The purpose of this review was systematic identification, analysis, and classification of the best inno vative solutions regarding early warning and alert systems. To find appropriate research, a search c an electronic database was performed. Web of Science, Scopus, Google scholar, DAREnet Knowledg Base, was the main source used for literature searches (Cvetkovic & Martinović, 2020). The studie were incorporated into the EndNote program after searching all databases.

Inclusion and exclusion criteria

Articles were considered for review if the objective of the research was some kind of innovative solu tions for early warning and alert systems. Furthermore, articles were included for review if they me the following criteria: (1) peer-reviewed, (2) useful and used by practitioners, and (3) related to these early warning systems, alert system, warnings, monitoring and observation, disaster (flood, earth quake, tsunami, landslides, drought, etc.), forecasting, (4) related to subtopics as models, framework technical equipment, standardization, evacuation. Articles that included some unusable solution, in sufficiently tested, scientifically unproven were excluded from the review.

Search outcomes

The initial search resulted in 250 papers and this number diminished to 70 after a review of titles and abstracts found that 180 articles had no relevance to the objectives of the review. A full-text reading of the remaining articles resulted in 50 studies that were considered appropriate for review.

TYPES OF EARLY WARNING SYSTEMS FOR NATURAL HAZARDS

There are traditional and advanced systems of early warning and alert systems in the world. Traditional ones usually consist of three phases: a) monitoring of precursors; b) forecasting of a probable event; c) the notification of a warning or an alert should an event of disasters take place (de León, Bogardi, Dannenmann, & Basher, 2006). Early warning systems differ strongly in their monitoring strategies and two main monitoring strategies can be distinguished (Sättele, 2015). The data contents of the monitored data are high, but the related lead times are low if the early warning systems monitor existing continuous risk event characteristics. If the early warning systems tracks precursors before the commencement of a hazardous event the data contents are decreased, but, the lead time is increased. Because of that, they vary in their spatial dimensions, lead time, design, and associated degree of automation. Fakhruddin and Chivakidakarn (2014) identify four elements for early warning systems to be effective that research has consistently found: (1) active input from vulnerable groups; (2) continuing public education and awareness initiatives; (3) multi-faceted delivery of the messages and the alerts.

The literature also promotes the fourth phase, which refers to indicating the beginning of disaster response activities after a warning has been issued. The four elements of people-centered early warning systems: risk knowledge; dissemination; warning service; response capability (de León et al., 2006).

2. Architectural Framework

The two monitoring devices are composed of Ultrasonic sensor to measure the distance of the water level, Arduino micro-controller that process the signal from the sensor, GSM module to send the data or information from the micro-controller to the computer server and a power source using Solar Panel, Regulator and Battery. Once a sensor is triggered, an output signal will be relayed to the micro-controller which serves as a switch that triggers the connected GSM module to send an alert message or water level status to another GSM modem connected to a computer server. Then, the developed program installed in the computer server will interpret and analyze the message received then automatically send a text message to the concern agencies' numbers stored in a database. Also, the developed program will then automatically relay the alert message or status by uploading to the developed website. Furthermore, concern agencies, local officials and the local communities could inquire about the current status by sending a message that contains keywords.

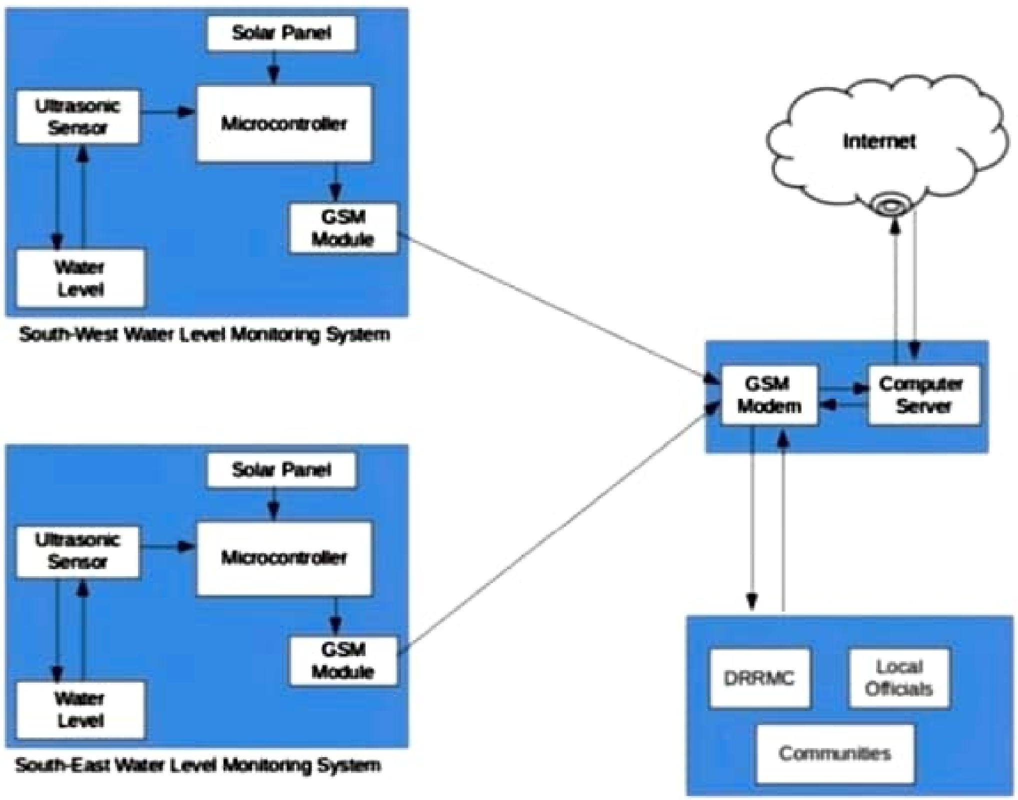

Figure 2. System Architecture

This paper presents the utilization of ultrasonic sensors because of its capability and reliability. Since the Philippines is considered among the most flood prone in the world due to variety of factors, the project NOAH relies on Ultrasonic sensors for water level monitoring. Ultrasonic sensors are deployed on hundreds of coastal tide gauge platforms that provide tsunami and tropical storm surge warning data. They are also deployed on similar platforms that monitor flooding on the different rivers. The newest flood warning system is being deployed to monitor flooding on urban street. And with continues development in ultrasonic sensing, the researchers opted to use this sensor for the project.

The use of GSM also presented in this paper for transmitting data and as mode of communication to the concern stakeholders of this project. Due to its simplicity and availability to the public now-a-days, it is very obvious that information dissemination can be easily achieved. Specifically, the study utilizes

Flood Monitoring