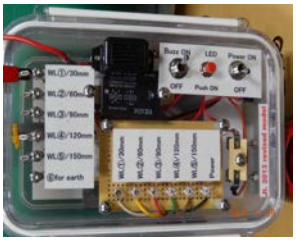
20 November 2016

Water Level Gauge and Rain Gauge for Community Early Warning System (CEWS)

Volunteers for the promotion of Community Early Warning

(VCEW)

FRONTISPIECE: Equipment for the community early warning system (CEWS) currently being produced by Volunteers for the promotion of Community Early Warning (VCEW) after years of improvement

	One sensing point	Two sensing points	Five sensing points
Monitor			
Water level gauge	 		
Rain gauge	 Rain storage	  One point sensor (Bolt type, Blade type)	  Five points sensor (Bolt type, Blade type)

INTRODUCTION

Flash floods and hydrological geo-hazards (debris-flows, landslides, slope failures) are occurring frequently in many countries in the world, and will increase in the future as the climate change continues. These hazards are caused by concentrated rains, and monitoring of such localized rainfall by national observation network is difficult. Besides, these hazards occur all of a sudden, and the government systems are not quick enough to issue/communicate warnings. These problems are particularly serious in developing countries where government system for monitoring, communication etc. is weak. Further, there are many cases where equipment provided by external assistance is not working properly due to technical problems relating to maintenance.

In view of these situations, development of equipment suitable for community early warning system (CEWS) was initiated in 1990s - 2000s in Central America and the Caribbean[1)] with the principle: "Assembly, operation and maintenance by community people themselves".

Following these initiatives, 'Volunteers for the promotion of Community Early Warning (VCEW)' in Japan continues to develop equipment for CEWS consistently in the same principle (Ref. End Note). It is to be noted that the Sendai Framework for DRR 2015-2030[2)] emphasized the importance of CEWS, in particular, simple and low-cost equipment.

This paper aims at introducing equipment suitable for community early warning system (CEWS) to persons/groups working for community disaster management in developing countries so that the community system will be further promoted. Moreover, VCEW expects that self-reliant early warning systems will be established in many communities in the world with this paper as a guide.

1. EQUIPMENT IN GENERAL

■ Overview of the equipment

PRESPIECE shows equipment for the community early warning system (CEWS) which VCEW is currently producing after years of improvement. It consists of:

- ✓ **Monitor:** to monitor water level and rainfall detected by water level gauge and rain gauge. Each time they reach pre-set levels, the buzzer sounds for alert and warning.
- ✓ **Water Level Gauge:** to detect water level when it reaches the pre-determined levels.
- ✓ **Rain Gage:** to detect rainfall when it reaches the pre-set levels. Rain gauge has two types of sensor: bolt type and blade type.

Each equipment has three types in terms of the number of sensing level: single level, two levels and five levels. However, equipment for other levels (three levels, four levels) can be assembled by slightly changing the equipment for five levels.

■ Characteristics of the equipment (advantages and limitations)

Equipment developed by VCEW has the following characteristics:

Advantages:

- ✓ Cheap in cost[3)]: Cost is cheap by using materials available locally in any developing country except for specific items such as the relay for the monitor.
- ✓ Simple in assembly: Inexperienced persons can assemble the equipment, although involvement of persons with knowledge of electricity is desired.
- ✓ Easy for O/M: Any trouble in O/M can be solved by persons who assembled the equipment, without resorting to external assistance which is costly and takes time.
- ✓ Safe in operation: Monitoring is done in the house without going out to the observation site under storm, mid-night and other difficult conditions.
- ✓ Operation without fail: Heavy rains and sudden floods are monitored without fail even if they occur in the mid-night, as the buzzer sounds each time the rains/water level reaches the pre-set level.

Limitations:

- ✓ Equipment is not for ”automatic recording”. Rains/water levels must be recorded manually.
- ✓ Equipment is not for “real time observation”. Rains/water levels are observed basically when they reach each pre-set level, although can be observed visually at any time.

■ Considerations in applying the equipment

✓ Water Level Gauge or Rain Gauge or in combination?

The water level gauge has the advantage that information on possible flooding provided by water level gauge is more accurate than that by rain gauge. However, the lead time for evacuation is less.

While, the rain gauge has the advantage that rainfall information provides a longer lead time than the water level. However, the accuracy in the flood prediction is less because of the complicated relation between rainfall and flood and limited number of observation site (usually one) which do not represent the rainfall over the catchment.
Combination of the two making use of their respective advantages is ideal, however, application will be limited to communities which are capable of such a rather complex system.

✓ One sensing point, two sensing points, or more than two sensing points?

One point sensor is for 'warning' level which indicates flooding is imminent and all people should evacuate immediately.
Two points sensor is for 'alert' level and 'warning' level. 'Alert' level indicates possible flooding and people are requested to prepare for evacuation, while aged persons and others in need of help should move to evacuation places.
Sensor with more than two sensing points is useful for communities which pursue evacuation in more stages, however, one or two sensing points will be effective enough for practical operation of evacuation at the community level.

✓ Setting of the alert level and the warning level

Initially, 'Alert' and 'Warning' levels shall be determined tentatively considering past floods, and shall be revised later as data on water levels/rainfall/flooding accumulate during flood events thereafter.

✓ Advice

From considerations mentioned above as well as experiences in developing countries, it can be said that water level gauge will be preferable to rain gauge, and one or two sensing points will be preferable to five sensing points in many communities in developing countries.

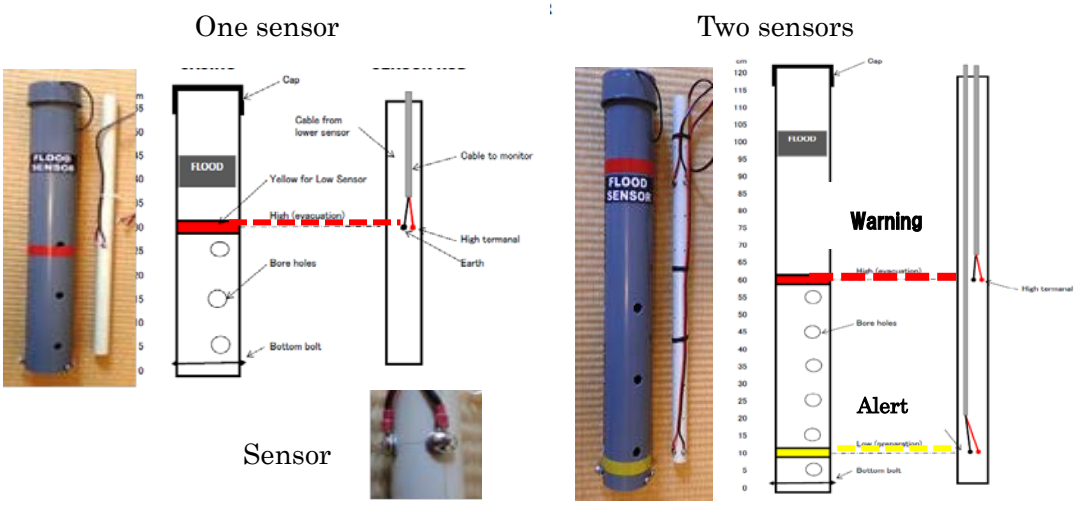
2. WATER LEVEL GAUGE

Details of the water level gauge for one sensing point and two sensing points are shown in Fig. 1.

One point sensor is for 'warning' and two points sensor is for 'alert' and 'warning'.

At alert level, people prepare for evacuation, and aged people and others in need of help move to evacuation places. At warning level, all people have to evacuate.

Fig.1 Details of the water level gauge with one and two points sensors



■ Installation

The purpose of the water level gauge is to detect alert level and warning level of flood water, therefore the gages are installed at the river side, on the bank slope or on a flat low land where water does not exist at normal time as shown in Fig.3.

The gages may be damaged if directly hit by debris etc. therefore installation sites should be carefully selected or protection measures are necessary. The gages may be fixed to a wooden/iron angle pile etc. driven into the ground or they may be attached to a big tree.

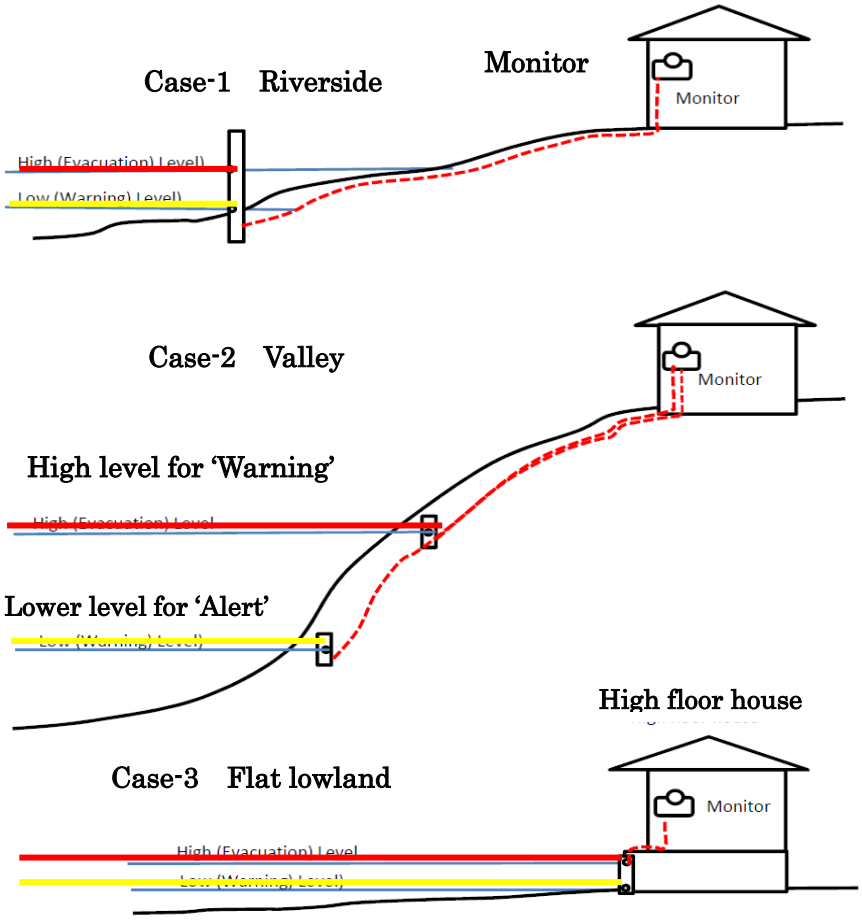
Fig.2 Installation of water level gauge

Fixed to a wood pile
(Solomon Is 2016)

Fixed to an iron angle
(Kenya 2013

Attached to a big tree
(Costa Rica 1999)

Fig.3　Installation of water level gauge (Example of two sensors system)



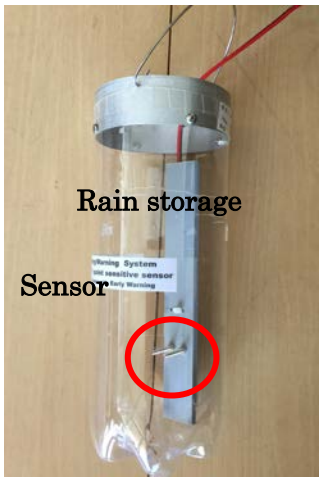
One rod with two sensors at the river side

A pair of one rod with one sensor at a valley where slope is steep or flood rises quickly

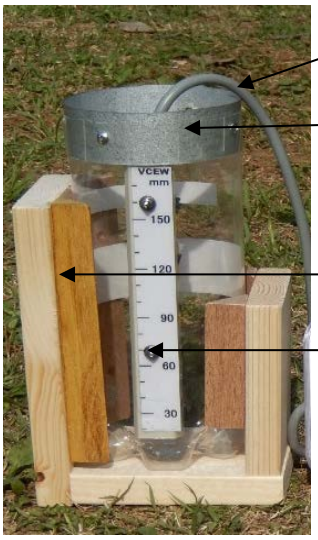
One rod with two sensors at a place where there are high floor houses in a flat lowland and flood rises slowly. The gauge can be attached to a pillar of the house.

3. RAIN GAUGE

Fig.4 Details of Rain Gauge



Example of one point sensor

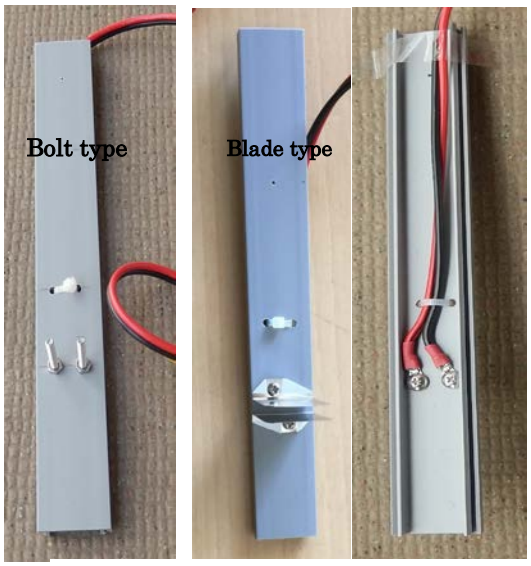


Cable to connect Sensor and Monitor

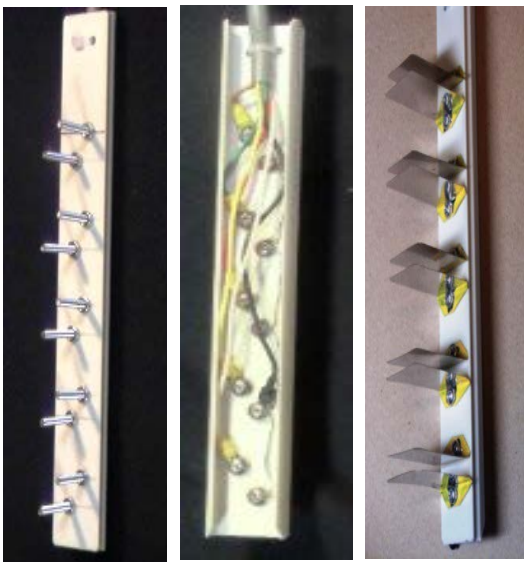
Reinforcing metal belt

Wood frame to support the rain storage

Scale and Sensor (Sensor is behind the scale)



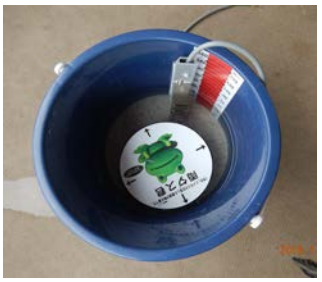
Example of one point sensor



Example of five points sensor

■ **Rain storage:** The material of rain storage should be durable against sun-shine as shown in Fig.5. Polyethylene bottle easily deteriorates. VCEW uses PET bottle (soft drink bottle, wine bottle) as a standard which is durable and easily available in most countries, although it is soft and requires reinforcing by metal belt etc. as shown in Fig.4.

Fig. 5　A variety of materials for the rain storage

			
			 Concrete is placed at the bottom to be stable against wind. A float is used to make the water level more visible.
Cookie can	PET soft drink bottle	PET wine bottle	Bucket (plastic, tin)

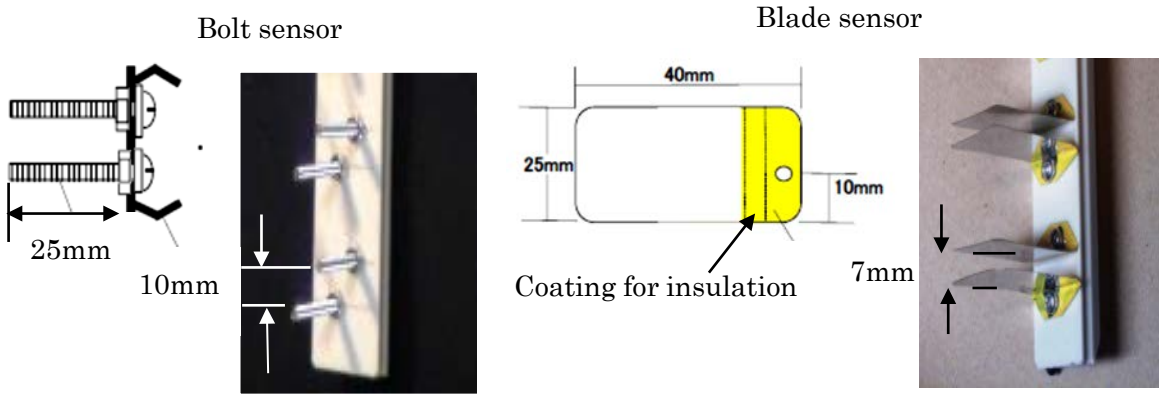
■ **Sensor: Bolt type or Blade type?**

Rain water is very pure and electric conductivity is too small for sensors to work properly. Various types of sensors were examined in terms of the shape and the space between the earth and the sensor, resulting in the two types of sensors: bolt sensor and blade sensor as shown in Fig. 6.

In the case of the bolt sensor, it is necessary to put a little salt in the rain storage to increase the electric conductivity, while in the case of the blade sensor, conductivity is much better than bolt sensor, and practically no problem has been found so far. However, the conductivity varies according to the location of the observation site and the time during the spell of rainfall (beginning or towards the end), therefore theoretically there are cases that the sensor may not work properly according to the local and rainfall conditions. It is also to be noted that assembly and repair works are easier in the case of bolt sensor than blade sensor.

As such, it is recommended to use bolt sensor, and, if blade sensor is preferred, it is recommended to conduct test of the performance of the sensor using actual rains.

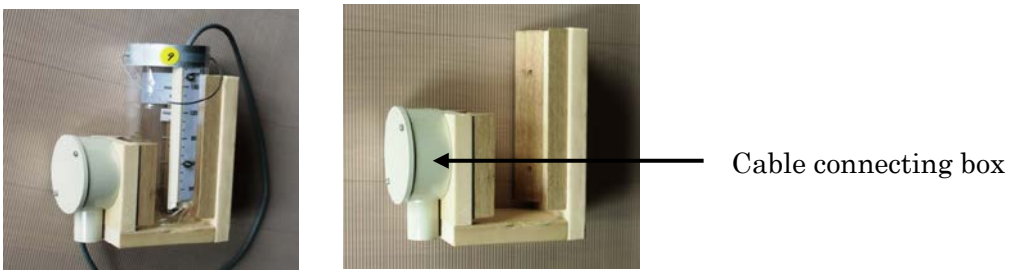
Fig. 6　Details of bolt sensor and blade sensor



■ Installation

The rain gauge should be installed where rainfall is not disturbed by houses, trees etc. Usually it is installed in the garden or on the roof of the house. Wood frame is used to hold the rain storage stable.

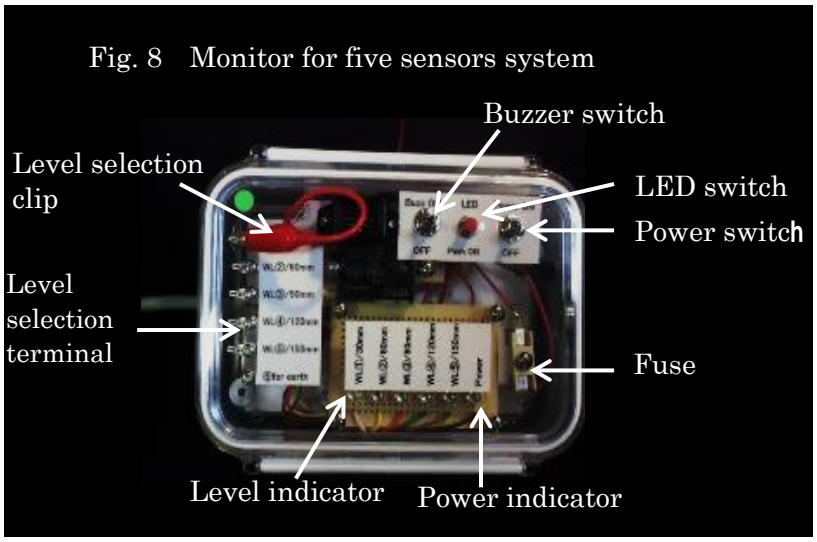
Fig.7　Wood frame and cable connecting box



4. MONITOR

Details are shown in Fig. 8 ～ Fig. 12.

Fig. 8　Monitor for five sensors system



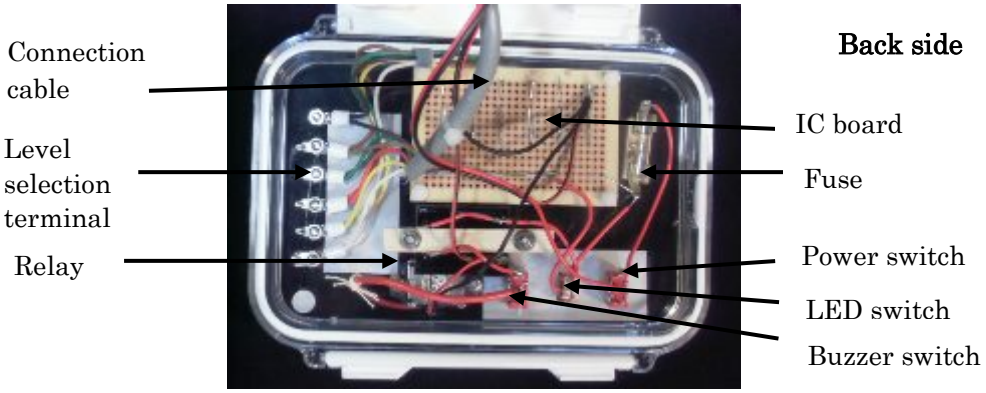
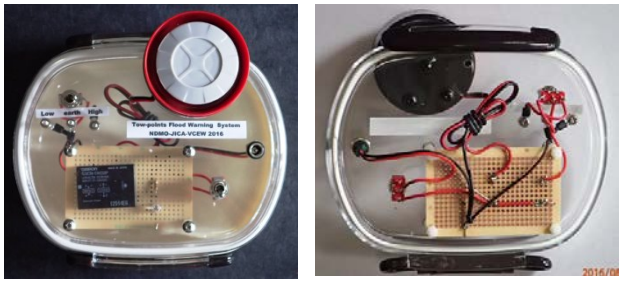
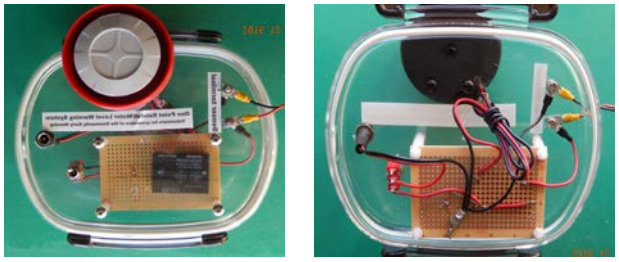


Fig.9 Monitor for two sensors system



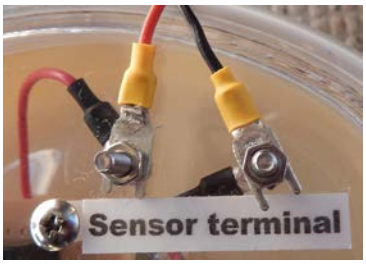
Left: Front side
Right: Back side

Fig.10　Monitor for one sensor system



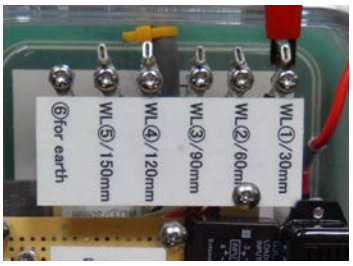
Left: Front side
Right: Back side

Fig.11 Sensor terminal



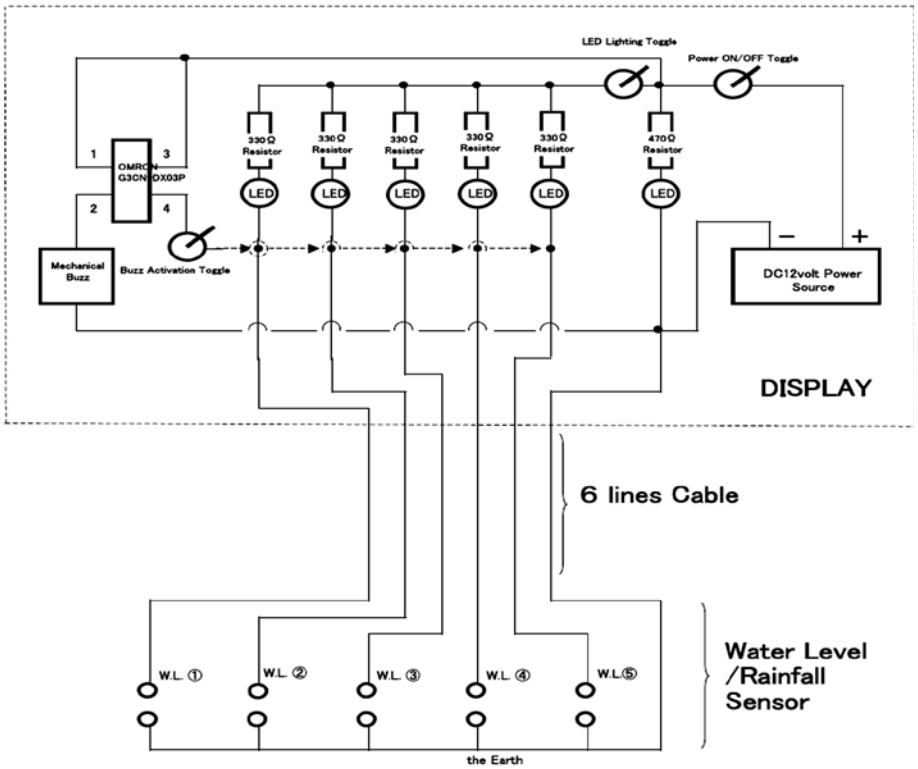
One sensor terminal

Two sensors terminal

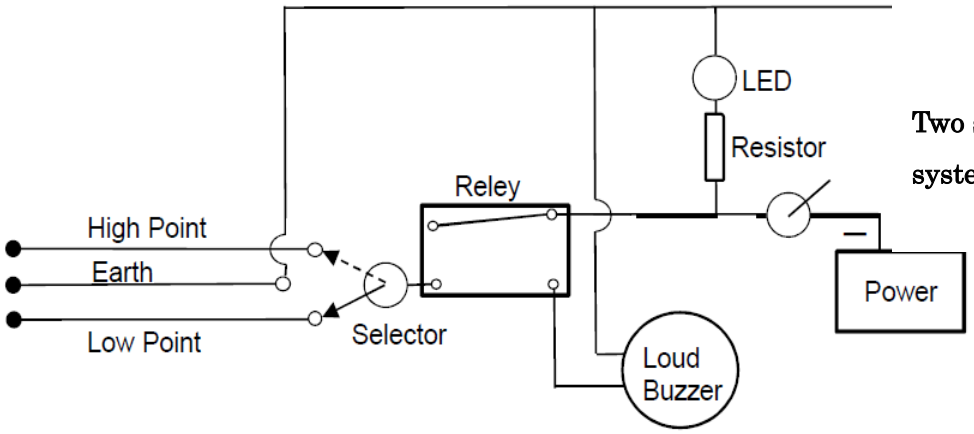


Five sensors terminal

Fig.12 Circuit diagram



Five sensors system



Two sensors system

■ Installation

Monitor: The monitor is to be placed at a location in the house which is convenient for the observer to work, such as living room, kitchen, study etc.

Power source: The 12 volt DC electricity can be supplied by (1) AC converter, (2) batteries, (3) solar panels with batteries, or combination of them. Considering the possibility of power failure due to storm etc., combination of (1) and (2) or (1) and (3) are desirable. Solar panels are recommended for rural areas where electricity supply is not stable or not available.

Connecting cable: The cable between the water level/rain gauge installed outside and the monitor in the observer's house should be buried in the ground or hung high above the ground to avoid damage by animals etc.

Fig.13 Connecting cable between gauge and the monitor

Works to bury the cable in the ground (Kenya, 2013)

Cable hanging high above the ground (Solomon Is., 2016)

5. OPERATION AND MAINTENANCE (O/M)

Main points of O/M are summarized in the table below. The observer and personnel responsible for inspection, repair etc. should be nominated in each community and clearly mentioned in the community disaster management plan. The community should have the primary responsibility for O/M, however, support of the government is indispensable for effective and sustainable O/M.

Main points of O/M

	Water level gauge	Rain gauge	Monitor
Dry season		Keep the gauge in the house or place a cover to prevent damage and weathering	
Beginning of rainy season		• Wash the rain storage and clean the sensor • Inspect sensor bolts and cord, and repair or replace by new ones if problems are found	• Check the power source • Check the connection between monito～cable～gauge
During rainy season			Leave the power off in normal time
When Alert or Warning is issued		• Empty the rain storage • Put a little salt in the rain storage	• Connect level selection clip to initial level • Turn on Power and Buzzer switches
During flood	• When initial level is reached and the buzzer sounds, record the time and the level • Connect the level selection clip to the next level • Repeat the same operation for each level (This is not necessary for one point sensor)		
After flood	Inspect the gauge after each flood, and repair if damages are found		

End Note

Volunteers for the promotion of Community Early Warning (VCEW) is a group of persons who wish to work voluntarily for the promotion of community early warning system(CEWS) in developing countries, making use of their respective experiences in developing countries and international organizations as well as in Japan.

VCEW develops water level gauge and rain gauge suitable for CEWS, and donates them to developing countries[4]. The intention is not to provide the equipment to all disaster prone communities but to a limited number of organizations (government organizations, NGOs etc,) which will be the core for mass production and will support communities in O/M, thus establishing a self-reliant system in each country. Technology transfer workshops in Nepal (2011), Fiji (2011), Kenya (2013) ad Solomon Is. (2016) is in line with this principle.

VCEW provides the equipment to international organizations as well[5], for the information sharing for the further improvement of the equipment, as well as for dissemination of the equipment to developing countries through their channels.

VCEW does not think that VCEW equipment is the best and applicable universally to all communities in the world. Rather, the intention is to offer the equipment as one of alternatives from which communities select the most suitable to them.

VCEW is pleased to send the equipment to any person/group/organization, in particular, to those who wish to assemble the equipment by themselves. Although the intention of this manual is to provide information necessary for assembly, not all information is provided. The actual equipment will also be useful together with this manual.

Foot Notes

1) The development of water level gauge was initiated in late 1990s after Hurricane Mitch by Dr. Juan Carlos Villagran when he was working for CONRED of Guatemala. CONRED is still producing the equipment for Guatemala and Central American countries. The development of rain gauge was initiated in early 2000s by Prof. Jacob Opadeyi of West Indies University, Trinidad Tobago under JICA CADM project with which he was closely associated.
2) "Sendai Framework for DRR 2015-2030" which was adopted at the 3rd World Conference for DRR in March 2015 emphasized the importance of CEWS as follows: "It is important to develop, maintain and strengthen people-centered forecasting and early warning systems …. Develop such systems through a participatory process. Promote the application of simple and low-cost early warning equipment and facilities and broaden release channels for early warning information" [Paragraph 33 (b)]
3) Cost varies according to the number of sensing points. Approximately, Monitor costs US$ 30 for one sensing point～US$ 40 for five sensing points. Likewise Water level gauge costs US$ 10～30; and Rain gauge costs US$ 5, except for the connecting cable which costs one US$/meter as of

September 2016.

4) The equipment has been sent to developing countries including Philippines, Taiwan, Laos, Thailand, Myanmar, Sri Lanka, Nepal, Kenya, San Tome and Principe, Fiji, Solomon Is., Guatemala, El Salvador and Barbados.

5) The equipment has been sent to international organizations including ESCAP, WMO, World Bank, IFRC, ICIMOD, ADPC and ADRC.

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