowly, it can cause serious damages to residential areas, roads, firms and so on.



Mauritius (Vallée Pitot)



Japan



The above photo shows that a landslide occurred in El Salvador in 2001. A landslide destroyed part of a town near San Salvador. In this case, an earthquake caused the landslide (Source: <http://kids.britannica.com/elementary/art-89137/A-landslide-destroyed-part-of-a-town-near-San-Salvador>)

2-2. Types of landslide

Landslide disasters can be divided into the following three categories according to the places where they occur and phenomena.



Slope failure



Debris flow



Landslide

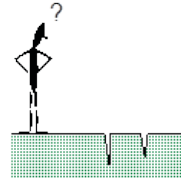
Source: NPO Sediment Disaster Prevention Publicity Center (SPC)

2-3. Signs of warning

The above disasters have several signs of warning before they actually occur. If you find any sign, please contact the appropriate Authority (please refer to the page 24)!

New Cracks

- Some new cracks have formed in the ground, and these cracks are getting bigger.
- Cracks on retaining wall.
- Cracks on paved roads and tunnels.

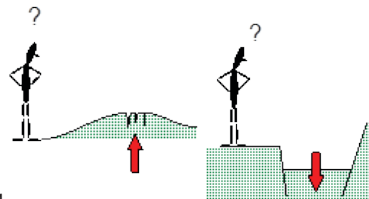


Small Rocks falling from a slope

It happens as ground condition becomes loose before landslide occurrence.



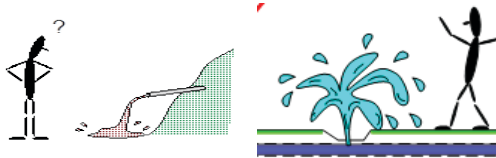
Swelling up / Cave-in of ground



Change of water volume and quality

*Target water: Spring water, mountain stream, groundwater

- The above water getting suddenly muddy
- Water gushing out from the earth.
- The amount of water rapidly increasing, or decreasing or drying up.



Unusual sounds by:

- falling of big stones
- rocks breaking down into smaller
- breaking of tree roots, tree branches rubbing against each other
- rumbling in the mountain



Unusual odours

- Earthly smell, burning, sour, woody smell, etc.

Others

- The ground is vibrating.
- Loosening or tensioning of electric cables.
- The shape of building has changed (you cannot close the door properly, a gap has formed on the wall).
- The bridge is partly warped.
- Wood floating in mountain stream

2-4. The places where landslides are likely to occur



Alluvial fan

Necessary precaution has to be taken if you live in the following places:

- Developed land Alluvial fan (= a fan- or cone-shaped deposit of sediment crossed and built up by streams)
- Mountainous area

3. Landslide in Mauritius

In Mauritius, landslide issues have become a major concern today due to recent natural disasters resulting from environmental changes and the increase of land development on steep slopes.

Over a hundred houses are in danger in many parts of Mauritius, because of possible landslides. In fact, over thirty locations were identified as vulnerable to landslides in 2012. Serious measures have to be applied to manage the situations.

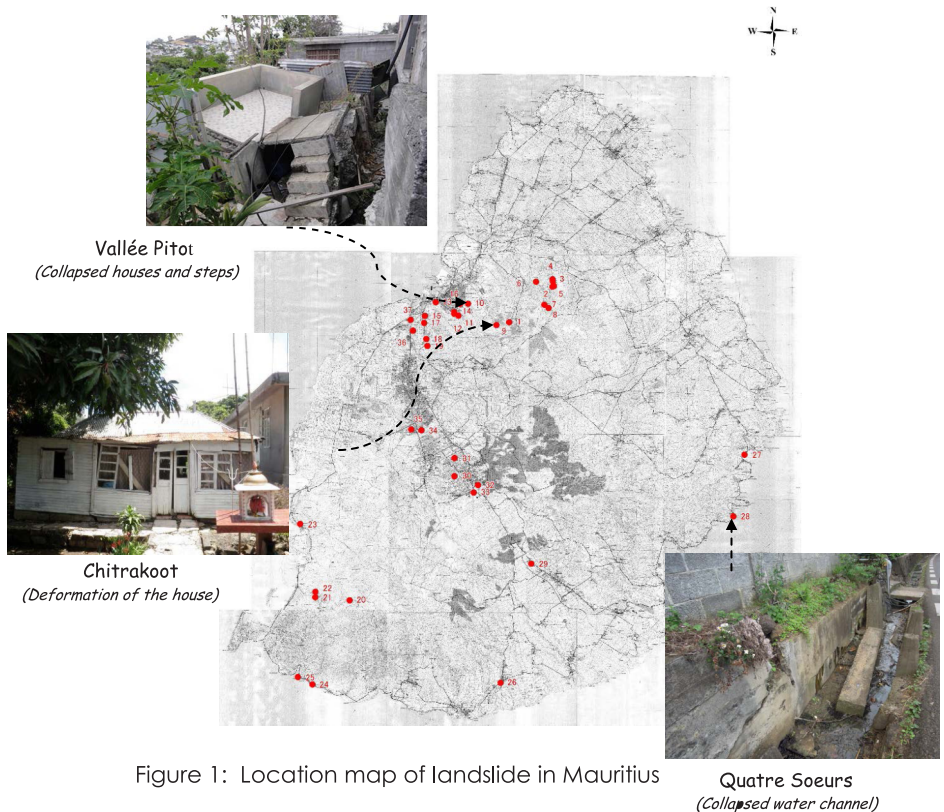


Figure 1: Location map of landslide in Mauritius

Table 1: List of Landslide-prone regions in Mauritius

No.	Area Name
Pamplemousses District Council	
1	Temple Road, Creve Coeur
2	Congomah Village Council (Ramlakhan)
3	Congomah Village Council (Leekraj)
4	Congomah Village Council (Frederick)
5	Congomah Village Council (Blackburn Lane)
6	Les Mariannes Community Centre (Road area)
7	Les Mariannes Community Centre (Resident area)
8	L'Eau Bouillie
Municipality of Port Louis	
9	Chitrakoot, Vallée des Prêtres
10	Vallée Pitot (near Eidgah)
11	Le Pouce Street
12	Justice Street (near Kalimata Mandir)
13	Mgr. Leen Street and nearby vicinity, La Butte
14	Pouce Stream
15	Old Moka Road, Camp Chapelon
16	Boulevard Victoria, Montagne Coupe
17	Pailles: (i) access road to Les Guibies and along motorway, near flyover bridge
18	Pailles: (ii) access road Morcellement des Aloes from Avenue M. Leal (on hillside)
19	Pailles: (iii) Soreze region
20	Montée S, GRNW
Black River District Council	
21	Plaine Champagne Road, opposite « Musee Touche Dubois »
22	Chamarel: (i) near Restaurant Le Chamarel
23	Chamarel: (ii) Roadside
24	Grande Rivière Noire Village Hall
Savanne District Council	
25	<i>Baie du Cap: (i) Near St Francois d'Assise Church</i>
26	<i>Baie du Cap: (ii) Maconde Region</i>
27	<i>Riviere des Anguilles, near the bridge</i>
Grand Port District Council	
28	Quatre Soeurs, Marie Jeanne, Jhummah Street, Old Grand Port
29	Bambous Virieux, Rajiv Gandhi Street (near <i>Bhowany</i> House), Impasse Bholoa
30	Cave in at Union Park, Rose Belle
Municipality of Curepipe	
31	Trou-aux-Cerfs
32	River Bank at Cite l'Oiseau
33	Louis de Rochecouste (Riviere Seche)
34	Piper Morcellement Piat
Municipality of Quatre Bornes	
35	Candos Hill at Lal Bahadoor Shastri and Mahatma Gandhi Avenues
36	Cavernous Area at Mgr. Leen Avenue and Bassin
Municipality of Beau Bassin/Rose Hill	
37	Morcellement Hermitage, Coromandel

Source: CYCLONE and OTHER NATURAL DISASTERS SCHEME 2012-2013

4. Why Landslide occurs?

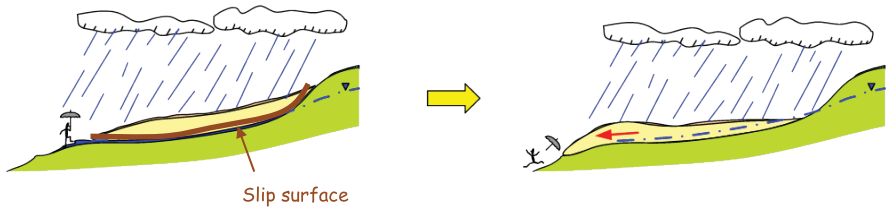
There are many triggering factors of landslide occurrence. The drawings below show major triggers.

Intense rainfall

Intense rainfall makes groundwater level higher. It will result in;

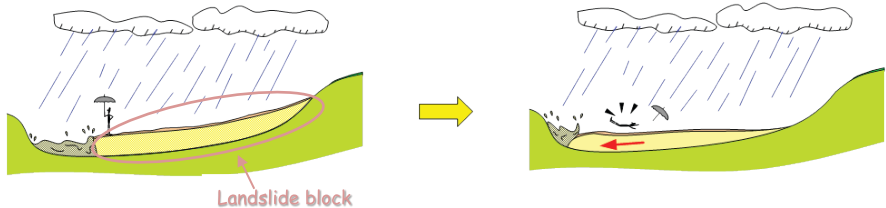
- > the load of the landslide block being increased.
- > the landslide block is lifted by groundwater pressure on slip surface
- > the landslide block become easily slippery on slip surface

Due to the above reasons, intense rainfall makes landslide more likely to occur.



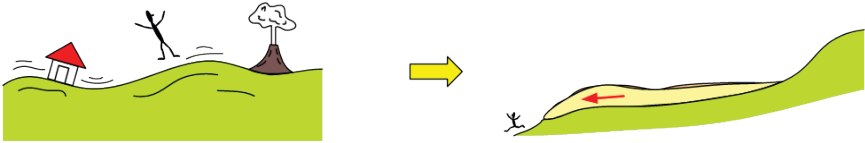
Fluvial Erosion (= erosion caused by streams, rivers and creeks)

In continuous heavy rain, river water level becomes higher, and river stream flows faster and with greater energy. It leads to erosion of the toe of the landslide block, and landslide will become activated.



Earthquake / Volcanic activity

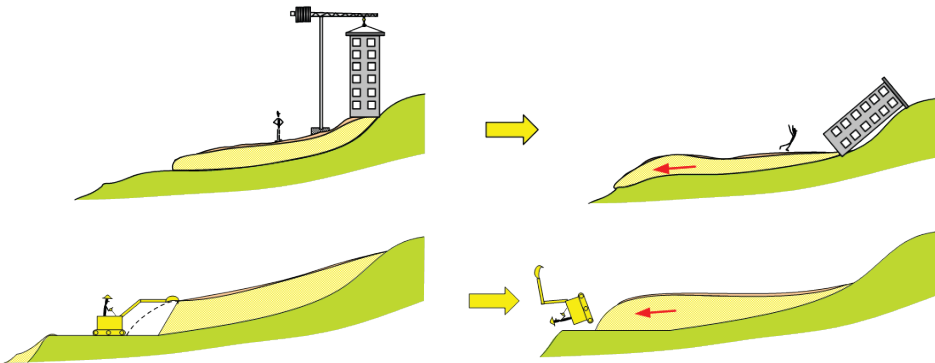
The movement of the earth's surface caused by earthquake or volcanic activity makes ground loose which sometimes results in landslide occurrence.



Human activities

Although the landslide block was kept inactivated, it will become activated if some buildings or facilities are developed on the head of the landslide block.

If the toe of landslide block is excavated for development, the landslide block may lose its balance that will result in landslide occurrence.



5. Features of a Landslide area

What you can observe in a landslide area?

The following scenes are common characteristics you can observe in a landslide area. If you find these scenes, necessary precautions should be taken.



Deformation in the steps



Deformation of the house



Deformation of the toe of landslide block



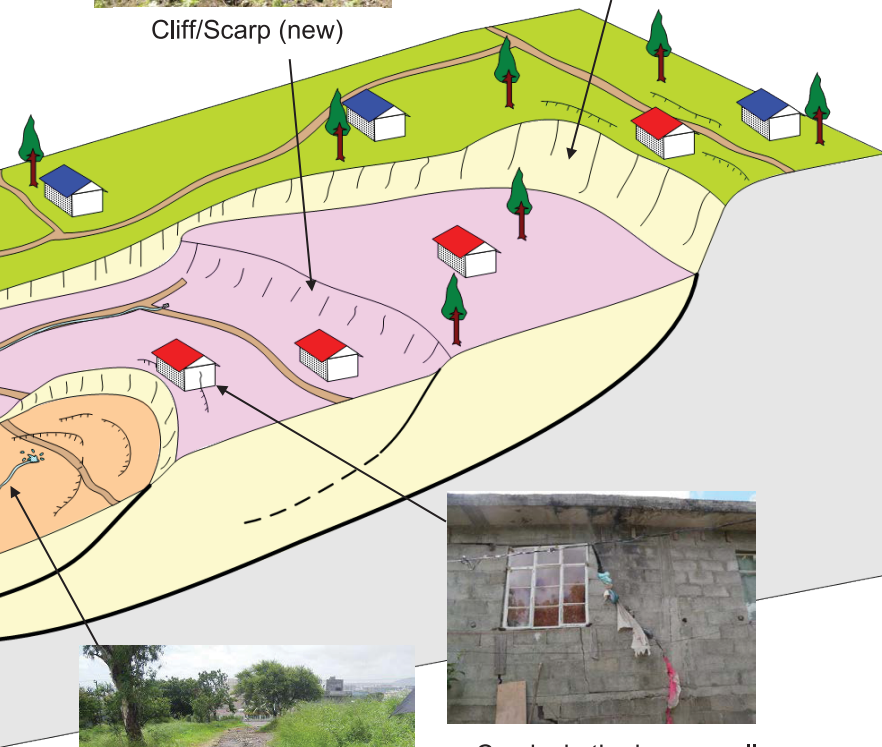
Tilted tree



Cliff/Scarp (new)



Cliff/Scarp (old)



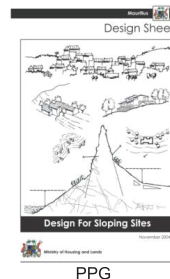
Trace of spring water flow



Cracks in the house wall

6. Development Activities in a Landslide Area

- In Mauritius, there are some legal systems/schemes which has legal binding force for land use policy/planning and can contribute to the landslide disaster risk management.
- **Planning Policy Guidance (PPG) 2004** is one of the legal schemes. The PPG aims to create a set of performance criteria and design standards that are applicable to most forms and scales of development, and assist Government and Local Authorities when considering permit applications.
- In the PPG, the design for sloping sites has the following design standards:



- Development will not normally be permitted on slopes steeper than 1:5 (20%).
- Above slopes of 1:10 (10%), and in areas of poor load-bearing capacity, the ground conditions should be checked and proposed structures certified by a qualified engineer. A site constraint analysis and written statement detailing all proposed mitigation measures should be submitted to and approved by the Permit Authority prior to the commencement of any on-site works.
- As a general guide, development should not be any higher than 45 meters above the mountain base or, in the case of slopes facing the sea, 45 meters above Mean Sea Level.



For more information, please contact the relevant town/municipal/district council or Ministry of Housing and Lands.



7. Ways of Coping with Landslide

7-1. Ways of coping with landslide

Generally, there are two (2) ways of coping with landslide.

- ① Relocation to a place which will be not affected by landslide disasters
- ② Prevention or control of landslide occurrence by implementing countermeasure works.

7-2. Advantages and Disadvantages of each way

Advantages and disadvantages of each way are shown below;

Way	Advantage	Disadvantage
Relocation	<ul style="list-style-type: none"> - You will not be affected by landslide (100%) 	<ul style="list-style-type: none"> - Need finance for moving - Difficult to find a place to move. - Take time to complete all the relocation procedure. - Need adjustment to the new living environment
Countermeasure works	<ul style="list-style-type: none"> - You will not be affected by landslide (70 – 95%) - It can protect socially important existing assets (roads, school, hospital etc.) - You can continue living in the same place 	<ul style="list-style-type: none"> - A huge amount of time and financing are required.



Meeting with inhabitants



Drilling work



Monitoring of ground movement



Installation of drainage

As shown in the table shown in the page 13, both ways have several requirements like financing, time and change of living environment etc. So, we need to choose the best way from cost-effectiveness, technical and social perspectives.

7-3. Importance of “Disaster Prevention”

The countermeasure works will normally take a few years complete, so that there are some possibilities that landslide might occur before completion of the works. And, **countermeasure works might not guarantee “100 %” to preserve people’s life and properties.**

When landslide has reaches a dangerous level, one might believe that the relevant authority will come and guide you for evacuation on time, but that will not always be possible due to the difficulties of access to one’s place under continuous heavy rain.

Therefore, we need to change our mindset to **“I am the only one who can protect myself from danger”**, instead of totally depending on the government.

Damages due to disasters can be reduced by human efforts such as establishing disaster prevention systems and raising people’s awareness on disaster prevention. **“Disaster Prevention” is a key concept to cope with landslide.**



Source: NPO Sediment Disaster Prevention Publicity Center (SPC)

8. Early warning and evacuation

8-1. Monitoring by the government

In order to take necessary action to protect one's own life, it is important to predict when landslides has reached a dangerous level.

“**Monitoring**” is helpful to judge a condition of landslide on a daily basis, and decide a timing for evacuation in emergency condition such as continuous heavy rain.

In some landslide-prone areas of Mauritius, the government has installed specific equipment like; automatic rain gauge, extensometer, and is regularly monitores landslide activity on site.



Monitoring of surface land movement (by extensometer)



Monitoring of rainfall on site (by rain gauge)

However, it is not possible for government offices to visit the site to check the site condition and monitoring data during heavy rain due to the difficulties of access to the site if it has water- covered and/or because of the road.

Therefore, it is risky to rely on government and wait for a decision to be made by government. We need to judge a condition by ourselves and make a decision by ourselves. How we can do so?

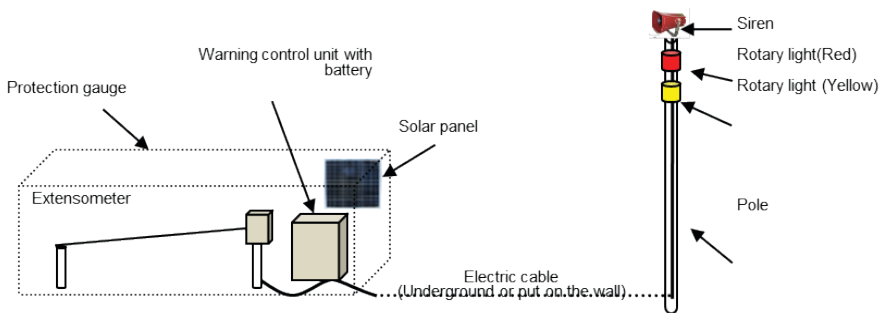
8-2. Early warning and evacuation system

(1) Monitoring of ground movement – “Alert system”

In the areas where extensometers have been installed, you might also have an “Alert system”, which is connected to the installed extensometers that monitor a ground movement. The system is very useful to know whether a landslide is activated or not.

Structure

The parts of the alarm added to extensometer consist of rotary lights (yellow and red), a siren, a warning control box (including the battery) and solar panels.



Notice : The electric cable are less than about 80m, because the voltage declines.



Alert system
(Chitrakoot)



Alert system
(Vallée Pitot)




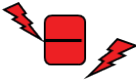
Siren and rotary lights (Red and yellow)

How to use?

Each yellow and red light give a signal for inhabitants, informing that the level of ground movement has become at the warning stage and the evacuation stage respectively.

The alert level for each stage is determined based on the actual monitoring data in your residence area. Please contact the appropriate authority to obtain the criteria, and fill figures in Table 2.

Table 2: Actions to be taken at warning and evacuation stages

Light color	Stage	Ground movement	What to do?
 Yellow light	Warning stage	mm/day	Call the Police, and be ready in the event of an evacuation
 Red light + Siren	Evacuation stage	mm/day	Start evacuation following the instructions given by the authority

Necessary actions should be taken according to the color of the light.

In the next page, you will find the systems of early warning and evacuation using the above alert system and simple rain gauge at home which is described in the page 19 - 20.

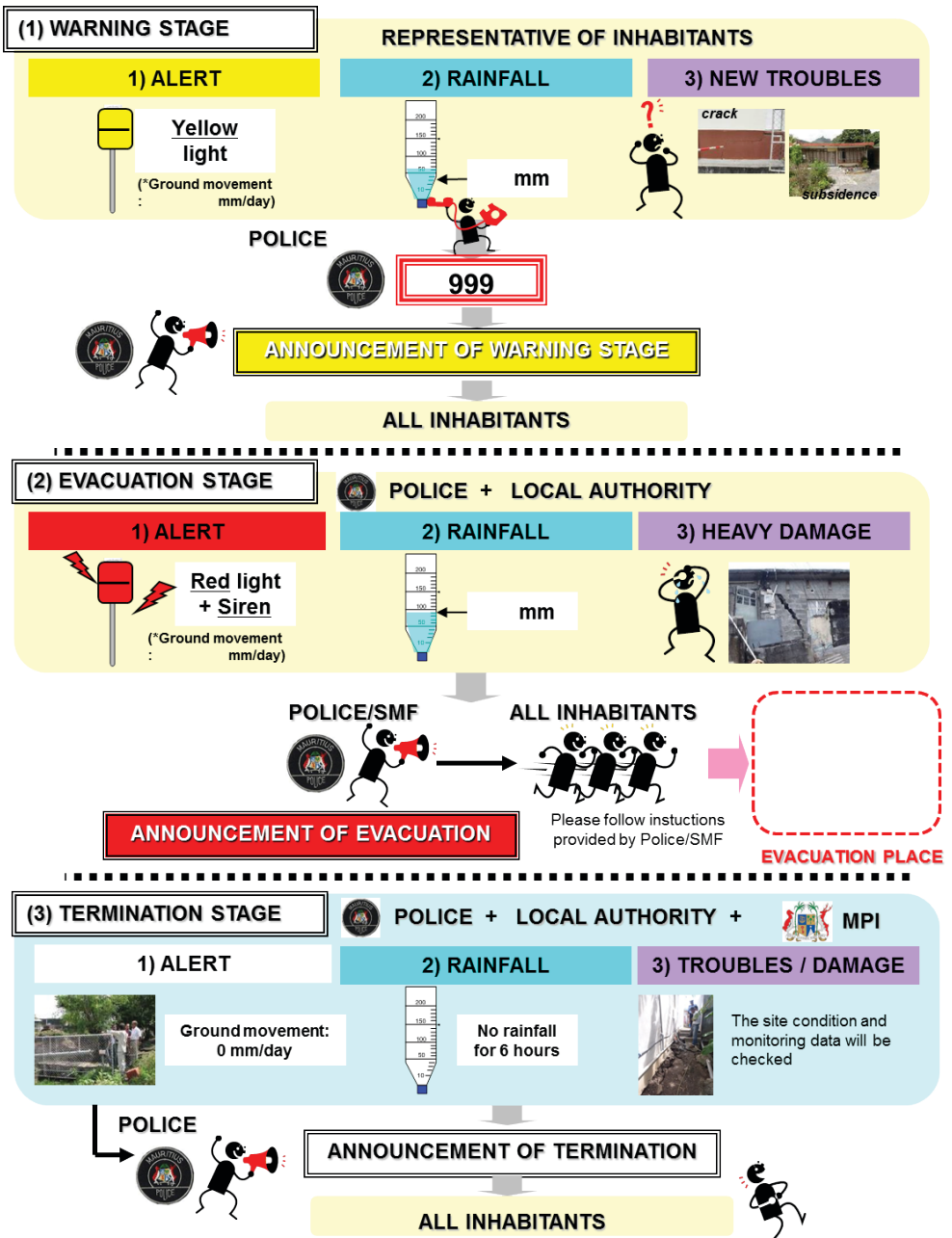


Figure 2: Early warning and evacuation system

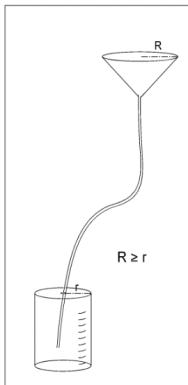
(2) Monitoring of Rainfall – “Simple rain gauge”

As described in section 4 (Page. 8), intense rainfall is one of the biggest triggers of landslide occurrence.

The following method will be useful to monitor the accumulated rainfall on site in a simple and easy way.

Structure

The structure of simple rain gauge basically consists of a funnel, a PET bottle and a hose as shown below.





How to use?

The next page gives the instructions how to use a simple rain gauge at home.

The criteria for both yellow and red lines should be determined based on the actual rainfall data in your residence area. Please contact the appropriate authority to obtain the criteria and fill in the Table 3.

Table 3: Actions to be taken at warning and evacuation stages

Line color	Stage	Amount of continuous rainfall daily	What to do?
 Yellow line	Warning stage	mm	Call the Police, and be ready in the event of an evacuation
 Red line	Evacuation stage	mm	Start evacuation following the instructions given by the authority

(1) Every morning (When you wake up every morning...)

1) Check the current weather at your place when you wake up every morning.



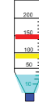
2) Follow the instructions described below.

Fine/Clear or Cloudy (NO RAIN)



Empty the bottle

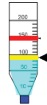
Rain (incl. drizzle)



Leave the water inside

(2) If the Water has reached the YELLOW line...

1) When the water has reached the YELLOW line, CALL the Police and INFORM them about the condition.



YELLOW line



Tel: 999

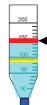
Tell the Police about:

- 1) What time did the water reach the yellow line?
- 2) Current weather condition (still raining or not).

2) Prepare for evacuation. Do NOT empty the bottle. The Police will be dispatched to your place after your call.

(3) If the Water has reached the RED line...

1) When the water has reached the RED line, TELL the Police who are on site, and INFORM them about the condition. Please CALL the Police if they have NOT arrived yet.



RED line



Tell the Police about:

- 1) What time did the water reach the red line?
- 2) Current weather condition (still raining or not).



Tel: 999

2) Evacuate according to the instruction provided by Police/SMF.

Figure 3: Instruction manual on the use of simple rain gauge



8-3. Evacuation center and route

Evacuation centers may include schools, public halls, community centers, etc. Check the local evacuation area near your house and make an access map.

For evacuation route, you need to avoid the active landslide block (To check with the appropriate authority).

My evacuation center:

Map:

8-4. Always be prepared

(1) Hold a family meeting

Set an evacuation place and a method of communication.



(2) Ready for emergency item

Your emergency pack should contain the following necessities. Place your knapsack near the doorway for easy access.

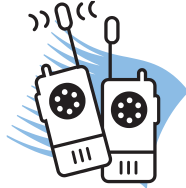


Portable Emergency Items

Foods	Drinking water Emergency foods (biscuit, canned food, retort foods, etc.) Powdered milk, baby bottle Knife, can opener	Clothing	Under wears Towels Raincoat Warm clothing
Medical Supplies	First-aid kits Medicine Diapers, sanitary products Tissue paper	Daily goods	Flash light, Radio, Batteries, Gloves, Disposable heating pads Pens, Plastic bags Cigarette lighter, Matches, Helmet, Protective hood
Valuables	Cash, bankbook, Medical card ID card		

(3) Inside the house

- ① Avoid putting things in the hallway and the entrance to secure a way out.
- ② Check emergency items; Flash light, portable radio, first-aid kits, emergency food, and so on.



(4) Safety check for the house

Carry out regular check and reinforcement.
Repair and reinforce any deteriorating concrete block wall.



(5) Cooperating with neighbours

Community collaboration is essential to share warning information, and at the site of rescue and evacuation.

It is very important to communicate with neighbours on a regular basis, and participate in the local emergency drill.



9. Emergency contacts



Disaster Emergency phone numbers are as shown below.

Emergency call (Hotline – 24 hours)	Emergency call (your nearest Local Police)

For further detailed information about landslide, please contact the following authorities;

Local Authority	Landslide Management Unit (LMU), MPI

The following shows the contact persons who will contact the above authorities on behalf of your community.

Contact person ①	Contact person ②





