Achieving Smart Resource Management for Better Disaster Management using Space-based Technology in Lowershire Basin, Malawi

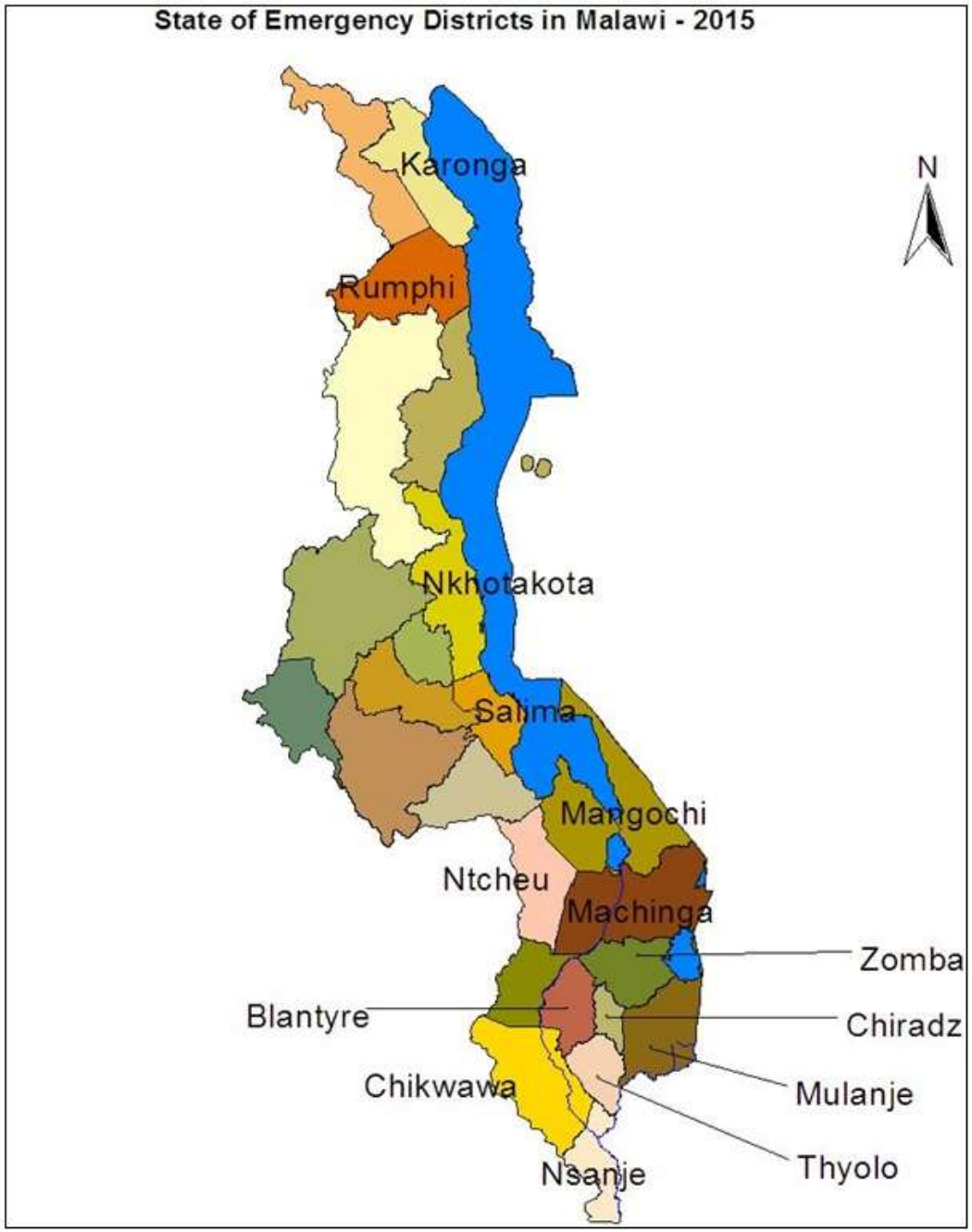
By

Donnex Chilonga

Mzuzu University, Malawi

Introduction

- Malawi is affected with floods every year.
- The January 2015 floods being the most recent.
- 174,000 people were displaced, 62 died and 153 people went missing.
- A State of Emergency was declared on 13th January in 15 districts of Nsanje, Chikwawa, Phalombe, Zomba, Blantyre, Chiradzulu, Thyolo, Mulanje, Balaka, Machinga, Mangochi, Ntcheu, Salima, Rumphi and Karonga.
- Hence the need to study and develop efficient tools to forecast these natural disasters, provide an early warning of a disaster and improve the first response calls for the provision of proper and prompt information to first responders.


State of Emergency Districts in Malawi - 2015
N
Karonga
Rumphi
Nkhotakota
Salima
Mangochi
Ntcheu
Machinga
Zomba
Blantyre
Chiradz
Chikwawa
Mulanje
Thyolo
Nsanje

Underlining questions

- What kind of information should be provided to first responders to improve their response?
- What is the best strategy to collect the information?
- How can this information be distributed in an efficient way?

SWARM INTELLIGENCE?

Swarm intelligence, an integrated system that aims at providing information to civil protection workers and first responders for early warning of a disaster (i.e. floods) and immediately after it. Such information will, among others:

- Enhance local understanding of natural disaster processes;
- Assist first responders in preparing for such and related events i.e. Early warning instruments for preparedness; Emergency recovery and relief;
- Assist in monitoring of potential dangerous situations using satellite technology instead of the unreliable traditional solutions;
- Help in the development of a real-time, web-based geographic information system (GIS) database platform which can be easily accessed for monitoring and risk mapping.

Swarm Intelligence & its uniqueness

- Swarm intelligence is the joint behaviour of a group of social insects, e.g. ants, where the agents communicate in the system either directly or indirectly using a distributed problem solving approach.
- Swarm intelligence is unique because:

a. It distributes data intelligently and innovatively through a NavCom and EO integrated systems;

b. It smartly identifies the useful real-time and/or survey-based data to be gathered, recorded and distributed.

c. It is a contemporary and advanced NavCom system for emergency rescue applications which involves the utilization of space systems and terrestrial enhanced wireless/mobile radio systems for the management of first phases of a disaster.

Space-based technologies and data collection

- One of the most important uses of satellites today is that of monitoring the Earth's environment and the processes that take place on it.
- Using these technologies it is possible to gather satellite images to create models of the changing planet, improving the understanding of Earth's dynamic processes and helping society to manage limited resources and environmental challenges.
- GNSS data can thus be obtained from permanent stations (PS) scattered within the AOI.
- Each station is equipped with a receiver, a geodetic antenna and a local acquisition system guided by specific software for storage of all positioning data and continuous compilation of all satellite signals and the recording of their code and phase over time.
- This information is broadcasted in real time by the transmission and receiver hardware of the permanent station.
- The data recorded can be accessed by authorized users for the entire area covered by the service.

Data Collection and Information exchange

- This is easily performed through the development of swarm network architectures, wireless networks, and advanced sensors.
- Three functional properties of the system-level procedure of a swarm sensor network are:

i. robustness
ii. flexibility
iii. scalability

- Two coordination mechanisms of swarm sensor network:

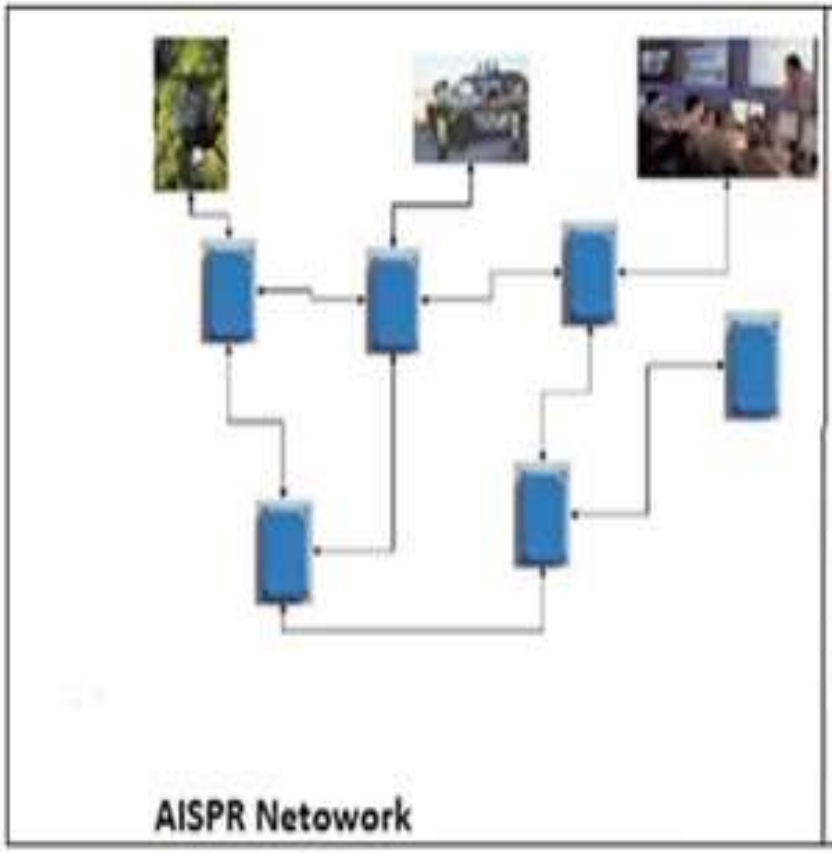
i. Self-organization
ii. Stigmergy

Adaptive Information System for Prevention and First Response (AISPR)

- This is an independent, serverless and all-encompassing network of multi-sensor nodes that provides an infrastructure that is able to route proper information to a diversified people in proper places and time during a disaster.
- The information given is time stamped and georeferenced ensuring reliability, availability, promptness, and security.
- Data processing is done using:

i. artificial adaptive systems, such as artificial neural networks;

ii. data collection and exchange of information.



AISPR Netowork

AISPR node in a building

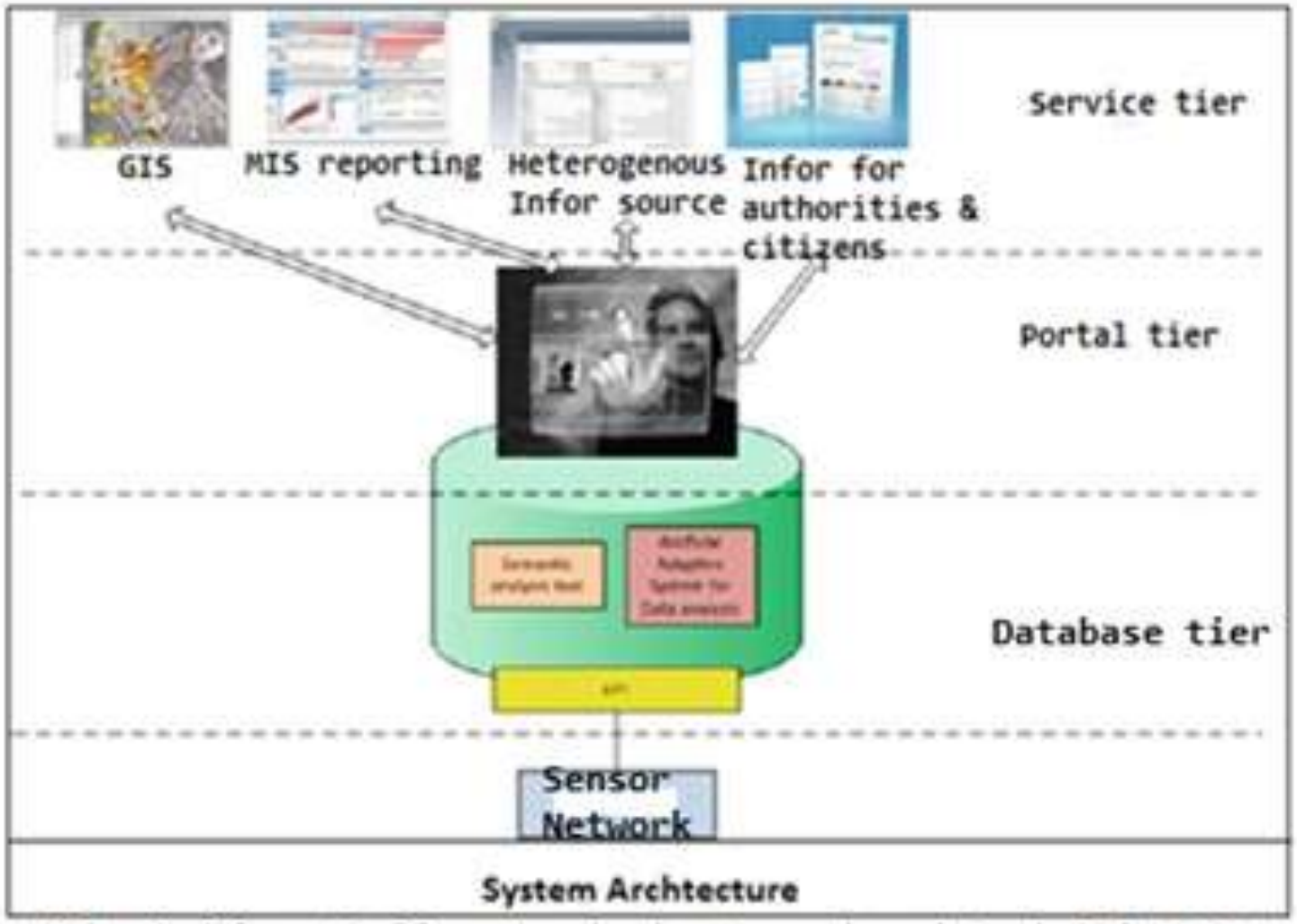
Adopted from Stallo, Ruggieri, Cacucci and Dominici, 2013

System Architecture

- Is based on a three-tier architecture:

i. the database tier,
ii. the portal tier, and
iii. the service tier

- Online forums are used to collect both structured and unstructured data coming from different sources (e.g. sensors, GPS, satellite measurements, folk information, interviews).
- Structured data and scientific measurements conducted in the area are directly stored in the database, whereas
- Unstructured data are processed using a semantic analysis tool and structured in order to be stored.
- Online forum subscribers access the database to find useful information.



Adopted from Stallo, Ruggieri, Cacucci and Dominici 2013

Illustration of the usability of the architecture in Lowershire Basin

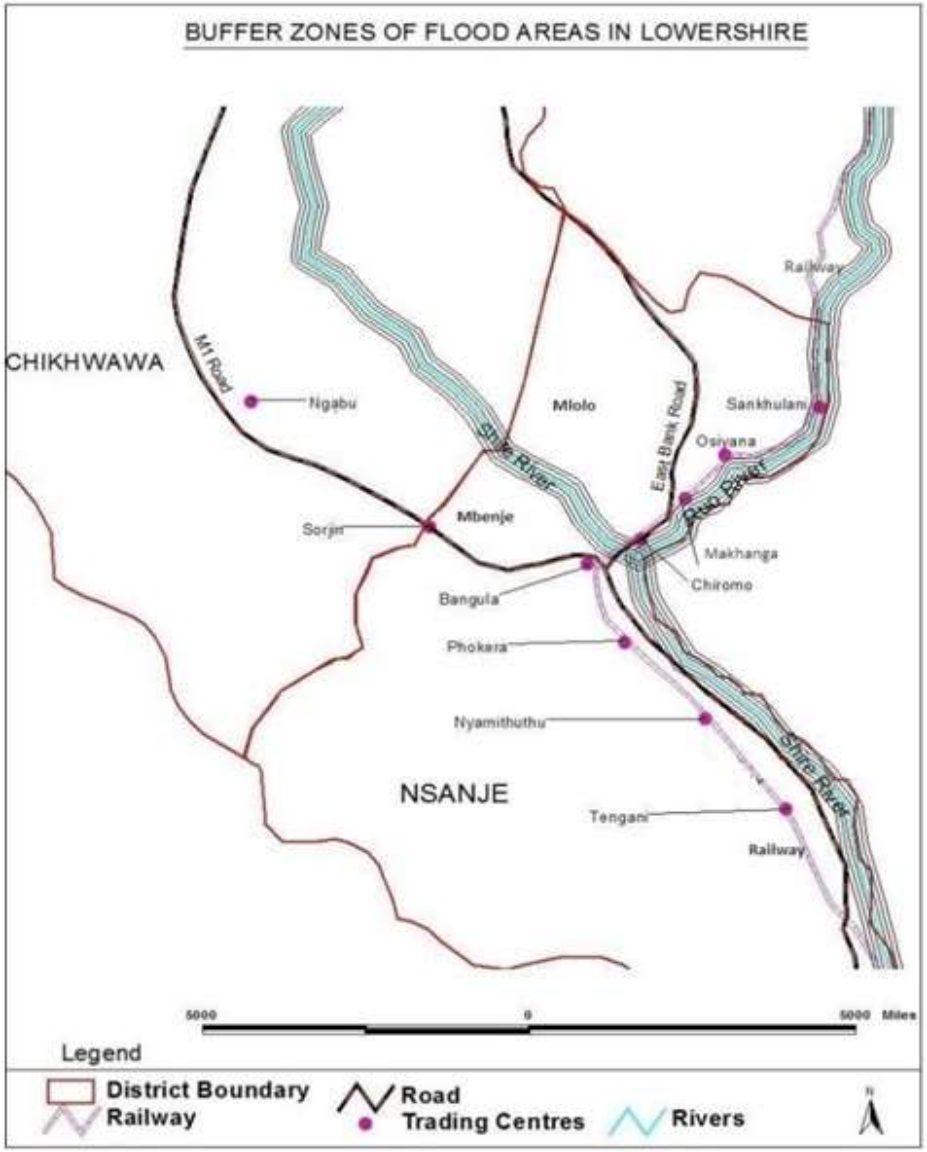


Illustration of the usability of the architecture in Lowershire Basin

- Let us analyze a typical flood disaster scenario at Mtayamoyo bridge on Mtayamoyo River in Nsanje district.

Illustration stage 1

- Soon after the floods on Mtayamoyo River, new data from the affected area, is available and stored in the database:

i. ‘‘on-ground’’ sensor data;
ii. airborne or satellite sensor data;
iii. direct information from the affected people;
iv. information from the civil protection workers in the area.

Illustration stage 2

Think of the collapse of the bridge.

- Sensors can record the event as well as people living in the surrounding area can also report the event.
- In case there is a direct call with a message such as, ‘‘Mtayamoyo bridge on Mtayamoyo River, at Bangula Trading Centre, is swept by water.’’ Using semantic analysis, the following information about the bridge can be stored ; hence, the following data should be available:

i. Geographic coordinate position of the bridge (i.e. Longitude and Latitude)

ii. Possible road obstruction

iii. Possible presence of victims

iv. Possible presence of displaced people around the bridge

v. Possible damage to property of displaced people

vi. Estimate of volume of water recorded by a sensor near the swept bridge

Conclusion

- Advancements in new geo-spatial technologies across the globe is a means to advance the decision-making process of first responders during a disaster.
- A system based on incorporation of space and terrestrial technologies can provide vital information to first responders for smart management of disasters.
- By creating a database that can be used to gather and exchange information about floods coupled with previous experiences of first responders, people involved in disasters, and scientists studying disaster processes, will allow for better preparedness and more effective responses to the future disasters, thus improving the capability to restore normal activity after a crisis situation.

Thank you for your attention