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A Survey of Global ICT Strategies for Monitoring and Preventing the Occurrence of Flood-Related Disasters

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ABSTRACT

Natural disasters are not peculiar to any particular geographical location, zone or country on the earth surface. Since the development of agriculture, human societies have experienced climate changes which have often had profound effects on human cultures and societies. Single-year precipitation- driven floods, wildfires, severe storms, hurricanes, tsunami and other climate-related events, occasioned by global warming, can cause severe economic damage and loss of life. In 2012, the famous River Niger and River Benue in Nigeria over-flooded their banks as a result of intense rainfall and the activities of neighbouring country, especially the opening of the Lagdo dam located in Cameroun. This natural disaster affected several Nigerian states including Kogi, Oyo, Lagos, Anambra etc. Several lives, homes and industries were affected, including a professional school for the training of sailors in Lokoja, the capital of Kogi State. Government agencies such as the National Emergency Management Agency (NEMA) made spirited efforts to ameliorate the effects of the disaster, but it was obvious that they were hitherto not adequately prepared for the magnitude of the disaster. As a result, all the inhabitants of all the communities along the rivers' coastal line were rendered homeless, in addition to severe effects on animals, birds and valuable property. Using the well-studied occurrence of Tsunami as a case study, this paper presents a mechanism for using Information and Communication Technology (ICT) to monitor and prevent the occurrence of flood related disasters, with particular reference to Nigeria. Tsunami typically results from series of water waves caused by the displacement of a large volume of a body of water like an ocean or a large lake. The major ICT preventive technologies that are highlighted are the alarm system and the bottom pressure sensor.

Keywords: Climate change, Tsunami, ICT, Natural disaster, Flood

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I. INTRODUCTION

Natural disasters are not peculiar to any geographical location, particular zone or country on the earth's surface. Human societies have experienced climate change since the development of agriculture. These climate changes have often had profound effects on human cultures and societies. Climate change, according to the United Nations Framework Convention on Climate Change [1], is a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere, and which, in addition to natural climate variability, is observed over comparable time periods.

Regardless of their locations on the planet, all humans experience climate variability and change within their lifetimes [2]. The most familiar and predictable phenomena are the seasonal cycles, to which people adjust their clothing, outdoor activities, thermostats and agricultural practices. This inter-annual variation in climate is partly responsible for year-to-year variations in crop yields, road maintenance, wildlife hazards etc. Single-year precipitation- driven floods can cause severe economic damage, including loss of life. Similar damage and loss of life can also occur as a result of wildfires, severe storms, hurricanes, tsunami and other climate-related events.

Tsunami, a Japanese word meaning "harbor wave", is used as the scientific term for a class of abnormal sea wave that can cause catastrophic damage when it hits a coastline [3, 4, 5, 6]. A tsunami is a series of water waves caused by the displacement of a large volume of a body of water, typically an ocean or a large lake. Earthquakes, volcanic eruptions, landslides, glacier carvings, meteorite impact, nuclear tests and other disturbances above or below water, all have the potential to generate tsunami [7]. The most frequent cause of tsunamis is an undersea earthquake. Tsunami waves do not resemble normal sea wave, because their wavelength is far longer. Although, the impact of tsunami is limited to coastal areas, but its destructive power can be enormous, beat human imaginations, and can affect entire ocean basins. It can as well destroy lives and drown loved ones, wash away property, cause mental effects (as the sound makes a person scared), and in some cases, may cause loss of sleep if heard at night and can equally wash away plants and livestock [6, 8, 9, 10]. Table 1 describes some of the notable tsunamis throughout the world [11].

Figure 1, Figure 2 and Figure 3 are pictorial views of the 26th December, 2004 Tsunami across the Indian Ocean which swept parts of countries like India, Thailand, Indonesia and Sri Lanka.

Generally, tsunami is a phenomenon which may be studied within such fields as Physics, Geology, Marine Engineering etc. Some of the international organizations that have been involved in carrying out research, monitoring or documenting the occurrence of tsunami include National Oceanic and Atmospheric Administration, United States Geological Survey, World Health Organization, Novosibirsk Tsunami Laboratory, and the Headquarters for Earthquake Research Promotion of Japanese Government.

In Nigeria today, the fact that tsunami had not occurred is not a justifiable reason for the various governments of the land (Federal, State and Local governments) to fold their hands. Since Nigeria is bordered by the Atlantic Ocean in the southern part, the occurrence of a tsunami is not an absolute impossibility, and as such, efforts should be made towards its prevention. A basic difference between a normal water wave (or displacement) and tsunami wave relates to the wavelength; the wavelength of the latter is much longer Hence, the study of tsunami and how it can be prevented via ICT is significant.

Two of the basic formulas for measuring the scales of Tsunami intensity or magnitude are as follows [7, 15, 16]

(i) Intensity Scales

The Soloviev-Imamura tsunami intensity scale defines the Tsunami intensity I as:

$$I = 0.5 + \log_2 H_{av} \quad (1)$$

where H_{av} is the average wave height along the nearest coast.

(ii) Magnitude Scales

On the tsunami magnitude scale M_t is defined as:

$$M_t = a\log h + b\log R = D \quad (2)$$

where a, b and D are a constants, h is the maximum tsunami wave amplitude and R is the distance of tide gauge from the epicenter

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It is noteworthy that both authors of this paper physically witnessed the 2012 floods in Lokoja, Nigeria. One of the earlier floods in Nigeria is the Ogunpa flood disaster. This disaster occurred in Ibadan, Oyo State, in 1980, when the Ogunpa River overflowed its banks.

II. ICT AND CLIMATE CHANGE

Information and Communication Technology (ICT) plays major roles in the climatic change migration and adaptation. This is increasingly being recognized between the climate change technology transfer negotiations, because according to the World Development Report 2010 [17], the use of ICT is predicted to reduce the total green house gases by 15% in 2020.

Beyond climate change mitigation, ICT has a prominent role to play in realizing Nigeria's vision 2020 mandate of building a large, diversified, sustainable and competitive economy that harnesses the energies and talents of its people and guarantee high standard of living and quality of life for its citizens.

Over time, the impact of ICT on sustainable development has often been underestimated by policy makers. The importance of this sector can be felt in the construction of ICT- enabled energy efficient buildings and electric appliances, manufacturing, logistics and power grids. Others include ICT- enabled business models, markets and lifestyles. It is clear that ICT, as both general purpose and specific technologies, are necessary in order to monitor, model, administer and disseminate climate change activities. ICT products are used for environmental monitoring such as monitoring of weather and climate change, deforestation using satellite imagery, environmental modeling and computer simulations of climate change. Other administrative uses include information sharing, environmental advocacy reduction, physical mail and paper use.

III. ICT STRATEGIES FOR PREVENTING THE OCCURRENCE OF TSUNAMI

ICT can be used as a measure to monitor and prevent tsunami, especially in Nigeria, in the following ways:

(a) Use of Tsunami Alarm System or Tsunami Warning System

The Tsunami Alarm System works everywhere in the world covered by the GSM network, provided one's mobile telephone is logged into a GSM network in the city (or country) where one is staying. The main feature of the Tsunami alarm system is its ease-of-use. One does not have to install or activate anything on one's mobile phone. All one needs do, is to subscribe to the tsunami alarm system on the website. That is, wherever one can use mobile phone for calls, one's tsunami alarm system will also be able to receive tsunami warnings. It does not matter to which GSM network one is logged on to. The Tsunami Alarm System receives earthquakes and tsunami warning information from a multiplicity of seismic measuring stations (and tsunami warning stations) from different cities all over the whole country. A seismic measuring station is a station that consists of seismographs [2]. A seismograph is a device that measures and record seismic waves. Nigeria is a country that has a very fast growth rate in terms of information and telecommunications. Even in the remote areas of the country, the GSM network is usually just as well-developed as in highly developed communities such as Abuja and Lagos. When one travels in areas accessible to tourists, one should not encounter any problem with the reception of mobile phone signals.

As a subscriber, one can be sure that one's tsunami alarm system does not miss any warning and that any tsunami will result into an alarm being sent to one's mobile telephone as soon as possible.

When a tsunami alarm is sent to subscribers, it is particularly important that it does not go unnoticed. In this way, one becomes aware of the message on one's display at anytime of the day or night and one will be able to ascertain when and where the tsunami is expected. The tsunami alarm system reliably ensures that subscribers and other people one may want to warn can apply life-saving measures several minutes before the arrival of a destructive tsunami [19].

(b) The use of a bottom pressure sensor.

When an earthquake strikes on the bed of an ocean, millions of tons of water are publicly pushed upwards or sinks dramatically downwards, thus generating a powerful wave. In deep water, the wave travels at extremely high rate of speed. The wave can be identified by a tsunami detector (tsunameter), which is anchored on the ocean floor and measures changes in water pressure when a tsunami passes above. Six of these instruments are deployed in the Pacific Ocean. When a tsunameter

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detects a tsunami, it sends acoustic signals to a buoy (a device which floats on water) on the surface. The buoy converts the signals to radio waves and relays the data to an orbiting satellite, which then alerts several warning centres. Warnings can then be sent out to the endangered regions immediately. Figure 6 explains the mode or operation of a tsunami pressure sensor system [7].

Apart from the specific ICT-based use of tsunami alarm system and pressure sensor system, other general measures for monitoring tsunami include the construction of tsunami walls and getting signals via the (erratic) behavior of animals.

IV. DISCUSSION

In general, it has been observed that about 80% of tsunamis occur in the Pacific Ocean. As a rule, a tsunami is possible anywhere in which there is a large body of water such as a lake. Indian Ocean was one of the most severe in modern times, especially in terms of the number of people killed. Many persons were killed in 14 countries which border the Indian Ocean. Furthermore, the 2011 tsunami in Tohoku, Japan, as well as the 1960, 1964, and 2004 tsunamis are classic examples of what is technically referred to as tele-tsunami.

It is pertinent that peculiar alarm system be developed for disaster-prone areas and made easily affordable. Government of Nigeria, as a matter of necessity, should do all within its power to encourage and provide the enabling environment for ICT experts/computer scientists, in collaboration with seismologists, oceanographers and other disciplines in the geographical, geological and disaster management agencies, to work together towards averting devastating disasters. And finally, advice from this group of experts and professionals should not be treated with levity. Professional associations - such as Institute of Electrical and Electronics Engineers (IEEE), Nigeria Computer Society (NCS) and Nigeria Society of Engineers (NSE) - have important roles to play. Relevant working groups within these associations need to be alive to their responsibilities in providing timely warnings and advice to the society.

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V. CONCLUSION

The importance of timely disaster warning in mitigating negative impacts can never be underestimated. Prevention is not only better but cheaper and safer than cure. ICT can play a significant role in highlighting risk areas, vulnerabilities and potentially affected populations by producing geographically referenced analysis through a Geographic Information System (GIS). Ultimately, it is the authors' hope that an appropriate (mathematical) model will be formulated for solving the peculiar floods in Nigeria, taking into consideration all the necessary variables . This is expected to lead to the development of electro-mechanical warning/alarm system for peculiar floods such as exist in Nigeria.

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Table 1: Some of the Notable Global Tsunamis

DATE	ORIGIN	DESCRIPTION/EFFECT	DEATH TOLL (ESTIMATED)
June 7, 1692	Puerto Rico trench, Caribbean	Port Royal, Jamaica was permanently submerged	2,000
1707	Tokaido-Nankaido, Japan	Tokaido-Nonkaido and environs were affected	30,000
October 28, 1746	Lima, Peru	Lima and environs were affected	3,800
November 1, 1755	Atlantic Ocean	Lisbon was destroyed	60,000
February 20, 1835	Peru-Chile Trench	Concepcion, Chile, destroyed	Not known
December 23, 1854	Nankaido, Japan	Nankaido and environs were affected	3,000
August 8, 1868	Peru-Chile Trench	Ships washed several miles inland, town of Arica destroyed	10,000 to 15,000
August 27, 1883	Krakatau	Devastation in East Indies	36,000
June 15, 1896	Japan Trench	Swept the east coast of Japan, with waves of 100ft (30.5m) at Yoshihimama	27,122
September 30, 1899	Banda Sea, Indonesia	Sea around Indonesia was affected	3,620
December 28, 1908	Sicily	East cost of Sicily, including Messina and toe of Italy, badly damaged	84,000
March 3, 1933	Japan Trench	9,000 houses and 8,000 ships destroyed in Sanriku district, Honshu	3,000
April 1, 1946	Aleutian Trench	Damage to Alaska and Hawaii	159
1958	Lituya Bay, Alaska, USA	This was caused by submarine landslides. The wave didn't travel far on the bay, but it struck the land almost immediately	2
May 22, 1960	South central Chile	Coinciding with a week of earthquakes. Damage to Chile and Hawaii	1,500 (61 in Hawaii)
March 27, 1964	Anchorage, Alaska	Severe damage to south coast of Alaska	115
August 23, 1976	Celebes Sea	Southwest Philippines struck, devastating Alicia, Pagadian, Cotabato, and Davao	8,000
July 12, 1993	Japan Trench	Okushiri Island devastated	200

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July 17, 1998	Papua New Guinea, Bismarck Sea	Arop, Warapu, Sissano, and Malol, Papua New Guinea, devastated	2,200
December 26, 2004	Indian Ocean, near Sumatra, Indoneisa	Coastal areas of Indonesia, Sri Lanka, India,Thailand, Somalia, Myanmar, Malaysia, and Maldives devastated	250,000
July 17, 2006	Indian Ocean, near Java, Indonesia	More than 5,000 people internally displaced in West Java province	668
2011	Tohoku, Japan	The tsunami crossed many oceans	Not known

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Figure 1: 2011 Tsunami in Sendai, Japan [12]

Figure 2: 2004 Tsunami in Phuket, Thailand [13]

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Figure 3: 2004 Tsunami in Thailand [14]

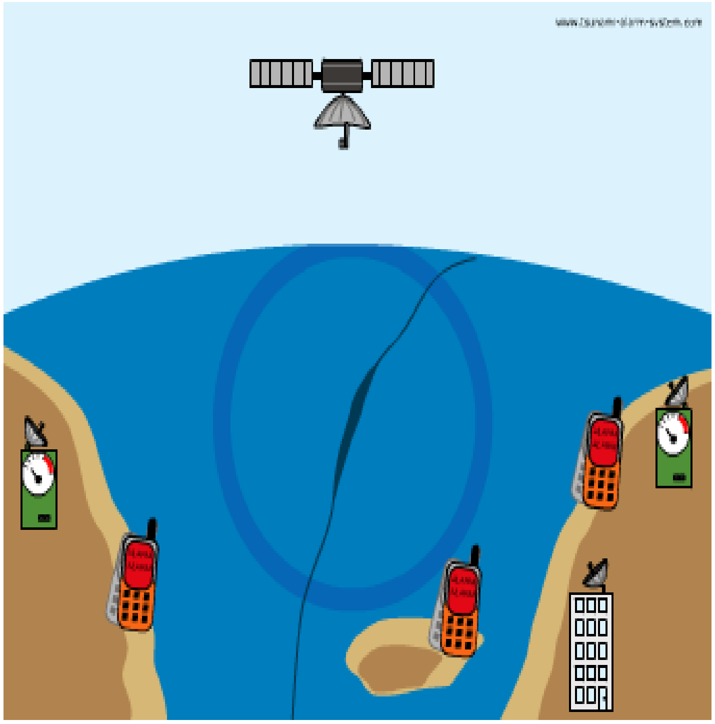

Figure 4: Simple tsunami alarm system [18]

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•Tsunami warning system

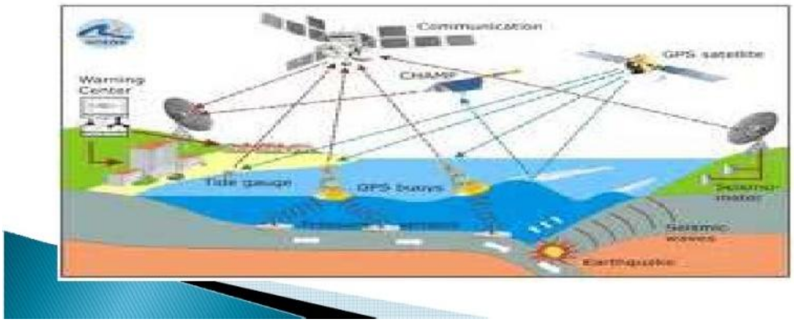

Figure 5: Complex tsunami alarm system [19]

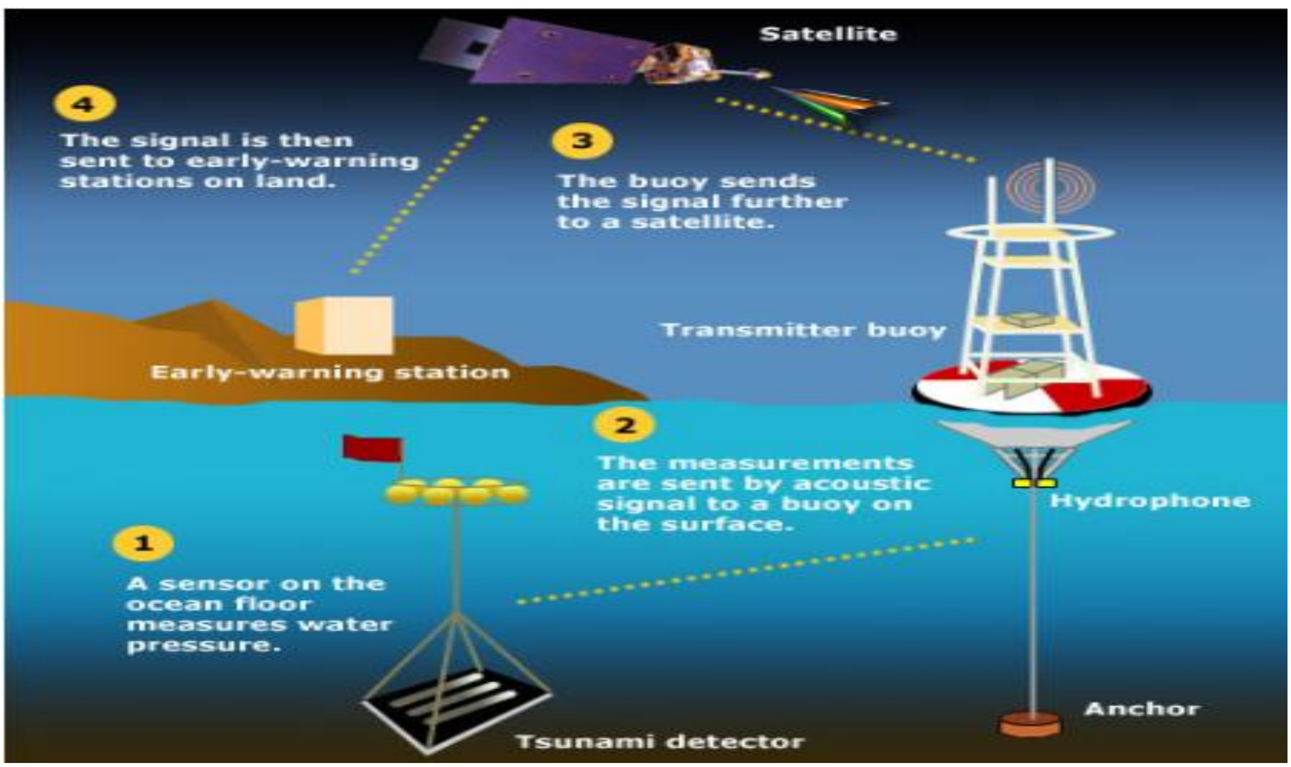

Figure 6: A pressure sensor system [7]