Semar Sandy-app: monitoring system for sandy soil irrigation based on android application

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Abstract. Indonesia's population increase leads to increase in food needs. The increasing need for food requires national food security. However the country faces the problem of agricultural land diminishing. Sandy soil is one of the suboptimal land that can be used for agricultural cultivation. Sandy soil leads to problems such as low water-holding capacity that will result in low levels of soil moisture. Soil moisture content is a very important factor in plant growth. Accordingly, we need an alternative solution to solve the problem. One of technology used in agriculture is an irrigation system. Therefore, the author proposes an idea in forms of Semar Sandy-App. Semar Sandy-App is a monitoring system as well as a system that provides direct supply water in the plant root zone. The system uses subsurface drip irrigation with perforated pipes then water comes out of the hole to wet the soil. This system can be a solution to optimize sandy soil through efficiency and effectiveness in providing water. The system can control and monitor the plant water requirements through the use of microcontroller that is connected directly to the android system, so it will increase agricultural productivity to support the availability of food for the community.

1. Introduction
Based on the result of Survei Penduduk Antar Sensus [1], Indonesia's population in 2019 reached 267 million. The population increase leads to the increase in food needs and requires ensuring food security. Food security is an effort to achieve sustainable development goals (SDGs). One of the problems that hinders the achievement of food security is widespread conversion of agricultural land into residential or industrial areas. According to BPS data in 2017, rice fields in Indonesia decreased by 7.65 million ha. The reduction in agricultural land has decreased food production, so it is necessary to extend agricultural land through sub-optimal land use.

Indonesia has a quite extensive sub-optimal land distribution in wetland and dryland [2]. Alternative sub-optimal that can be used for cultivation is sandy soil. The potential for sandy soil in Indonesia is 1,060,000 ha with a coastline of 106,000 km, so it has great development opportunities [3]. Utilization of sandy soil faced the problems with the characteristics of soil such as crumbly soil structure, loose consistency causing very fast permeability, and low field capacity [4], and water holding capacity is very low, only 1.6% - 3% of the total available water [5]. The low water holding capacity causes nutrients to be easily leached, the ability to absorb cations is low, and soil moisture content is low, so sandy soil is poor in nutrients which results in low soil fertility. So far, the irrigation system used is conventional irrigation which causes farmers to do watering more intensively that
wastes time and energy. Therefore, the management of sandy soil as agricultural cultivation needs to be carried out, one of the solutions is used by irrigation system which utilizes technological advances.

The irrigation system plays a major role in increasing agricultural crop production. However, so far irrigation is still working manual such as joint wells (sumur renteng), pantek wells (sumur pantek), and fog irrigation which are less effective and efficient for plant growth. Therefore, it needs an irrigation system that works efficiently to supply the water requirements of the plant. Drip irrigation is an irrigation system with a small and constant flow of water which is very efficient because of the low evaporation and run-off processes. Drip irrigation has the advantage of giving the water more precisely and evenly around the plant and discharge arrangements and operating time.

Utilization of irrigation technology that effectively and efficiently as a tool for monitoring and automatic watering can be used as a control to determine the water content in the soil [6]. Technological developments are advancing through the integration of Android-based devices or smartphones. The monitoring of agricultural cultivation can be carried out remotely via the farmer’s smartphone. Semar Sandy-App idea is the brainchild of subsurface drip irrigation system deliver water directly to the plant root zone on sandy soil. The novelty is the lack of irrigation systems on sandy soil that directly integrated into smartphones. This innovation is expected to solve the problem of agricultural cultivation in sandy soil and increase the efficiency and effectiveness the use of water resources then supports plant productivity to achieve the national food security.

2. Methods
The method used in the Semar Sandy-App idea are literature study and the research and development. Method of literature study was collecting by literature comes from a source of primary literature (scientific journals, research, and books) and secondary literature sources on sandy soil, irrigation, monitoring technology, and android. This literature review contains general statements made in style of the language itself. The main thoughts are discussed briefly, objectively, critically, and related to previous theories. Not only being a compiler, but also acting as an analytical and critical thinker so it’s able to merge several existing concepts. The research and development method is a research method used to develop ideas by designing a prototype in laboratory scale Semar Sandy-App.

3. Discussion
Sandy soil is a sub-optimal land that has a low water-holding capacity. Irrigation in sandy soil is still carried out simply through surface irrigation which has a weakness such as evaporate and leaching. Research about irrigation is limited to sumur renteng [7], sumur pantek, and fog irrigation [8]. The advantage of sumur renteng is an efficient because irrigation will provide in main reservoir and the risk of water loss (evaporation) during distribution can be minimized, but irrigation is still conventional and ineffective. Sumur pantek and fog irrigation have the advantage for suppressing the growth of pests and weeds. However, this irrigation system has several drawbacks such as requiring large material costs and high diesel power. Therefore, irrigation technology innovation works effectively and efficiently is required.

Subsurface drip irrigation is one type of irrigation in agricultural cultivation. Subsurface irrigation is providing the water gradually below the soil surface using pipes that are immersed in the soil and supply the water directly to the plant root zone through groundwater flows [9]. Subsurface irrigation is the best irrigation which has an efficiency level higher than other irrigation [10]. The drip irrigation system is needed for increased crop production because water is applied to the root directly, thereby minimizing water loss through percolation, run-off and evaporation [11], and allows the application of fertilizers, pesticides, and other water-soluble chemicals effectively once. Drip irrigation significantly improves all agronomic parameters of giza plants compared to sprinkler irrigation systems [12]. However, application of irrigation is not integrated the monitoring system. The monitoring system is used as part of controlling the provision of water for plants by using Android technology that can be monitored and facilitate the process. Monitoring process can improve the effectiveness of irrigation to support agricultural production [13].
Semar Sandy-App is a system that provides irrigation directly to plant root zone. Provision of proper irrigation (goals, timing and amount) would be beneficial in improving agricultural productivity. Semar Sandy-App uses subsurface irrigation through drip irrigation with a perforated pipe, so the water out of the hole discharge specified according to moisten the soil in the plant root zone. In addition, this system can control and monitor plant water requirements through the use of a microcontroller that connected directly to the Android system on a smartphone. The system uses Soil Moisture Sensor YL-69. This sensor consists of two electrodes which will read moisture in surrounding area, so current will pass from one electrode to the other. The value of the current is influenced by the size of the resistance due to the humidity around the electrodes. If the resistance is small, the current passing through the electrodes is a lot, so the humidity will be high [14]. Flowchart Semar Sandy-App showed in Figure 1.

![Flowchart Semar Sandy-App](image)

**Figure 1.** Flowchart Semar Sandy-App

Soil moisture sensor will measure soil moisture around the plant. Changes in soil moisture content will be read by a soil moisture sensor as the amount of voltage. The sensor readings are forwarded to the Arduino Uno Atmega 328 to be processed through the programming language. Then the Arduino is connected to NodeMCU so that it can send data and send it back to the Android application. NodeMCU system works with limitations, ie minimum limit on the value of the critical point and a maximum limit on the value of field capacity. The minimum and maximum limits depend on the type of plant. If the value of the sensor readings has passed the predetermined minimum and maximum limits, it will be forwarded as output to the relay. Relay will give a signal on/off Solenoid Valve. Then the irrigation system operates automatically in accordance changes in soil moisture content. This
process is repeated continuously until the soil moisture content is always in the range between the critical point and field capacity. The relay will turn on the Solenoid Valve when the soil is in a critical condition ($\leq 40\%$) and turn off the Solenoid Valve when the water supply in field capacity ($\geq 60\%$). This is because most plants have good growth in field capacity conditions. Field capacity in irrigation management presented the availability of soil moisture content [15]. Field capacity is a condition where water is only in micro-pores of the soil which is known as available water, while the macro pores of the soil are occupied by air [16].

![Sandy-App](image)

**Figure 2.** Display of Semar Sandy-App

Sandy-App created using Android Studio in communication between NodeMCU and Android applications used MQTT protocol. MQTT is sending and receiving messages protocol that allows multiple devices to send and receive data in the form of a string with ease. MQTT requires a broker that functions as a message receiver on an incoming topic and forwards the message. This application will immediately display the calculated data from the sensor so the calculation data will always be updated and can be monitored periodically. Display of Semar Sandy-App showed in Figure 2.

Semar Sandy-App application will display the data on the calculation of the sensor immediately so the data will update and monitor the calculation in real-time. Semar Sandy-App uses a simple interface that contains several menus, including:
- **Menu Home:** Contains menu as Menu Status, Information, and Settings.
- **Menu Status:** Displays the calculation data such as soil moisture, humidity and irrigation status, weather, day and time.
- **Information menu:** Presents a graph of changes in soil moisture over time.
- **Settings Menu:** Contains application and privacy guideline, policy, and service as well as the option to exit the application.

4. **Conclusion**

Semar Sandy-App is a monitoring system for plant water requirements and a subsurface drip irrigation system through the use of a microcontroller that's directly connected to the Android system on a smartphone. This system can be a solution to increase agricultural productivity of sandy soil through the efficiency and effectiveness of providing water for plants, so it will support sustainable food availability. Recommendations idea addressed to local governments to adopt Semar Sandy-App. Farmers as direct beneficiaries should actively participate in the implementation of this system because farmers are the social capital in determining the success of implementing Semar Sandy-App. Agricultural extension workers and practitioners should take part in intensive mentoring. The integration of the various stakeholders will support the successful of implementation this system so the goals can be realized.
References
[1] BPS 2015 *Profil Penduduk Indonesia Hasil SUPAS 2015* (Jakarta: BPS)
[2] Mulyani A and Sarwani M 2013 *Jurnal Sumberdaya Lahan* 7 47–57
[3] BPP Lembang 2011 *Bertani di Lahan Pasir Pantai* [http://www.bbpp-lembang.info/index.php/arsip/artikel/artikel-pertanian/492-bertani-di-lahan-pasir-pantai](http://www.bbpp-lembang.info/index.php/arsip/artikel/artikel-pertanian/492-bertani-di-lahan-pasir-pantai)
[4] Herawati A, Syukur A and Shiddieq D 2011 *Prosiding Seminar Nasional HITI* vol 10 (Surakarta: Jurusan Ilmu Tanah Fakultas Pertanian UNS) pp 220–7
[5] Saputro T 2015 *Agriculture research center di lahan pasir pantai baru Yogyakarta (dengan pendekatan Green Architecture)* (Surakarta: Fakultas Teknik Universitas Muhammadiyah Surakarta)
[6] Yudhana A and Putra M C F 2016 *Prosiding Annual Research Seminar* 2016 2 277–80
[7] Kunaiﬁ A A, Limantara L M and Priyantoro D 2011 *Jurnal Pengairan* 2 1–14
[8] Sumarna 2018 *Irigasi kabut untuk lahan pasir* (Yogyakarta: Dokumen Pemberdayaan Inovasi Desa. Bursa Inovasi Desa)
[9] Yulinda A, Rachmanita W and Rudiansyah O 2014 *Perencanaan jaringan irigasi daerah Bakalan Gajah Kabupaten Muara* Thesis (Palembang: Politeknik Negeri Sriwijaya)
[10] Hussein M A G and Mohamed S A E M 2012 *African Journal of Agricultural Research* 7 5962–76
[11] Daccache A, Knox J W, Weatherhead E K, Daneshkhah A and Hess T M 2014 *Agricultural Water Management* 147 1–9
[12] Khattab E A and El-Housini E A 2019 *Iraqi Journal of Agricultural Sciences* 50 753–8
[13] Singh D V K, Kushwaha D S, Taram M and Taram A 2015 *International Journal of Engineering Trends and Technology* 27 183–5
[14] Syamsiar M D, Rivai M and Suwito 2016 *Jurnal Teknik ITS* 5 261–6
[15] Turek M E, de Jong van Lier Q and Armando R A 2020 *Geoderma* 376 1–17
[16] Hendriyani I and Setiari N 2009 *Jurnal Sains & Matematika* 17 145–50