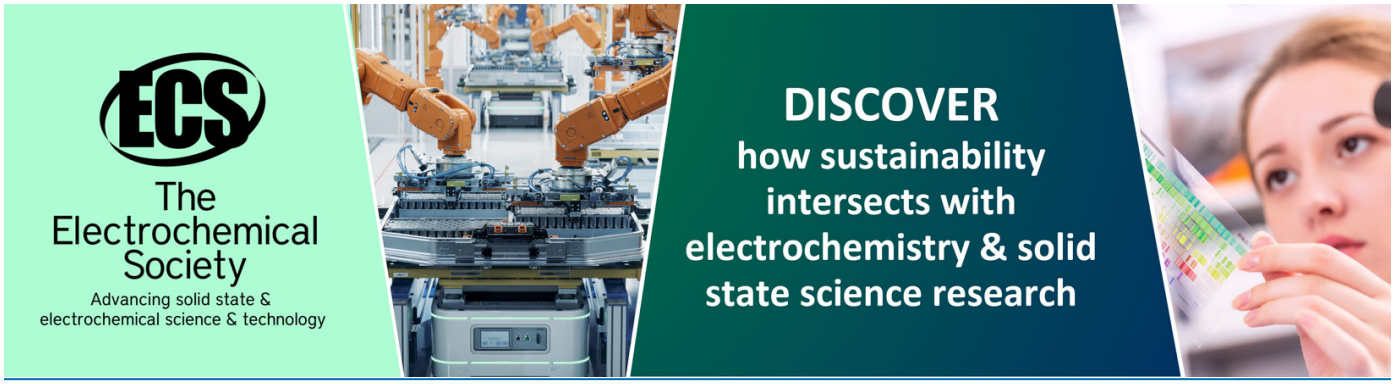
Volcansmart Early Warning Systems Based Land Surface Temperature at the Disaster-Prone Region of Merapi Volcano, Regency of Sleman



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Volcansmart Early Warning Systems Based Land Surface Temperature at the Disaster-Prone Region of Merapi Volcano, Regency of Sleman

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Abstract. Based on statistical data, land surface temperature can be the main parameters in the prediction of eruption of Merapi [1]. The eruption of Merapi in 2010 resulted in the victim's death as much as 347 people with the most victims in the Regency of Sleman i.e. 246 inhabitants [2]. This problem caused the latest information came a result of information coming not directly acquired community. Rescue many souls before the eruption happens very needed, therefore the necessary information that can be used in the community directly, through application of pre disaster mitigation of the eruption volcanic activity report in Android applications. This research use Research and Development to create VEWS report by the method of linear Sequential Model consisting of 5 stages, namely: the phase of analysis and study of literature; design system; Assembly hardware; coding; and testing. The results of this research are developing Volcansmart VEWS at the disaster-prone region of region Sleman. Measurement of land surface periodically through these applications can improve community preparedness in daily activities on the Facies Proximal of Merapi volcanic activity report.

1. Introduction

Volcansmart Early Warning Systems is one of the early warning system development of Merapi volcanic activity report using an instrument of Land Surface Temperature (LST) was done on the Disaster-prone Region III Sleman, Merapi's volcano. The disaster-prone region III Sleman is the area that has the greatest chance of eruption affected Merapi's volcanic activity report after the eruption 2010 [2]. LST is one instrument that can be used as predictors of the eruption of Merapi's volcanic activity report [1]. LST Merapi's volcanic activity report was installed less than 1 km from the Summit of Habanero as one area that has the most active fumarole temperatures [1].

LST usually detected using remote sensing, however due to its resolution is too broad and sometimes hindered the cloud [3, 4], the field of monitoring and remote sensing has been revolutionized by wireless

sensor network [5] then the placement area of land surface temperature sensors placed on the rocky land around near of Merapi crater [6].

The monitoring system of Merapi, operated by BPPTK (Hall investigation and technology development of Volcano) – Volcano Observatory of Yogyakarta which belongs to CVGHM (Centre of Volcanology and Geological Hazard Mitigation), is mainly based on seismic, deformation and geochemical measurements [7, 8]. But yet there are Monitoring LST as one instrument, though there have been many journals that connect between the LST and volcanic activity report.

LST is a kinetic quantity, independent of wavelength, that represents the thermodynamic temperature of the skin layer of a given surface, i.e. a measure of how hot or cold the surface of the Earth would feel to the touch [9]. The unit of LST is Kelvin [K]; Degree Celsius [°C] is also commonly used [6].

LST is a key variable in climatological and environmental studies. However, accurate measurements of LST over continents are not yet available for the whole globe [10]. This parameter is very easy to know when volcanic activity report will erupt, as it did in the Merapi volcanic activity report in 1996, the sensor on top of the Solfatara volcanic activity report noted increased Habanero Merapi land surface temperature averages around 180 C started three weeks before the eruption temperature rises to 300 C [1].

This research is based on the manner and extent of discussion of the problem is Research & Development. Based on the form and methods of implementation, this method uses research LSM (Linear Sequential Model) [11]. The purpose of this research is to monitoring Merapi volcano eruptions using Volcansmart EWS (Land Surface Temperature and Humidity Instruments), this is because there has been no increase in temperature monitoring tool the surface of land in the area of the slopes of the volcanic activity report that records, send and inform the data directly to android applications.

To be effective, early warning systems must be people-centred and must integrate four elements: (1) knowledge of the risks faced; (2) technical monitoring and warning service; (3) dissemination of meaningful warnings to those at risk; and (4) public awareness and preparedness to act. Failure in any one of these elements can mean failure of the whole early warning system [12]. Volcansmart EWS uses four main requirement the EWS by making four product, namely: tools, applications, web and Guidelines of Volcansmart EWS.

2. Research method

Workflow Volcansmart EWS consists of: Volcansmart EWS Tools, Terminal Server, Home Server and the users (Community App) (Fig 1). Volcansmart tool is placed on the rocky land around near of Merapi crater, then submit data of temperature from a distance (telemetry) are sent to the terminal via WiFi Module, the terminal sends to a home server, later the server sends to the home community (Figure 1), this system ever used in testing in the mountainous region of semiarid area mountains slopes are complicated [13], while Merapi Volcano is not as complex landscape as in semiarid area mountains slopes.

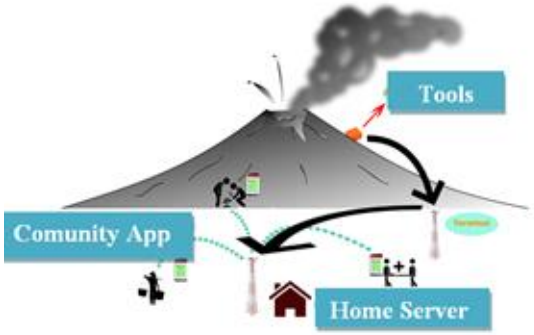

Figure 1. Workflow of volcansmart early warning systems.

Volcansmart EWS use method Linear Sequential Model (LSM). LSM consisting of 5 phases repeat i.e.: the phase of analysis and study of literature, designing systems, hardware Assembly, software coding, and testing. The five stages of it would be repeated until the fulfillment of ideal conditions, namely the system functioned well as planned [11].

2.1. Analysis and the study of literature

The analysis and study of literature about the condition of the slope of merapi and community disaster preparedness merapi, to the Tower observation monitors regarding how to work the alarm automatically, and carried out observations regarding the current condition of merapi. Implementing this phase will work gathering information necessary (primary and secondary data) and ordered them to produce reference and limits to design systems, mechanical design, hardware interfacing, sensors, microcontroller and web information system as well as making the system remote control.

2.2. System design

Figure 2 shows the stages of the design of the schematic system, which consists of: input, process, output, administrator, field test. Inputs are used i.e. LST Sensors (does not have a high temperature capacity because it is not the temperature of the thermal crater). Then, input the data processed using the arduino microcontroller, then the process is transferred to the output. Input, process, and output were merged into the Volcansmart tools are given power and transmit data transmission via Wifi Module. The data is sent to the home server (fig. 1), on the home server data instruments later LST will be processed as an administrator the additional data for determining the temperature field. Therefore, the activities of the next field test at Merapi Volcanic Slope Vegetation Non, then make the system android application for people (figure 2).

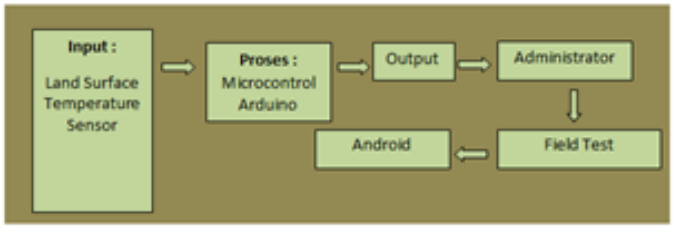

Figure 2. Scheme design stage of the system.

2.3. Software and hardware assembly

On the stage of Assembling Software made the coding on the microcontroller and coding on the communication based remote Internet of things between device users with the interfacing. Graphical User Interface that contains a menu for remote interfacing. The Assembly done on microcontroller hardware software, and the backend, the interfacing on the web and interfacing using Android smartphone. Temperature sensors used in this research is infrared temperature sensor, this sensor has the capability to measure the temperature of objects without physical contact. Microcontroller ATMega8535 serves as an ADC (Analog to Digital Converter) to change the signal sent by the sensor so that it can be read by the computer.

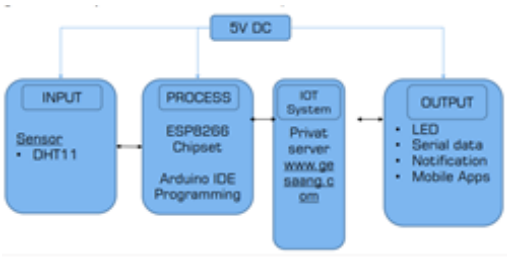

Figure 3. Construction phase software.

Assembly hardware (Figure 4) implementations contain mechanical installation, sensor as input, processor by the microcontroller, and output on the graphical user interface over the web, and the android smartphone. All the power supply for the hardware using energy self-sufficient by utilizing cell fotovoltaic, solar panels. The use of a temperature sensor the sensor is still using DHT 11, actually for the use of the household environment temperature sensor has been made, namely: the power Sensor with LC 234^{0}C [13], however there has not been a public sale for the tool.

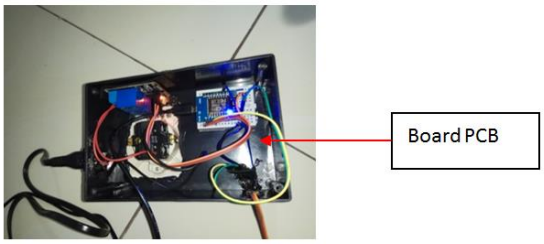

Figure 4. Assembly hardware in the lab of electro, YSU.

2.4. Testing and evaluation

2.4.1. DHT 11 sensor test. DHT 11 temperature accuracy ± 2^0 C and Humidity accuracy ± 5% RH, besides DHT 11 considered to be temperature measuring and wireless sensor network system, which has replaced the Field of monitoring and remote sensing on the LST [14]. The measurements of the temperature and humidity instrument of various prem ises and have done analysis of the data acquired from the project. Here are some proof regarding the analysis.The images subjected below are the proof that the system has been setup in an environment and been monitored since the installation. Humidity measurement shows good accuracy, visible moisture is between 86%-87% (Figure 5). The table also shows data on the place of the sensor that indicates the correct point with folders. And on the table device code displays the name of the location of the sensor is installed. On the dashboard of DHT 11 (Figure 6) indicated the data graphic from data table of humidity test, which shows the graphics follow the results of table data accurately.

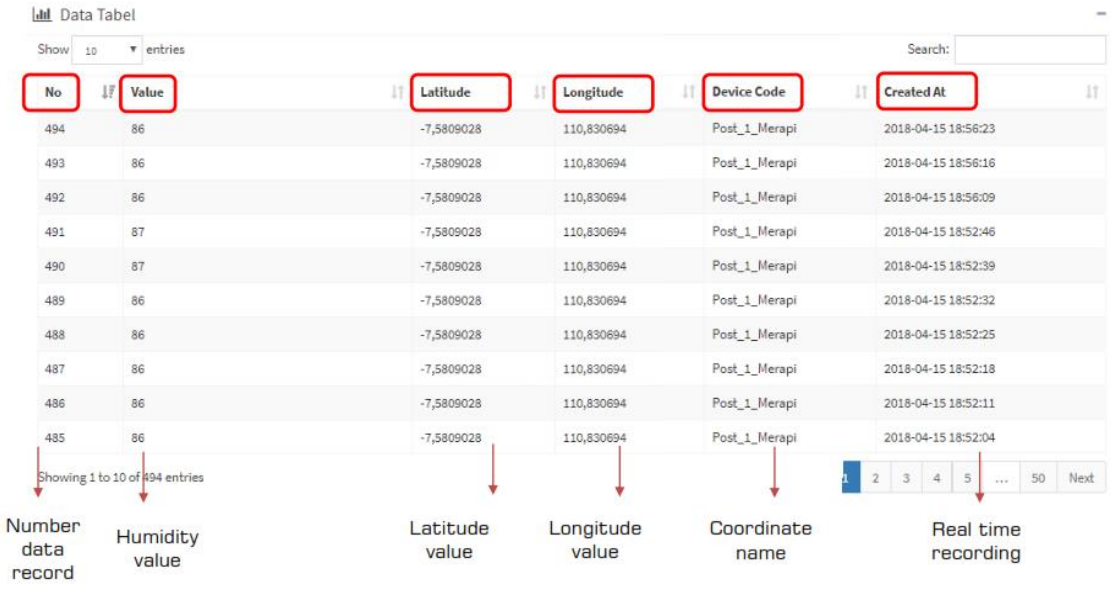

Figure 5. Data table DHT 11 sensor test (Humidity).

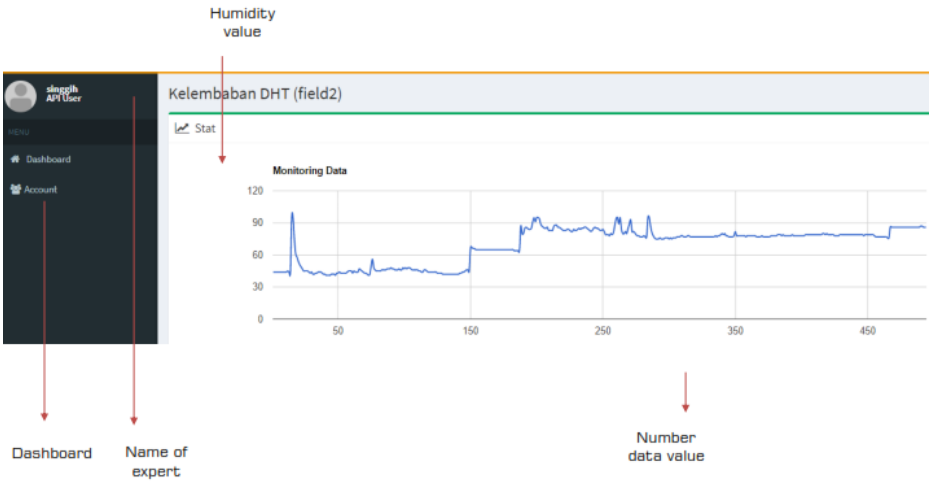

Figure 6. Dashboard DHT 11 sensor test (Humidity).

DHT 11 Sensor Temperature has temperature accuracy ± 20 C are excellent for measuring of LST [14]. DHT 11 can measure temperatures between 0-50 0 C, it does not become a penghalkang for the measurement of temperature is not because LST LST active crater, but around the slopes of Merapi's volcanic activity report that there was no vegetation as a condition of measurement LST [6].

At the time the presentation was found to diruangan measured room temperature indicates the temperature of the 29^0 C (figure 7) on the data table, and in the graphic in the Dashboard also shows the temperature of 29^0 C (figure 8) on the measurement of 485-495 that exists in the data table (Figure 7).

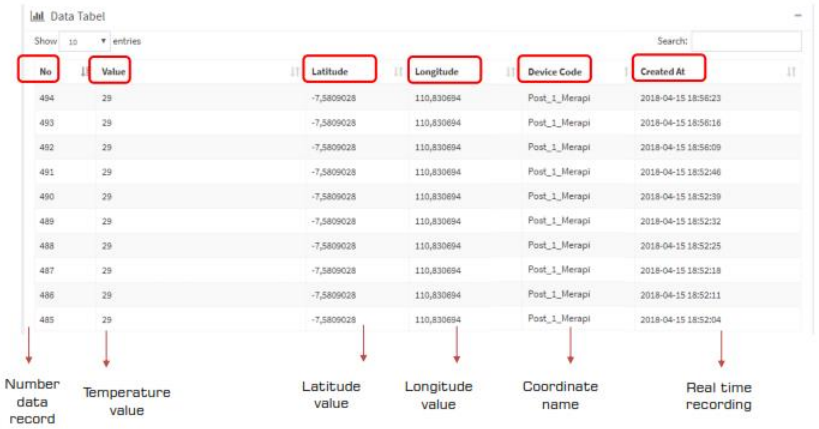

Figure 7. Data table DHT 11 sensor test (Temperature).

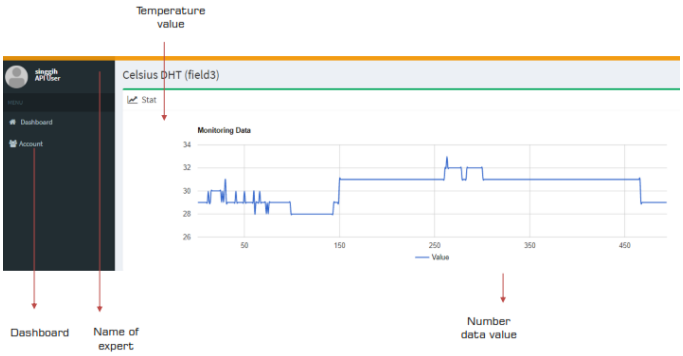

Figure 8. Dashboard DHT 11 sensor test (Temperature).

2.4.2. Data transmission test. Data transmission sent by distance measurement (telemetry). Data Table (Table 1) shows there is delay programming average 4000 ms, delay data recording in the server ± 7 s, Smartphone and delay Notification ± 2 s delay. number of telemetry namely ± 11 Second, it shows the measurement is very good, because the required data field is actually just the temperature and humidity on average at any given time, with the continuous measurement makes the data more markedly if the temperature there was known not normal in time. Internet speed required (kb/s) very little that is only approximately 3 KB/s, this is very efficient for measurement.

Table 1. Data transmission test.

No	Delay Programming (ms)	Delay data recording in Server (s)	Delay Smartphone Notification (s)	Internet Speed (kb/s)
1	4000	7	2	2,67
2	4000	7	2	2,46
3	4000	7	2	2,55
4	4000	7	1	2,55
5	4000	7	2	2,21
6	4000	10	2	4,12
7	4000	7	3	3,06

In addition to its territory (Figure 9) which must be exposed without vegetation, Geomorphology Analysis area fasies active volcanic activity report [15] is the primary base in the installation of sensors, power supply and transmission in an active volcanic activity report Piroksimal Fasies. DHT11 sensor testing can be said to be good and successful because of the range of the value obtained in accordance with the DHT11 sensor datasheet. The results of the data delivery and data acquisition results data appearance in smartphones can run well and true.

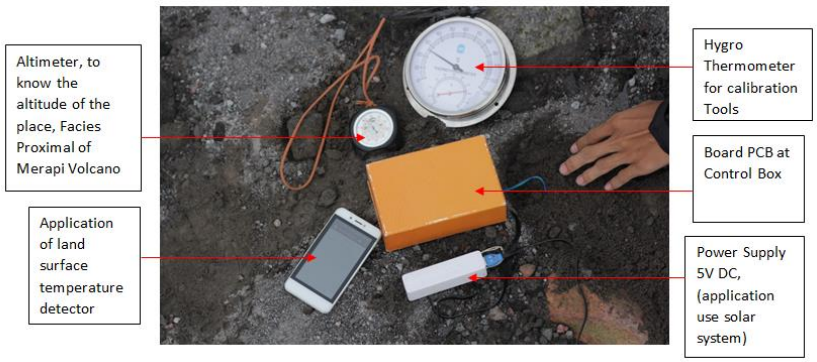

Figure 9. Land surface temperature detector testing volcanic activity report in the field and Android applications.

2.4.3. Volcanic alert level test

Table 2. Volcanic alert level test [17, 18].

No	Range Temperature (Celsius)	Temperature test (Celsius)	Data Recorded	VAL Status
1	0-32	28	28	Normal
2	32-37	35	35	Waspada
3	37-39	38	38	Siaga
4	>39	50	50	Awas

The distance of the Volcanic Alert Level Test used i.e. data logging the temperature of MINERAL RESOURCES at Mount Kelud [16], renge temperature is also extremely suited ketikamelihat increase LST in Mount Merapi (1998) using NOAA [1]. At the time of the test, the temperature in the test shows between temperature data, recorded and VAL has a consistent data status (Table 2). Can be seen in the application (figure 9), at a temperature of 30^0 C, unknown status indicates a Normal Active (Active Normal). VAL status on this application using VAL Indonesia [17].

3. Results and discussion

Early Warning Systems using Land Surface Temperature Instruments consist of: (1) Instrument of sensor, processor, output, iot systems, and power supply, (2) EWS Volcansmart application in the form of Home, Graphics, and VAL fiture, (3) Web Volcansmart EWS consisting of Home, Home features, history and culture, graphics, control panel, EWS Volcansmart charts and guides, (4) the EWS Volcansmart Manual consists of guidance on the use of tools and applications, as well as community responses. A series of tests performed involving telemetry-linked devices to applications and the web, in the form of DHT 11 Sensor Test, Data Transmission, and VAL Test provide good and accurate results.

3.1. Volcansmart app

Volcansmart android application has three early features, namely the display home, display graphics and display Display home VAL (Figure 10). android application Volcansmart contains the last record temperature and humidity of Merapi Volcano. On the display of the home there is a description of the Volcansmart the name of the recording, the recording location, latitude and longitude the territory tool Volcansmart is installed, this is to facilitate the discovery of the site in the field and facilitate community know the place the installation tool.

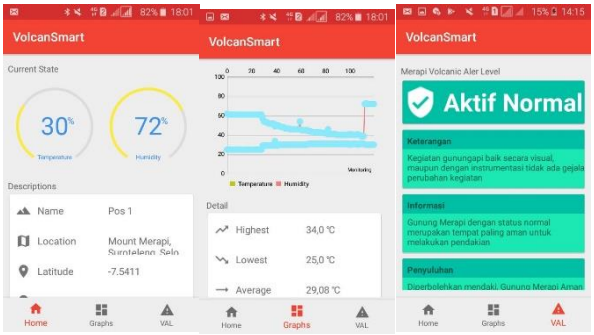

Figure 10. Volcansmart EWS applications display at level 1 with "*Aktif Normal*" status (English: Normal), (left: Home fiture) (center: Graphic fiture) (right: VAL feature) (Description: **use Indonesian Language because the application only for Indonesia Volcano Slopes Comunity; if used in other countries, need to use local government policy**)

Display graphics containing graphics from the recording of temperatures, by displaying the highest temperature logging detail, temperature recording and the lowest average temperature recording (Figure 10). Recording of temperature is done continuously, so that the temperature fluctuations will be known directly by Volcansmart Android application user community. If the sensor is a time to die, like damaged because of the eruption at beware status (Figure 11), then the features of VAL in the application remains running with information submitted manually through the home server. The use of the land surface temperature sensor which is more resistant to hot lava is needed, however, because of limited funding, in this research uses only sensors very affordable DHT 11.

The features in the VAL consists of feature level VAL, status of volcanic activity report, description, action, appeal, radius and level VEI. the level of VAL feature level using VAL Indonesia. VAL Indonesia are divided into four levels of VAL, namely: Level 1, Level 2, Level 3 and Level 4 [17]. Level 1 has a "*Aktif Normal*" status (Normal Active), with the display in green (figure 9). Level 2 has a "*Waspada*" status (Vigilant), with a yellow appearance. Level 3 has a "*Siaga*" status (Standby), with an orange-colored display. Level 4 has a "*Awas*" status (Beware) and the display is red.

VAL overview describes the main objective of Volcansmart is to provide information, level, status, VEI, and distance radius safe against volcanic activity report. VAL is very dynamic display, can change at any time, in accordance with the status of Merapi's volcanic activity report with little to do against temperature and Display features VAL. VAL on application first developed by New Zealand researchers [18] with different instruments monitoring.

Description of observations visually as well as remote sensing on Merapi's volcanic activity report. Information/actions intended for the direction of the related parties, both climbers, as well as community disaster agencies to perform actions that should be performed when VAL level increases, like Level 3 to Level 4 (Figure 11). While the advisories contain directives to the users to give information security community.

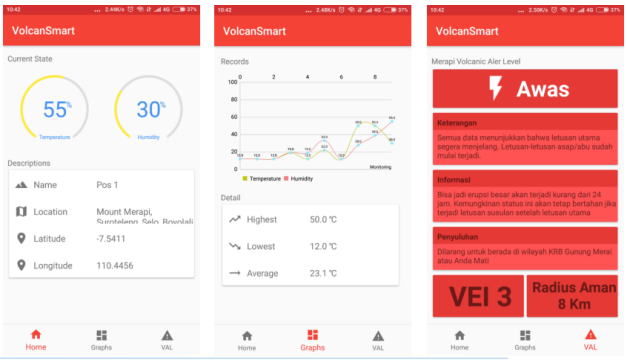

Figure 11. Display application volcanic alert level at level 4 "*Awas"* status (English: Beware), **(Description: use Indonesian Language because the application only for Indonesia Volcano Slopes Comunity).**

Level VEI is a Volcanic level International scale Index Explositivity to know how great the power of volcanic activity report [19]. Secure RADIUS is used to find out how far the safe distance of the community can access the area of the slopes of Merapi's volcanic activity report. Feature level VAL, volcanic activity report status, description, action, and an appeal is an automatic feature, which is static based on the study of the literature that has been done. While radius features secure and Level VEI is dynamic, and requires a home server to see the continuous development of the level and the safe radius VEI [20, 21], but on the level of a normal active status feature Level and Secure the fixed Radius VEI.

3.2. Volcansmart EWS web

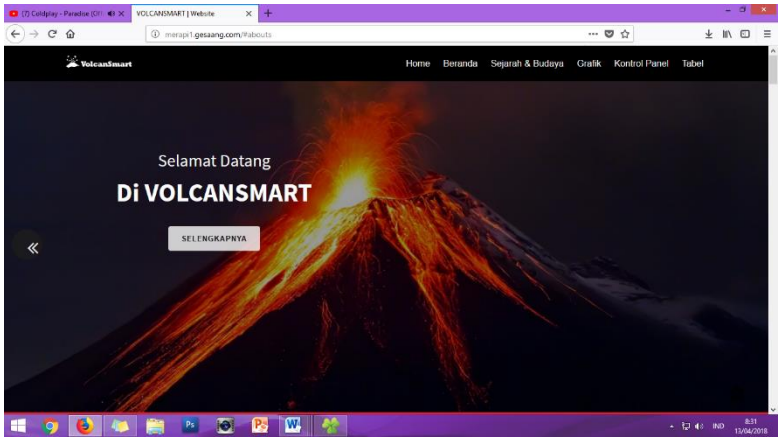

Figure 12. **.** Display home web volcansmart EWS (Description: Use Indonesian Language because for Indonesian Comunity Response).
(source: http://merapi1.gesaang.com)

Web Volcansmart EWS can be accessed on the web site: merapi1.gesaang.com (Figure 12). Volcansmart EWS Web consists of Home, Home features, history and culture, graphics, control panels, tables and guides. Volcansmart EWS Web accessibility is used as a mayarakat in knowing information Volcansmart EWS openly, and provides education from history and culture to the cognitive knowledge through Volcansmart EWS Guidelines (Figure 12) can be downloaded on the Web Volcansmart (Figure 11). Volcansmart EWS Guidelines is a tool usage instructions and the application in the field. Volcansmart EWS guideline is expected to minimize the impact of Merapi eruption, because it has a good community response directives for strengthening public education that is less about Merapi's volcanic activity report.

4. Conclusions

The System is integrated part of DHT11 sensor as temperature and air humidity sensors with ESP8266 chipset as the controller to do the process, calculate, monitoring, and send the data of Land Surface Temperature and humidity. The system will send notification based on the level of temperature of the air temperature around fasies proximal of volcano. Based on the test of the system work on the Merapi Volcano, it was found that on the information send faster and more informative than the existing conventional way.

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