IoT-based Disaster Management: A Case of Technological Mitigation in Indonesia

Asep Id Hadiana[1], Melina[2], Faiza Renaldi[3]
Department of Informatics, Science and Informatics Faculty, Universitas Jenderal Achmad Yani
asep.hadiana@lecture.unjani.ac.id, melina@lecture.unjani.ac.id, faiza.renaldi@unjani.ac.id

Abdul Talib Bon
Department of Production and Operations, University Tun Hussein Onn Malaysia, Malaysia
talibon@gmail.com

Abstract

Indonesia is one of the countries prone to natural disasters because geographically Indonesia is crossed by the Pacific Ring Fire Zone and the Alpide belt. Also, Indonesia is at the tectonic plate meeting. West Bandung Regency, as part of the territory in Indonesia, is inseparable from the threat of disaster. The Internet of Things plays a vital role in disaster management and preparation. Several other studies have proven this. The lack of research on the architecture of natural disasters in developing countries encourages the authors to conduct this research. In this study, a disaster preparedness architecture was created with a case study in West Bandung regency, Indonesia. The architecture designed is expected to help the Indonesian National Board for Disaster Management or BNPB in responding to a disaster in their area.

Keywords
Disaster Management, Internet of Things, IoT, system architecture, Indonesia

1. Introduction
Indonesia is one of the countries prone to natural disasters because geographically Indonesia is crossed by the Pacific Ring Fire Zone and the Alpide belt. Also, Indonesia is at the tectonic plate meeting. Indonesia is located at the confluence of active tectonic plates, active mountain paths, and tropical climates, making parts of the region vulnerable to natural disasters. The number of victims of the accident is classified as very high compared to other countries. The government agency responsible for disaster management is the National Disaster Management Agency abbreviated as BNPB, which is a non-structural organization for disaster management under the President and is directly accountable to the President. BNPB has branches in each province called BPBD or the Regional Disaster Management Agency. Countermeasures carried out by BPBD are pre and post-natural disasters. For the process of handling post-natural emergencies, including handling refugees and distributing natural disaster relief logistics.

West Bandung Regency is a regency in West Java Province, Indonesia, as a result of the expansion of Bandung Regency. The total area of West Bandung Regency is 1,305.77 km2, located between 06 ‘41’ to 07 ‘19’ South Latitude and 107 ‘22’ to 108 ‘05’ East Longitude. The average height of the area of West Bandung Regency is 110 meters and a maximum of 2,243 meters above sea level. The slope of the area varies from 0-8%, 8-15% to above 45%, with the boundary area to the west of the Cianjur Regency, north of Purwakarta Regency, and Subang Regency, east of Bandung Regency, Bandung City, and Cimahi City. At the same time, in the south, it borders with Bandung Regency and Cianjur Regency. The area of West Bandung Regency is considered less profitable because it consists of many hilly-proof basins and in certain areas very prone to natural disasters.

According to data from the local government, four types of natural disasters occur in West Bandung Regency, including landslides, flash floods, whirlwinds, and ground movements. In 2015 there were 63 incidents of landslides, 17 hurricanes, and 0 floods. In 2016 land movement disasters with as many as six events, the number of natural disasters up to November includes landslides 143 events, tornado 15 events, and flash floods five events; in 2017, there were 122 incidents of landslides, 48 cyclones, six floods, and seven ground movements. In 2018 up to July there were 106 landslides, 26 tornadoes, 5 flash floods, and 7 ground movements.

© IEOM Society International

Due to rapid urbanization, inadequate emergency facilities and vulnerability to extreme weather incidents, developing nations are contaminated material to the threats of natural catastrophes and also have little means to minimize their impacts. As a result, as shown in a World Bank report, over 95% of all disaster-related deaths occur in developing countries.

The presence of monitoring systems, warnings, and real-time decision support can be a determining factor in reducing the negative effects of disasters in urban environments. Early warning and decision support systems provide information about approaching dangerous hazards. It further facilitates follow-up actions to reduce the associated risks and loss of life, and reduce the material and economic impact of a disaster. Such systems have benefited greatly from the latest advances in Information Technology such as the Internet of Things (IoT). IoT technology currently available is very advanced and has the potential to be quite useful in disaster situations. Disaster management planning depends heavily on the topology, climatic conditions, vegetation, etc. of the region, as well as the available resources of the machinery(Sinha et al. 2017).

Disaster management systems (DMS) and related technologies have a very important role to ensure the resilience and security of human life. Several resources such as wireless sensor networks (WSNs), delay-tolerant networks (DTN), mobile ad hoc networks (MANET), vehicle ad hoc networks (VANET), low-power wide area networks (LPWAN), and cellular networks to manage disasters can be utilized by DMS (Butt 2019).

Communication between machines is the core principle of IoT. Sensor networks based on the Internet have recently received attention. Sensors are connected to the Internet and sensor information is collected through the Internet on the server (Sakhardande, Hanagal, and Kulkarni 2016). The Internet of Things (IoT) refers to the growing physical objects network with an internet connection IP and communication between them and other Internet-enabled devices and systems. Internet of Things (IoT) refers. The IoT is a large network of battery-operated apps. While they also connect to each other through the internet, via standards like Bluetooth they can communicate directly to each other without it. IoT sensors and infrastructure devices allow the monitoring of information on roads, bridges, buildings, energy grid systems, and public transport – in real time, by public security officers and development planers. Preventive maintenance and repairs can be given priority, structures can withstand future weather during normal operations, and unsafe assets closed. IoT might make bridge failures and the corresponding loss of life and mobility a thing of the past. Natural disasters are frequent in the world, affecting both developed and developing countries. Different populations and countries are more or less vulnerable to the effects of disasters.

Although a broad range of IoT based applications such as intelligent house buildings, smart cities , smart vehicles, traffic management, healthcare and critical infrastructure systems have been researched, only some efforts, particularly for developing countries, have unfortunately been centered on integrated IoT-based architecture of natural disasters. Therefore, with a case study in West Bandung, Indonesia, the authors propose an IoT-based disaster preparedness architecture.

2. Related Works

Several studies have been conducted regarding the use of IoT in disaster management.

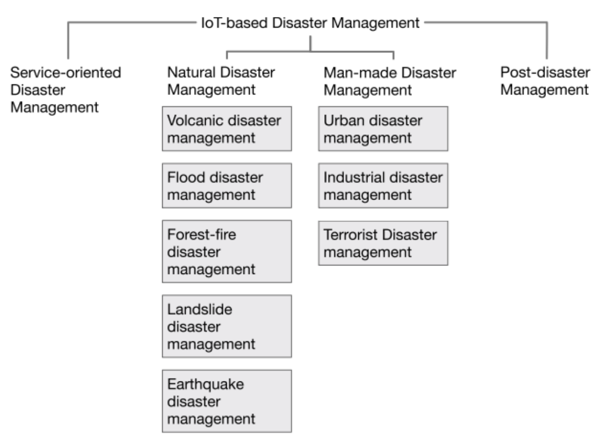

Figure 1. Classification of IoT-based disaster management systems (Ray, Mukherjee, and Shu 2017)

(Ray et al. 2017) has made knowledge taxonomies related Classification of IoT-based disaster management systems, can be seen in the figure 1. Based on the taxonomy, we will describe the work related to the categories: Volcanic disaster management, flood disaster management, forest-fire disaster management, landslide disaster management and earthquake disaster management.

2.1 Volcanic Disaster Management

Volcanic eruptions are also a frequent disaster, and several studies regarding the use of IoT in volcanic eruptions have been carried out. (Awadallah, Moure, and Torres-González 2019) is introducing the use of long-range (hereinafter LoRa) technology, among the most famous LPWANs, for volcanic monitoring. First LoRa-based low-power and low-cost wireless sensor networks to measure groundwater level in heat abnormality areas in volcanic areas were already established. A total of 8 sensors were dispatched on the Teide volcano in Tenerife. These outcomes offer decent strength for appropriate volcanic monitoring. Meanwhile, (Carrera-Villacrés et al. 2020) discusses a fog gathering system that is based on the innovation of water moisture towers and the Internet of Things (IoT) with real-time monitoring. Their system enables environmental variables to be monitored while providing alternative sources of environmental fog water

2.2 Flood Disaster Management

(Sood et al. 2018) present the case of Big Data-HPC Convergence IIoT Flood Management System and illustrate the utility and efficacy of IIoT, including a complete description of our design, algorithms, experiment measures, findings, and review. Their flood risk management service can lead to IoT, Big Data, and HPC convergence and also provide further effective warning systems and evaluation. (Fang et al. 2015) provides an innovative strategy to snowmelt flood advanced warning based on geoinformatics (i.e. remote sensing (RS), geographic information systems (GIS) and global positioning systems (GPS)), the Internet of Things (IoT) and cloud solutions. It consists of the following elements including IoT technology and facilities, cloud information storage, management system, applications, and services. (Perumal, Sulaiman, and Leong 2016) Propose a water monitoring system based on IoT that monitors water activity in real time. Our project is based on the concept that the water level can be a very important parameter when it comes to flood events, particularly in disaster-prone areas. The water level sensor can detect the target threshold, so if the level of water exceeds the variable, the message will be transmitted to it in real time.

2.3 Forest-fire Disaster Management

Another natural disaster is forest fires. IoT plays an important role in combating forest fires. This is reflected in several studies that have been conducted. (Kalatzis et al. 2018) proposes adoption by hierarchical architecture of the principles of Edge and Fog to the domain of UAV-based forest fire detection applications. This three-stage ecosystem brings together the powerful cloud computing resources, the rich fog computing resources, and the UAVs' sensing capabilities. The layers collaborate effectively to resolve the important challenges posed by the case for early forest fire detection. Initial experimental evaluations of key performance metrics show the reliability and complex distribution of essential resources, such as CPU / RAM, battery life and network resources. (Trinath Basu et al. 2018) uses the ESP8266 of the Arduino IDE. Similarly, the Node MCU interface to LCD displays us whether or not the frame status is known. Therefore, Node Mcu interface with the Ethernet module helps the customer to know the prevailing condition message more about it. It indicates to the customer that fire is found. At whatever point the customer is not in control proximity, this framework is extremely helpful. Any time a fire takes place, the system automatically activates and alerts the consumer by sending an alert to an app on the Android smartphone user or page that is available. A survey found that in the forest, fire detection has resulted in around 80 per cent losses. (Dubey, Kumar, and Chauhan 2019) use the internet of technology to solve this issue. On the paper, the Raspberry Pi microcontroller and necessary sensors were used in the initial fire detection model. For data collection and analysis, the centralized server is used. For prediction, Feed-forward is used for a fully linked neural network. The admin and people in the area would then get a warning call.

Smart Forest is an Internet of Things (IoT) concept that defines areas of a forest where remote sensing is applied to collect environmental data. The prediction of wildfires at an early stage is one of the key objectives of Smart Forests. The equipment required for such monitoring, however, typically includes a complex and costly sensor and network infrastructure and central processing capacities for analyzing data from several thousand sensors. (Neumann, De Almeida, and Endler 2018) propose a solution that uses the concept of Mobile Hubes to focus on edge computing. The developed IoT prototype framework for Fire Detection on that paper is based on ContextNet and uses Event Processing Agents (EPAs) that run on forestry-carrying smart phones.

© IEOM Society International

2.4 Landslide Disaster Management

The rock, soil, or debris is a landscape down a sloped portion of the earth. The earthquake, the volcano, or other factors that make the slope unstable are responsible for the landslide. Geologists, researchers who are studying Earth's physical formations describe landslides sometimes as a type of mass loss. A lot of research has been done to observe landslides using the IoT approach. Internet communication networks provide a major infrastructure for communication. IoT feature enables the landslide early detection system to support the network of wireless sensors. (Sofwan et al. 2017) discusses how the system can collect data from several sensors using an Arduino ATMega 2560 microcontroller. The physical parameter measured and actual are obtained that indicates that sensed data are supplied by the system. By different methods such as Weights of Evidence and Logistic Regression (LR), (Moulat et al. 2018) has identified areas prone to landslides. This is why, in the sense of an alarm system, we establish a robust monitoring model for population evacuation in the event of imminent danger. It consists of more than just field sensors and uses data collection systems to capture sensor measurements, automated data processing, and view current conditions, usually through the Internet of Things (IoT). This design is a grounded remote monitoring system. In short, (Moulat et al. 2018) describes a new approach to tracking when hillslopes are ready for sliding and may signal rapid and destructive movement at an early stage. This also tracks ongoing up-to-date or in real-time monitoring information, offers timely information on land-lifting operations, facilitates our knowledge of land-life events, and allows for more efficient technology and premedication.

In various applications such as landslide detection, waste management, water quality monitoring in rivers and lakes, etc., Wireless Sensor Networks (WSN) play an important role here. WSN's intelligent grids are one of the most important technology systems. The key issue with the current power grid is that it is not reliable, because power failure can not be predicted. Energy shortages and a lack of knowledge of energy supply and consumption limits are the primary factors behind energy failures. This increases the cost of power consumption and gives the impression that power is not inexpensive for users. (Viswanathan et al. 2018) focuses on the integration and security challenges of IoT into the smart grid. The Smart City Framework, a building community equipped each with a photovoltaic system that could share the electricity according to the decision taken by the control station, also includes a solar collector. In this sense, the Smart Grid model is cost-effective utilizing alternative renewable energy generators to meet local energy demands.

2.5 Earthquake Disaster Management

Earthquakes arrive without notice, making it one of the natural hazards most feared. Japan has experienced many significant seismic disasters in its history, strongly addressing earthquake risks, enforcing stringent building codes and investing in emergency response resources. Since then, a big Japanese earthquake causes extensive damage and loss of lives. An early warning system for earthquakes provides protection for business and individuals. Industrial practices that allow employees to secure critical equipment can be stopped prior to the start of an earthquake. Within the protected places during an earthquake, people should take precautions to help mitigate damage and loss of life.

A stand-alone system with a low-cost acceleration sensor and lowest processing power for earthquakes is introduced by (Lee et al. 2019). In this regard, they first select a suitable acceleration sensor by evaluating 4 different sensors for performance and accuracy. They are using a simple machine learning approach to detect earthquakes that train an earthquake detection model with regular movements, building noise, and previously reported earthquakes. In the awareness of the effects of disasters, which impacts humanity in many respects, the technical advancements of satellite image research will play an important role. (Rajput et al. 2020) are proposing an integrated earthquake management system for disaster prevention, preparedness, response and recovery through IoT, sensor and profound learning models. They will draw on their model from past studies, taking into account the effect of devastation, which contributes to relief efforts, disaster response and emergency management. Their research findings can enable mankind to quantify and track the effects of a catastrophe through tools and methods of data analytics.

(Spalazzi, Taccari, and Bernardini 2014) uses ontologies to describe computer and human understandable definitions of items in order to promote the communication between physical objects and IT systems. Recent work has also shown how IoT can benefit from the use of IoT technology in several scenarios to accompany complex tasks in which active participants are physical subjects. Initially, the Semantic Sensor Networks have been expanded with notions and positions that classify actuators by the W3C Semantic Sensor Networks Incubator Group. This leads to the concept of an entire network of ontological subjects.

© IEOM Society International

In representing, storing, interconnecting, researching, and organizing things-generated and consumed the knowledge, semanticized technologies may play a key role. (Taccari et al. 2015) offers a number of thought methods based on the on-going IoT ontology for use in an emergency response scenario to determine the viability of this approach. The situation of their works is the treatment of earthquakes.

3. Proposed IoT Disaster Management Architecture

As seen in figure 2, the first is the actual layer of sensors capable of sensing and gathering information from the environment Its work involves the collection of physical parameters or the identification of other intelligent devices. Then we come to drives which can impact environmental changes. For instance, a sensor senses that the water level has changed and that the soil is shifting, and therefore the actuator gives automatic signs when the dusk is over.

The Internet gateway layer then comes. Before entering the eventual processing point, the data coming from the sensors must be prepared. In essence, the data that is received in the analog form must be aggregated and digitalized, and that is done with the help of an Internet portal that routes it via WLANs or other networks. The two layers above are closely intertwined, so that pre-processing selection can be done in real-time. These gateways are compatible with additional features such as analytics, malware protection, and data management.

The pre-processed data then enter the edge IT systems for further data analysis. While the above two layers are situated at the actual device site, a remote location or other edge locations, not up to the data center, will be equipped with an edge IT processing system. The IoT data is usually so massive that you will consume immense amounts of network bandwidth and flood your infrastructure if you directly send it to the data center or server. As a result, leading systems analyze core IT infrastructure to reduce the burden.

The final stage is the analyzed, management and storage of data in strong IT systems. These data need more analysis and do not need immediate feedback. This is perfectly suited to a data center or a cloud-based system. The findings here take a while, but the information is more detailed and can be combined with other information for deeper perspectives.

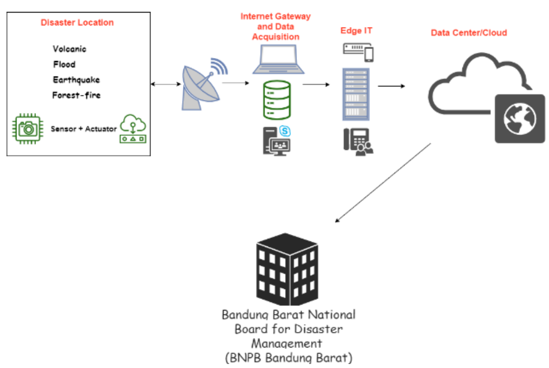

Figure 2. Proposed IoT Disaster Management Architecture

Public agencies and emergency response teams need to set up communications networks between the mobile devices of citizens of a danger area and IoT sensors in a field in order to respond with precision. In this way, a local disaster response can be facilitated and accelerated. The system will respond to data received from the IoT sensors and signals from citizens' mobile devices, based on data obtained. In the case of a flood for example, An IoT solution would centrally monitor, analyze, and predict flood situations by the state irrigation department. It will warn the authorities and the public of the possible occurrence of a flood automatically. The solution uses sensor data from different sites, including reservoirs, dams, canals, and canals, and also helps to minimize loss of life and mitigate property damage. It is consolidated via a central dashboard with maps for monitoring in real-time. In case of a threshold violation and predictive algorithms used to forecast a flood scenario, automatic warning notification can be determined based on parameters including rainfall. It is capable of saving property loss and lives Citizens with precise flood forecasts and geographic zones affected. Vast quantities of information accumulate quickly in a critical situation. Agency workers have to respond rapidly with incoming data to an ever-changing situation. There are also few other situations where speed is so critical. Quick time access to timely and accurate situation data enables respondents in rapidly changing circumstances to make informed decisions. The inability to obtain information from a number of sources that are managed, exchanged, and used between all the parties concerned also poses a challenge to the first responders.

© IEOM Society International

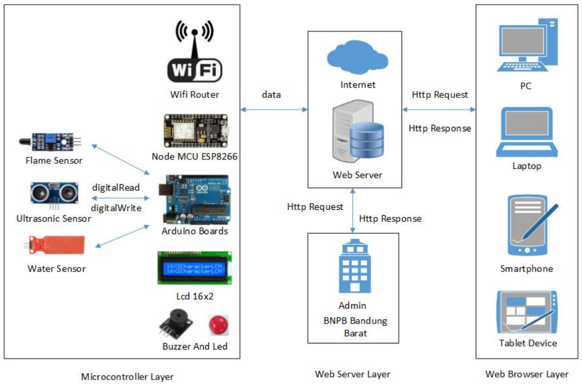

Figure 3. IoT Sensor Architecture

In figure 3, we can see IoT sensor Architecture. Sensors play an important role in IoT. Here we use several sensors namely: Flame sensor, Ultrasonic Sensor and Water Sensor. The flammable sensor is regarded as a sensor that is most sensitive to normal light. This is why it is used in flame detectors for this sensor module. In the range 760 nm – 1100 nms from the light source this sensor otherwise senses the flame's wavelength. The high temperature sensor can be readily impaired. This sensor may therefore be positioned somewhere away from the blaze. Flames can be observed from a distance of 100 cm and an angle of detection of 600. An analog signal or a digital signal is the output of this sensor. Such sensors are used as a blaze detector for firefighting robots. As water level sensor and a water flow sensor as a water flow speed sensor we use an ultrasonic sensor. Two ultrasonic sensors are used for calculating the water level and a water flow calculating sensor for measurement of the water volume. WLAN Module ESP8266 Node MCU is a SOC (System on a Chip) that provides any kind of microcontrollers to access the Wi-Fi network with an integrated TCP / IP Protocol Stack. With a large and growing platform for helping the project, the ESP8266 module is extremely cost effective. In this paper Arduino offers the ESP8266 Wi-Fi board the real-time data to be submitted to the dedicated site or application in order to log and track data. The sensor has an ESP8266 communication module, which links directly to the Internet. For transferring messages is the Data Queuing Telemetry Transportation (MQTT) protocol.

4. Conclusion

Indonesia is one of the countries prone to natural disasters, because geographically Indonesia is crossed by the Pacific Ring Fire Zone and the alpide belt, and also Indonesia is at the tectonic plate meeting. Indonesia is located at the confluence of active tectonic plates, active mountain paths, and tropical climates, making parts of the region vulnerable to natural disasters. West Bandung Regency is a regency in West Java Province, Indonesia. The area of West Bandung Regency is considered less profitable because it consists of many hilly-proof basins and in certain areas very prone to natural disasters. This research has proposed a disaster preparedness architecture in West Bandung Regency. In the architecture, BNPB as the most responsible party for disasters in the area has a central role. Where in the architecture, every disaster-prone area is installed sensors and actuators. When a disaster occurs, it will send data about the disaster that occurred to be sent to the gateway which is then forwarded to the IT edge for further analysis. The results of the analysis will be sent to the cloud to be displayed in the disaster dashboard that can be accessed by the BNPB to manage disasters and make the right decisions related to disasters that occur.

Acknowledgements

This work is supported by Hibah Penelitian Internal Universitas Jenderal Achmad Yani 2020 funded by LPPM Universitas Jenderal Achmad Yani.

References

Awadallah, Shadia, David Moure, and Pedro Torres-González. 2019. "An Internet of Things (IoT) Application on Volcano Monitoring." *Sensors (Switzerland)* 19(21).

Butt, Talal Ashraf. 2019. "Context-aware Cognitive Disaster Management Using Fog-based Internet of Things." *Transactions on Emerging Telecommunications Technologies* (February):e3646.

Carrera-Villacrés, David, Jose Luis Carrera Villacrés, Torsten Braun, Zhongliang Zhao, Javier Gómez, and Joffre Quinteros-Carabalí. 2020. "Fog Harvesting and Iot Based Environment Monitoring System at the Ilalo Volcano

© IEOM Society International

in Ecuador." *International Journal on Advanced Science, Engineering and Information Technology* (1):407–12.

Dubey, Vinay, Prashant Kumar, and Naveen Chauhan. 2019. "Forest Fire Detection System Using IoT and Artificial Neural Network." Pp. 323–37 in *Lecture Notes in Networks and Systems*. Vol. 55.

Fang, Shifeng, Lida Xu, Yunqiang Zhu, Yongqiang Liu, Zhihui Liu, Huan Pei, Jianwu Yan, and Huifang Zhang. 2015. "An Integrated Information System for Snowmelt Flood Early-Warning Based on Internet of Things." *Information Systems Frontiers* 17(2):321–35.

Kalatzis, Nikos, Marios Avgeris, Dimitris Dechouniotis, Konstantinos Papadakis-Vlachopapadopoulos, Ioanna Roussaki, and Symeon Papavassiliou. 2018. "Edge Computing in Iot Ecosystems for Uav-Enabled Early Fire Detection." Pp. 106–14 in *Proceedings - 2018 IEEE International Conference on Smart Computing, SMARTCOMP 2018*.

Lee, Jangsoo, Irshad Khan, Seonhwa Choi, and Young Woo Kwon. 2019. "A Smart Iot Device for Detecting and Responding to Earthquakes." *Electronics (Switzerland)* 8(12).

Moulat, Meryem El, Olivier Debauche, Saïd Mahmoudi, Lahcen Aït Brahim, Pierre Manneback, and Frédéric Lebeau. 2018. "Monitoring System Using Internet of Things for Potential Landslides." Pp. 26–34 in *Procedia Computer Science*. Vol. 134.

Neumann, Guilherme Borba, Vitor Pinheiro De Almeida, and Markus Endler. 2018. "Smart Forests: Fire Detection Service." Pp. 1276–79 in *Proceedings - IEEE Symposium on Computers and Communications*. Vols. 2018-June.

Perumal, Thinagaran, Md Nasir Sulaiman, and C. Y. Leong. 2016. "Internet of Things (IoT) Enabled Water Monitoring System." Pp. 86–87 in *2015 IEEE 4th Global Conference on Consumer Electronics, GCCE 2015*.

Rajput, Sameer, Amar Ippili, Divya Puraswani, Shubh Johri, Aarathi Nadathur, and Subhankar Dhar. 2020. "Impact of Earthquakes Based on Satellite Images Using IoT and Sensor Networks." Pp. 551–54 in *2020 International Conference on COMmunication Systems and NETworkS, COMSNETS 2020*.

Ray, Partha Pratim, Mithun Mukherjee, and Lei Shu. 2017. "Internet of Things for Disaster Management: State-of-the-Art and Prospects." *IEEE Access* 5(i):18818–35.

Sakhardande, Prabodh, Sumeet Hanagal, and Savita Kulkarni. 2016. "Design of Disaster Management System Using IoT Based Interconnected Network with Smart City Monitoring." Pp. 185–90 in *2016 International Conference on Internet of Things and Applications, IOTA 2016*.

Sinha, Akash, Prabhat Kumar, Nripendra P. Rana, Rubina Islam, and Yogesh K. Dwivedi. 2017. "Impact of Internet of Things (IoT) in Disaster Management: A Task-Technology Fit Perspective." *Annals of Operations Research* 283(1):1–36.

Sofwan, Aghus, Sumardi, M. Ridho, Abdul Goni, and Najib. 2017. "Wireless Sensor Network Design for Landslide Warning System in IoT Architecture." Pp. 280–83 in *Proceedings - 2017 4th International Conference on Information Technology, Computer, and Electrical Engineering, ICITACEE 2017*. Vols. 2018-Janua.

Sood, Sandeep K., Rajinder Sandhu, Karan Singla, and Victor Chang. 2018. "IoT, Big Data and HPC Based Smart Flood Management Framework." *Sustainable Computing: Informatics and Systems* 20:102–17.

Spalazzi, Luca, Gilberto Taccari, and Andrea Bernardini. 2014. "An Internet of Things Ontology for Earthquake Emergency Evaluation and Response." Pp. 528–34 in *2014 International Conference on Collaboration Technologies and Systems, CTS 2014*.

Taccari, Gilberto, Gabriele Bernardini, Luca Spalazzi, Marco D'Orazio, and Waleed Smari. 2015. "Earthquake Emergencies Management by Means of Semantic-Based Internet of Things." Pp. 318–27 in *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*. Vol. 151.

Trinath Basu, M., Ragipati Karthik, J. Mahitha, and V. Lokesh Reddy. 2018. "IoT Based Forest Fire Detection System." *International Journal of Engineering and Technology(UAE)* 7(2):124–26.

Viswanathan, Athira, N. B. Sai Shibu, Sethuraman N. Rao, and Maneesha Vinodini Ramesh. 2018. "Security Challenges in the Integration of IoT with WSN for Smart Grid Applications." in *2017 IEEE International Conference on Computational Intelligence and Computing Research, ICCIC 2017*.

© IEOM Society International

Biographies

Asep Id Hadiana is a lecturer at the Universitas Jenderal Achmad Yani, Cimahi, Indonesia. His research area is Disaster Management and geographical information system (GIS). He completed his graduate education from Padjadjaran University (UNPAD) and continued his master's degree in information systems from UNIKOM.

Melina is a lecturer in the department of informatics, Universitas Jenderal Achmad Yani, Cimahi, Indonesia. She graduated with a degree in computer science from UNPAD. Then continue and complete the Masters in mathematics in ITB. Her research fields are in mathematical modelings and expert systems.

Faiza Renaldi is an assistant professor in the department of informatics, Universitas Jenderal Achmad Yani, Indonesia. He received his Master of Business Informatics at Universiteit Utrecht, The Netherlands in 2006. Amongst his research interests are health informatics, information systems/information technology management, e-government, agile project management, and IT entrepreneurship.

Abdul Talib Bon is a professor of Production and Operations Management in the Faculty of Technology Management and Business at the Universiti Tun Hussein Onn Malaysia since 1999. He has a Ph.D. in Computer Science, which he obtained from the Universite de La Rochelle, France in the year 2008. His doctoral thesis was on topic Process Quality Improvement on Beltline Moulding Manufacturing. He studied Business Administration in the Universiti Kebangsaan Malaysia for which he was awarded the MBA in the year 1998. He has a bachelor's degree and a diploma in Mechanical Engineering which he obtained from the Universiti Teknologi Malaysia. He received his postgraduate certificate in Mechatronics and Robotics from Carlisle, United Kingdom in 1997. He had published more 150 International Proceedings and International Journals and 8 books. He is a member of MSORSM, IIF, IEOM, IIE, INFORMS, TAM, and MIM.

© IEOM Society International