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Fish as Early Warning System Animal Disaster Mitigation Cold Lava Technology Integrated Remote Sensing and GIS (Geographic Information Systems)

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Abstract—Cold lava is a type of secondary danger of catastrophic volcanic eruption. Until now there is no early warning system that is capable of detecting effective disaster cold lava. But nature has provided a natural homeostatic mechanism which is one component of a natural early warning system that has not been explored, one of which is the diversity of wildlife that serve as bio-indicators. So far, the potential of wildlife and their behavior can be used as an indication of a natural disaster (animal early warning system), the limited results have not been a lot of research and applications directly because there is no proper method and easy to apply. Here the authors try to give you an idea on how to utilize remote sensing technology and GIS (Geographic Information Systems) to determine the direction of flow of cold lava, by analyzing the behavior of migratory fish as an object to be observed. The selection of fish as the observed object because fish is an aquatic species that is able to capture the early symptoms of the presence of cold lava flow. Species of fish are very sensitive to the presence of early symptoms of cold lava flow because the fish have seen behaviors that are related either individually or collectively. A wide variety of fish behavior is a way for the fish to interact dynamically with the environment. Sensitivity and instinctive response of fish to changes in nature, would pose a danger which is not owned by humans. It can be used as an early warning of natural disasters that will and is happening, so it can be used to raise awareness before disaster occurs. Fish will migrate when the disaster happened so cold lava can be detected using GIS (Geographic Information Systems) and Remote Sensing. By knowing the direction of migration of these fish it can be seen that the area of disaster cold lava safe and predictable direction of flow of cold lava disaster mitigation that can be done to reduce the negative impact.

Keywords—Animal early warning system, fish, cold lava, GIS (geographic information systems), remote sensing technology

1. INTRODUCTION

INDONESIA has 129 active volcanoes, 15 of which are categorized as critical volcanoes. The mountain is located along 7,000 kilometers of the volcanic belt Aceh to North Sulawesi through the Bukit Barisan, Java, Bali, Nusa Tenggara, Maluku, Central Sulawesi and North Sulawesi. Every year there is an average of one huge volcanic eruption. The area around the volcano is a fertile area so that the area has many residents and used as agricultural land or plantations. More than 3 million people living in restricted areas (Hazard I) or regional alert (Danger II). This causes a volcanic eruption could threaten the safety of people living near the volcano area (Sarwidi, 2005).

Note from the Directorate of Volcanology and Geological Hazard Mitigation (DVMBG), states that to date are classified as volcano alert status (active) is high on the Mount Merapi volcano, Mount Talang in Solok, and Mount Anak Krakatau in Banten. Assigned volcano alert status (moderate activity) include the Tangkuban Perahu in Bandung and mountain Egon Flores. While the volcano alert status (low activity) consists of Mount Semeru in Lumajang (East Java), Mount Reef the play Ethan and mountain in North Sulawesi and Halanah in Maluku mountain (Nurhadi, 2005).

The threat of a volcanic eruption and loss of life and property damage settlement. Damage and casualties caused by lava flows, throwing stones, ash, hot clouds, toxic gases, and others (National Aeronautics and Space Institute, 2002). Danger of volcanic eruptions halved by the time, namely the main danger (primary) and follow-up (secondary). Both are at risk of damaging and deadly (Coburn, et al., 1994).

Major Hazards (Primer)

The main danger from volcanic eruptions are a direct danger occurs when the outbreak is ongoing. Type the dangers are hot clouds, throwing material incandescent, rain of ash, lava, toxic gases, and tsunamis (Coburn et al., 1994).

Danger Following through (Secondary)

The danger is the danger of follow up volcano that occurred after the last outbreak. In the event of a volcanic eruption, there will be a buildup of material in a variety of sizes at the top of the peak and slopes. On arrival the rainy season, most of the material will be carried away by the

rain and mud formed as flood rock (lava cold) that could damage any settlement (Coburn et al., 1994). Lahar dingin conditioning is a term of the Java language, which has become an international term, is the flow of water (rain, snow melt) mixed regularization tefu (volcanic material) derived from the top of the body that have been destroyed by the volcanic eruption. Cold lava flow and density high speed so as to hit and carry boulders up to 2 meters in diameter. The temperature of lava is the same as the surrounding temperature, and the sedimen are breccias with fragments of lava are subrounded (Anonymous, 2010).

There are several reasons why the lava cool to look out for, including as cold lava exerts a very powerful lunge. This is evidenced by the fall of a number of bridges made of concrete footings that can be crumbled by cold lava lunge, a large volcanic materials such as stone and sand can pile whatever passed by. Disaster cold lava can occur in as quickly as a long-term, because the material is swept into a pile of cold lava occurring gradually, and reached the area by cold lava flow, can throw farther than the distance to reach the clouds warm or hot lava (Anzenhira, 2010).

Basically geological disasters such as earthquakes, volcanic eruptions, and tsunamis, a natural phenomenon that can not be prevented, but that might be done is to reduce the risks or negative impacts wherever possible. Efforts should be made to anticipate and mitigate the adverse impacts of natural hazards mitigation is to do, that all actions taken to reduce the impact of a natural disaster. Mitigation can be done before a natural disaster occurs, including the preparation and actions of long-term risk reduction (Coburn et al., 1994). Disaster mitigation and includes the activities of protective actions beginning with the action of physical activity until such procedural techniques standard in the handling of a hazard (Sudirman 2005). One of the key components in disaster mitigation is an early warning system. According Sutomo (2005), the early warning system is needed to control and detect natural disasters like cyclones, floods, forest fires, earthquakes, volcanic eruptions and the like. Early warning system is instrumental in reducing the negative impact of natural disasters, including the number of casualties or material loss or property. Development of the system early warning in Indonesia, many refer to the information technology adopted from overseas. The implementation of an early warning system by using advanced information technologies, facing many obstacles that require large cost to build and maintain, and require a telecommunications system to deliver the information to the population (Sutomo, 2005). NASA's website tells us that three of the four tsunami warning equipment installed since 1948 in Hawaii, has been damaged and expensive maintenance cost. Evacuate the system repair cost as much as 68 million USD (Sunotoyo, 2005). Early warning system in Indonesia still has many limitations and shortcomings so that a given role is still very minimal and ineffective. It can be seen from the condition of earthquake monitoring network owned Climatology Meteorology and Geophysics (BKMG). BKMG owned equipment is still inadequate since semi-manual system, the availability of data varies, data processing facilities has been inadequate, and the seismograph is still short

periods (Sutomo, 2005). In addition, parts of Indonesia in the form of islands will require more equipment disaster warning, so the cost of the required also increases.

Basically, early warning systems are already available in nature as one of the natural homeostatic mechanism. Indonesia's biodiversity is one of the components of natural early warning system that has not been explored, one of which is the diversity of wildlife. So far, the potential for wildlife and his behavior as an early warning of natural disasters (animal early warning system), is still widely studied in the research stage and not yet widely applied directly. According Sunotoyo (2005), developed countries such as Japan and China have made use animal behavior as an indicator of impending earthquakes. Changes in animal behavior that occurs before the natural disaster comes, can be used as bio-indicators of impending natural disasters. According Shiddiqy (2005), the animal has seen behavior interrelated individually and collectively. Various kinds of animal behavior is a way for these animals to interact dynamically with the environment. Sensitivity and animal instinct to respond to hazards that are not possessed by humans, can be used as an early warning of natural disasters, so it can be used to raise awareness before disaster occurs. Utilization of animal and its behavior as an early warning of natural disasters, is much cheaper and simpler than an early warning system with high technology (Sunotoyo, 2005).

Animals have senses that are very sensitive to sound, touch temperature, vibration, electrostatic and chemical activity and magnetic and electric fields. It makes animals can feel and know the early presence of vibrations caused by earthquakes or volcanic eruptions. Earthquake vibrations cause fluctuations in soil and water, while the storm (tornado) cause electromagnetic changes in the atmosphere. Some animals have senses of hearing and smell are so sensitive to taste and determine when natural disasters. Research in the field of acoustic and seismic communication indicates that some species of fish are sensitive to low-frequency vibrations and is able to detect distant earthquakes before humans feel (Sunotoyo, 2005). Some experts argue that animals are able to detect changes in the Earth's magnetic field that occurred during the earthquake. Elephants and mice have the seismograph, while dogs and bats have sonograf device that detects the flow of magma in the earth. Dogs have the sharp smell, snakes are very sensitive to changes in temperature to 0.02 degrees Celsius, and pigeons have electromagnetic sensitivity (Supriatna, 2005).

Some of the animals are able to feel a tsunami that will come when the earthquake happened in the sea. Species of birds, dogs, elephants, and tigers can detect infrasonic frequencies between 1-3 Hertz. While humans can only hear sound frequencies between 100-200 Hertz, so that more animals have sensitivity to low frequency sound waves which humans can not hear. Several alternative theories related to the sensitivity of the animals in natural disasters and has gained approval from many experts are (1) the animal can feel the change in the magnetic field occur ie in the epicenter, such as pigeons, turtles, and bees; (2) species fish are very sensitive to variations of the electric load changes in water that is sometimes signal the beginning of an earthquake;

(3) organisms that live in the soil can respond to changes in the polarity and concentration of atmospheric ions or particles loaded, so this makes the animal is able to detect the effects of ionization air from radon gas released from the earth before the earthquake occurred; (4) the piezoelectric effect also suggests that pressure changes occurring in the crystal kwarsa kind, will produce electric charge on the surface of the crystal. It is assumed that evokes a strong enough electrical energy and cause the ions are distributed (spread) before, during and after an earthquake, so that the animal can feel the earthquake rumble through sensitivity to wind (Suntoyo, 2005). According Shiddiqy (2005), most animals have the capacity hearing (auditory capacities) over the man. In addition, animals can provide a reaction to the emission of ultrasonic sound vibrations mikroseismik of fault rocks. Fluctuations in Earth's magnetic field can cause abnormal behavior in animals. Some animals have the sensitivity to variations of the earth's magnetic field that occurred near the epicenter. Changes in Earth's magnetic field can influence the process of migrating birds and disrupt the navigation capabilities of fish. In addition, the charged ions can get out before the earthquake. This causes the charged ion particles can change the power cord wave transmitter in the brain of animals.

Development centers warning of natural disasters in every disaster-prone areas, not everything can be done. This is because the form of the islands of Indonesia where there are still many areas that are not reachable. One alternative solution that could be done in maintaining the mitigation of natural disasters in Indonesia is leveraging animal behavior as an early warning of natural disasters combined with technologies such as remote sensing and GIS (Geographic Information System) that mitigation actions better.

Mitigation of Natural Disasters in Indonesia

Disaster in the old paradigm is an event that occurs suddenly and separated from normal human life. In general disaster is still considered as a sudden event that can not be predicted and raises many questions, resulting in physical damage even fatalities. But in the new paradigm, the disaster is seen as something that is part of normal human life and does not occur suddenly (Blakie et al., 1994 in Rustiady, 2005). It is a great means little impact caused by the nature disaster is more determined and influenced by human factors in responding to the disaster. The response can be a disaster management (disaster management), which is the action that is anticipatory and preventative in dealing with issues in an effort to reduce the impact of disasters that arise.

The scope of disaster mitigation in Indonesia is very broad, with regard to the complexity of the potential disasters on land, sea and air, or interactions between them (Syamudin et al., 2004). The nature of the geological disasters are sudden, causing prediction efforts remained unsuccessful. Therefore, most businesses either in anticipation of natural disasters is the mitigation. Mitigation may mean reducing the losses resulting from natural disasters. In principle, mitigation is a good-faith effort is the preparation of physical and non-physical in the face of natural disasters. Physical preparation can be a disaster area of spatial planning and building codes. While

the non-physical preparation can be education about natural disasters, namely to recognize the symptoms of natural disasters; reaction pre-disaster and post-disaster. The risk of natural disasters that struck the community, depending on the severity of the disaster and the preparation itself or community resilience in the face of disaster (Soeristadja, 1989). According to Yuichi Morita, earthquake and tsunami expert from the University of Tokyo, the large number of casualties and the extent of the area affected by the tsunami caused by the absence of an integrated early warning system to provide information about the coming disaster.

Natural Disaster Mitigation Animal Based Early Warning System

In the scientific study of disaster preparedness or disaster management, early warning systems is one of the important parts and shape the implementation of mitigation. Early warning systems in general is a system to detect natural disasters and provide warning to the public to remain vigilant and prepare before a natural disaster. The early warning system consists of two main components, namely a sensor network to detect the activity of disasters (earthquakes, tsunamis, and volcanoes) and communication infrastructure to provide a warning to the people around the disaster-prone areas. Provision of high-tech early warning system would require huge funds for both infrastructure costs and maintenance costs (Suntoyo, 2005).

Early warning of natural disasters can be obtained naturally from animal behavior prior to the disaster. Animals can be used potentially as a low-tech early warning systems that cost less than high-tech early warning system. The researchers suspect that the ability to hear and acoustic senses owned animals, allowing the animals to hear or feel the vibrations of the earth and went to a safe place before disaster strikes. It can be seen from the small number of animals that died during the tsunami in Aceh in 2004. Kiyoshi Shimamura, a medical doctor in Japan present the results of studies related to the strange behavior of biting and barking like a dog that goes beyond the limit, can be used as a tool to predict the occurrence of earthquakes. The study was associated with the earthquake in Kobe in 1995, killing about 6,000 people. Researchers from Turkey, Sheldrake also conducted a study on the behavior of animals before the earthquake in California in 1994 and 1999 Turkish earthquake. According to Sheldrake, the results of his research showed that dogs behave strangely and can not sleep in the middle of the night, the birds in the cages looked nervous, and cats always look scared and want to hide before the earthquake.

Based on the facts, theories and research related to the strange animal behavior before a natural disaster, the sensitivity is expressed as the animal's odd behavior can be used as an early warning system of natural disasters both earthquakes, volcanic eruptions and tsunamis. According Suntoyo (2005), in applying animal behavior as an early indicator of the occurrence of natural disasters, the infrastructure needs to be supported and integrated communication systems and adequate. The communication system is needed to disseminate information about the early signs of the existence of

natural disasters and other instructions, either through television, radio, internet or submission of information by word of mouth. In addition to this, education about the dangers and signs of the coming of natural disasters, the results of remote sensing and GIS as well as the dissemination of evacuation procedures or techniques to the general public, is a factor that is very important and necessary to mitigate.

Remote Sensing

Remote sensing is the science of acquiring, processing and interpreting images that have been recorded from the interaction between electromagnetic waves with object (Prahasta, 2008). In general remote sensing has the aim to obtain and analyze information about the earth without direct contact. Because without direct contact, we need a media that can be used for observation and analysis for users. The media image is a picture of an object is the result of the acquisition of the sensors integrated in a vehicle that serves to detect the electromagnetic radiation reflected and absorbed by the object. The appearance of an object can be determined by interpreting the reflection or absorption of electromagnetic radiation, each object has a characteristic reflection or absorption of different.

Image interpretation is an activity to determine the form and nature of objects that appear in the image. There are eight elements in the interpretation of the convergent use to recognize an object which is on the image, the eighth element is the color/hue, shape, size, shadow, texture, pattern, site and association (Lillesand and Kiefer, 1994). From eight the interpretation elements, it might be color/hue is an element of interpretation of the most commonly used and can be directly used by the user to start the interpretation and considered as the elements of the most easily recognizable.

A remote sensing system is highly dependent on the energy of electromagnetic waves. In the world of remote sensing, there are two power systems on the vehicle are passive systems and active systems.

- **Passive System.** In a vehicle that uses a passive system, the main source of power required by the satellite comes from the energy source that comes from the sun. Some rides that use this system include Landsat, SPOT, NOAA, MODIS, and others.

- **Active System.** In a vehicle that uses an active system, the main source of power required by the satellite comes from energy sources generated by sensors integrated on the satellite. Some rides that use this system include Radarsat, Jers, ADEOS, and others.

Process Systems Remote Sensing Active and Passive



Figure 1. Energy reflected and emitted by the sensor remote sensing (Prahasta, 2008)

In remote sensing both in active or passive systems, a number of processes that involve the interaction between the radiation and the intended target there are several key components, namely:

1. Energy sources; is the first element in providing electromagnetic waves to a target, can be from the sun or transmitted by the satellite sensors integrated.
2. Electromagnetic waves that reach the earth's surface
3. Objects that are on the surface of the earth
4. Electromagnetic waves are reflected or returned to the earth's surface.
5. The energy that has been stored to be transmitted to the treatment received by the station to be processed imagery.

Geographic Information Systems (GIS)

Information Systems Geografis or Geographic Information System (GIS) is a computer-based, information system, designed to work with data that has a spatial information. This system can capture, check, integrate, manipulate, analyze, and display spatial data in referencing to the condition of the earth. GIS technology integrates common database operations such as query and statistical analysis with visualization and analysis capabilities are uniquely owned by the mapping. Ability in what distinguishes GIS with such other information systems makes it useful to describe the various groups, plan strategies, and predict what happens (Deny, 2003).

This system was first introduced in Indonesia in 1972 under the name Data Banks for Development. The emergence of the term Geographic Information System is today when triggered by the General Assembly of the International Geographical Union in Ottawa, Canada in 1967. Developed by Roger Tomlinson, who then called the CGIS (Canadian GIS - SIG Canada), used to store, analyze and manipulate data collected for Canada land

inventory (CLI- Canadian land Inventory) an initiative to find out the ability of land in rural Canada by mapping various information on land, agriculture, tourism, wild, birds and land use at a scale of 1:250000. Since then, the Geographic Information System developed in several continents, especially the Americas, Europe , Australian Continent, and the Asian continent (Edy, 2005). As in other countries, in Indonesia GIS development begins within the government and military. Since the rapid development of GIS be supported by the resources in moving in an academic environment (campus).

Objectives and Benefits

Preparation of this paper is expected to contribute scientific information about potential and behavior of organisms, especially fish as a natural component of an early warning system as well as one of the supporting components in implementing an early warning of natural disasters that are equipped with an integrated remote sensing information and GIS (Geographic Informasi System) as the basic information about early detection of natural disasters are cheap, easy and fast in order to reduce the impact of natural disasters for the people, both the number of casualties and losses caused.

II. IDEAS

Current Conditions

Cold lava is a type of secondary danger of catastrophic volcanic eruption. Process this disaster happened precisely when the primary phase of the volcanic eruption had stopped. However, the threat and the impact is no less terrible with the primary threat to the catastrophic bursts of hot clouds and lava. Since early December 2010, Merapi cold lava flow started to go to different areas around Merapi. Even in the White River basin, the Merapi cold lava flow causes the rupture dozens bridge connecting several villages. In addition, traffic flow across the region , almost paralyzed with damaged roads by the brunt of a giant volcanic material such as stone and sand (Anneahira , 2010).

Ever Proposed Solution

The early warning system consists of two main components, namely a sensor network to detect the activity of disasters (earthquakes, tsunami, and volcanoes) and communication infrastructure to provide a warning to the people around the disaster-prone areas. Provision of high -tech early warning system would require huge funds for both infrastructure costs and maintenance costs (Suntoyo, 2005).

Development of an early warning system in Indonesia, many refer to the information technology adopted from overseas . The implementation of an early warning system by using advanced information technologies, facing many obstacles that require large cost to build and maintain, and require a telecommunications system to deliver the information to the population (Sutomo, 2005).

According Suntoyo (2005), developed countries such as Japan and China have made use animal behavior as an indicator of impending earthquakes. Changes in animal behavior that occurs before the natural disaster

comes, can be used as bio-indicators of impending natural disasters. Utilization of animal and its behavior as an early warning of natural disasters, is much cheaper and simpler than an early warning system with high technology .

Proposed idea

Species of fish are very sensitive to changes in electric charge variation in the water, sometimes a sign beginning the earthquake, changes in the water electric charges allegedly due from the piezoelectric effect. The piezoelectric effect indicates that the changes in pressure that occurs in similar quartz crystal, will generate an electric charge on the surface of the crystal. It could be expected to generate a strong enough electrical energy and cause the ions distributed (spread) before, during and after the earthquake, so that the fish can sense earthquakes rumble through sensitivity to the wind. The earthquake itself is a vibration in the earth's surface caused by the release of energy abruptly. Meanwhile, a cold lava flow of water (rain water, snow melt) that mixed debris TEFRA (volcanic material) derived from the upper part of the body that have been destroyed by the volcanic eruption. Cold lava flows with high velocity and density so as to hit the rocks and bring up to 2 meters in diameter. This stream is also causing a vibration that occurs piezoelectric effect resulting in interference with the fish and the fish will eventually migrate away from the direction of flow of charge. Direction of migration of these fish is an area that is safe from disaster cold lava and can be detected using GIS (Geographic Information Systems) and Remote Sensing. By knowing the direction of migration of these fish it can be seen that the area of disaster cold lava safe and predictable direction of flow of cold lava disaster mitigation that can be done to reduce the negative impact .

Animals are living things that always interacts dynamically with its environment. This interaction is shown through behavior that looks and interrelated individually and collectively . Each animal has a unique behavior and specific. This behavior is an innate trait and reflection characteristics of the animal species that can distinguish it from other animals. Special behavior owned animal species will not be changed by the learning process even though all the other traits can be changed (Shiddiqy, 2005).

The fish is a member of vertebrate poikilothermik (cold-blooded) that live in water and breathe with gills. Fish are vertebrate groups with the most diverse species number more than 27,000 worldwide. Fish can be found in almost all waters that are large either freshwater, brackish water and salt water at varying depths, from near surface to several thousand feet below the surface (Wikipedia, 2011).

Assist Parties to Implement Idea

To realize this program , the following are the roles of each element or related parties , namely :

a. Government

It is expected that government and institutions to cooperate environmentalists prepare integrated natural disaster mitigation with an early warning system involving animal, especially in fish, remote sensing and GIS as one component in an integrated early warning system. Government through the disaster management agency

should be able to make policies that regulate and control the implementation of the mitigation program.

b. Research institutions .

Required the cooperation of research institutions to examine the specifics of the particular relationship of animal behavior that indicates certain natural disasters as well.

c. Researchers .

Researchers are key elements for the development of this program . Researchers sometimes still is individual, in the sense that less can work with researchers at other institutions. Though the technology has been mastered remains to be combined or integrated with other technologies in order to produce something to be desired. Limitations of the research funding is also still a dominant factor for the researchers is not creative work. Besides referrals from each institution to the researchers must often be given .

Strategic Steps To Do

- Determine the area or place that is often experienced disaster cold lava is around the volcano.
- To monitor the behavior of the fish in the river that is located around the volcano either when disaster strikes and in normal circumstances the use of GIS and Remote Sensing. So that it can be seen that the unusual behavior of the fish in the fish when there is a disaster like cold lava.
- Coordinate with the research institute of government agencies and disaster mitigation in order to distribute information about the existence of a disaster cold lava on the surrounding community.
- Establish cooperation between the relevant parties in order to create an integrated research in order to establish an early warning system for effective disaster warning system utilizing animal as a natural sensor of nature

III. CONCLUSION

Proposed Concept

Disaster cold lava has caused casualties and material losses that quite a lot, as well as the development of centers of disaster warning in disaster-prone districts do not all get done. This is because the form of the islands of Indonesia where there are still many areas that are not reachable. One alternative solution that could be done in maintaining the cold lava hazard mitigation in Indonesia is leveraging fish behavior as early warning disaster cold lava while still using technologies such as remote sensing and GIS (Geographic Information System) that mitigation actions better.

Implementation Techniques that Will Do

Deployment techniques at this writing that is the use of early warning systems in fish integrated with remote sensing technology and GIS (Geographic Information System) with cold lava hazard mitigation applications .

Predicted Outcome Will Be Raised

In principle mitigation efforts include preparation well

in the face of natural disasters that are physical (structural) and non -physical (non- structural). Preparation could be the development of physical infrastructure such as barrier beaches, river embankments, anti- earthquake building and places to evacuation centers, early warning systems, and coastal forests (green belt). While this can be a non-physical preparation spatial concepts, disaster mitigation education, and regulation (law) (Sampurno, 2004). The risk of natural disasters as a result of events or disasters which befell a group of people, depending on the weight of the lightest disasters and community preparedness or resilience in the face of disaster (Soeriatmadja, 1989). Associated with it then the mitigation of natural disasters should not be non- structural, but can be arranged through the development of research centers are expected to provide all information about natural disasters, including information on remote sensing and GIS (Geographic Information System) as well as the utilization of animal behavior bioindicator be of natural disasters (animal early warning system).

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