International Journal of Engineering Trends and Technology
ISSN: 2231–5381 / https://doi.org/10.14445/22315381/IJETT-V71I6P230

Volume 71 Issue 6, 303-309, June 2023

Original Article

Dryness of Somalia's Agriculture: Modernizing the Irrigation System

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Received: 26 December 2022 Revised: 04 May 2023 Accepted: 23 May 2023 Published: 25 June 2023

Abstract *- Somalia heavily depends on agriculture, contributing to its gross domestic product (GDP), export revenues, and employment. Somali farmers use their traditional irrigation methods, resulting in a low level of agricultural production. Our research developed a system that automates irrigation to increase efficiency and production. The proposed system uses the Internet of Things (IoT) devices to monitor farm conditions and act upon the data that these devices collect. This system irrigates the farm automatically by irrigating the farm based on soil moisture level or by scheduling irrigation time. Also, the system irrigates the farm using SMS Massage for irrigation or a mobile application by turning the on/off switch on the mobile application. The deployed system is real-time, cost-effective, and user-friendly, that Somali farmers can afford and adopt.*

Keywords *- Agriculture, IoT, Irrigation, Arduino Uno, Soil moisture sensor.*

1. Introduction

In Somalia, agricultural production was and still is second only to livestock before and after the civil war broke out concerning its contribution to gross domestic product (GDP), export revenues, and employment (Warsame et al., 2021). The regions with the most rainfall are the country's most productive agricultural regions. The precipitation pattern is divided into the Deyr (October – December) and the Gu' (April – June) seasons. However, increased precipitation unpredictability in timing and spatial distribution poses a considerably more significant threat to agricultural productivity and rural lives. Somalia's annual precipitation ranges from less than 100 millimeters in arid and semiarid coastal regions to 600–800 millimeters at higher elevations along the Juba and Shabelle rivers in the South. Also, the Juba and Shabelle are highly susceptible to alternating floods or water shortages due to water projects, intensified use for Ethiopia's agricultural development in the Shabelli catchment area, and the deterioration of upstream barrages (World Bank, 2018).

Since the government and other institutions cannot provide sufficient technical and support services, Somali farmers continue to use their traditional methods —low agricultural production results from this method. The major issues include ineffective farming systems, a lack of technical expertise, and innovative irrigation techniques(Abdullahi & Arisoy, 2022). In addition, Somalia's agriculture is more vulnerable than other sectors to climate and weather extremes, such as temperature changes, unpredictable rain patterns, and a rise in the frequency of floods and droughts (Mohamed & Chaiyapa, 2016). The agricultural drought frequently happens in Somalia and severely affects the irrigation system resulting in food insecurity (Dahir et al., 2023).

Smart Irrigation is an application of watering the farming ground in assistance to the growth of crops. Such automated applications could control and monitor the water flow to the crops to utilize the amount of water used for plantation (Gungor & Hancke, 2009), (Gutierrez et al., 2014). Many experts agree that smart irrigation systems conserve water compared to traditional irrigation systems across various scenarios. In this regard, several studies indicated substantial water savings from 40% to as high as 70% (Taneja & Bhatia, 2017), (C et al., 2018).

Smart irrigation is how we modernize the irrigation system without human involvement or with only system monitoring(Komal Kumar et al., 2019). Sensors like a soil moisture sensor, humidity sensor, and temperature sensor can be used to automate the irrigation system by measuring the amount of water in the soil and the weather (Monica et al., 2018). Irrigation is more effective and efficient when using an automated procedure, allowing the farmers to concentrate on other farming tasks (Angelin Blessy & Kumar, 2021), (Rawal, 2017). The impact of irregular, insufficient, or excessive water patterns on agriculture can be reduced by implementing an effective and efficient irrigation system that takes conservation measures because there is far too much suffering in the agricultural industry due to problems with insufficient or timely irrigation (Guleria et al., 2020).

The Internet of Things (IoT) provides a wide range of opportunities to transform traditional systems into devices interacting with the environment (Omar & Mason, 2019)(Mohamed Omar & Paul A. J. Mason, 2019). Several IoT-based solutions have been developed previously. Taneja, K. et al. proposed a system that automatically irrigates the farm when the soil is dry and sends the data to an open-source application and API called "ThingSpeak" (Taneja & Bhatia, 2017). However, their system lacks the capacity to detect rainfall, which can confuse by leading the system to try to stop the water when it already exceeds the normal level. Ismail N. et al. also developed a system that monitors the soil condition and the environment and then displays the data in an Android application. Using the application, the farmer can irrigate the farm or set it into an automatic mode(Ismail et al., 2019). Although, their proposal lacks the functionality to disseminate information if the internet is disconnected.

To the best of our knowledge, there have been no significant developments in agricultural irrigation systems in Somalia, despite the challenges faced by farmers in the region. The lack of access to reliable irrigation systems has reduced crop yields and failure, ultimately affecting farmers' livelihoods. To address this gap, we developed an integrated approach that utilizes automation technology to assist farmers in irrigating their farms. Our system is designed to automatically flush the farm based on the amount of water needed by the crops, ensuring optimal crop growth and reduced water waste. The system can also be controlled manually via a mobile application or SMS, providing farmers with flexibility and control over their irrigation needs. This proposed system addresses the limitations of existing irrigation systems in Somalia, making it suitable for the region's unique environmental conditions.

2. Methods

In our study, we created an integrated system that automates farm irrigation using Internet of Things (IoT) devices to effectively and efficiently meet the agriculture industry's technological needs. The implementation occurred at multiple farms, each with different locations and separate sensor devices. The devices are an Arduino Uno, a temperature and humidity sensor, a rain sensor, a soil moisture sensor, a relay module, a water pump, and a GSM/GPRS modem. Also, we implemented Mobile Application using Flutter and Firebase to manage the irrigation remotely, sending SMS or turning it on or off. Below, figure 1 shows how the sensors are integrated to form the system.

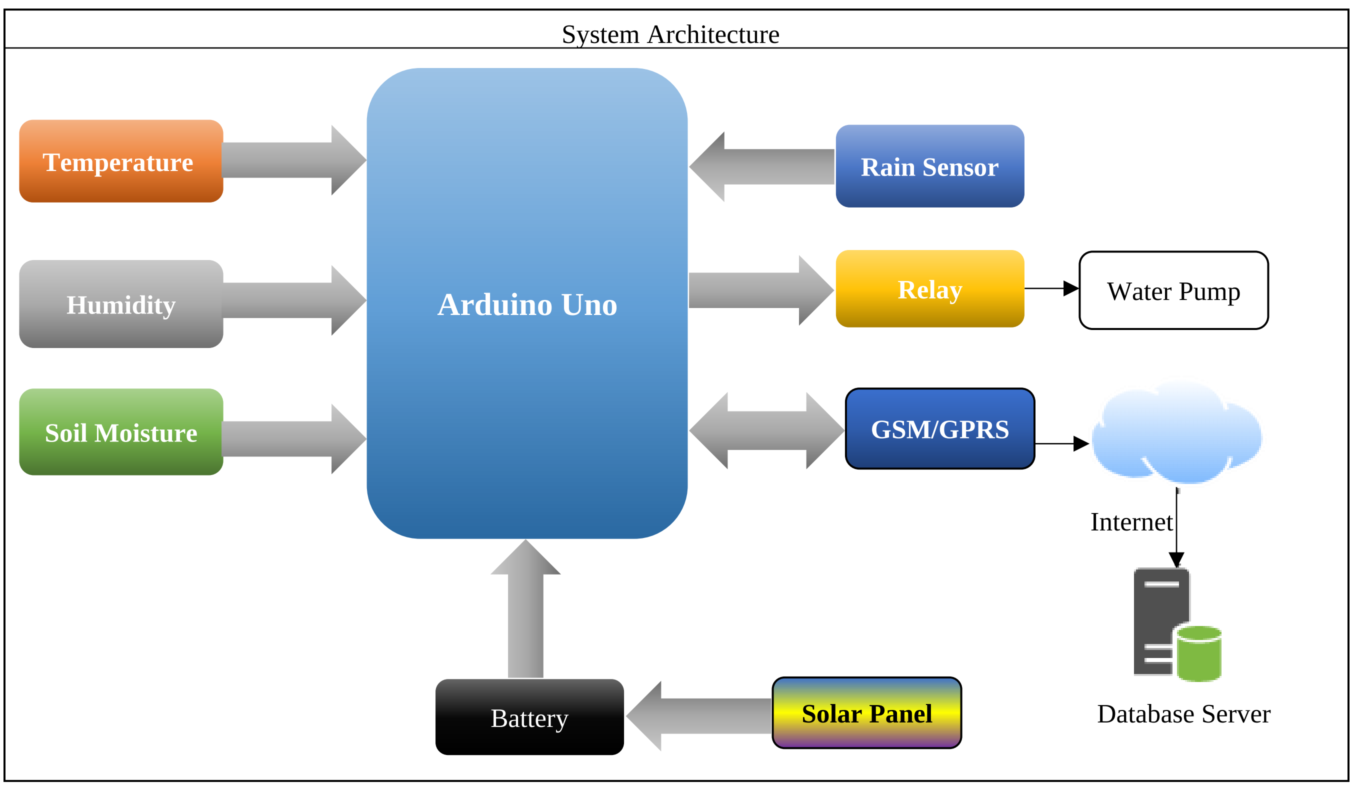

Fig. 1 Proposed system architecture

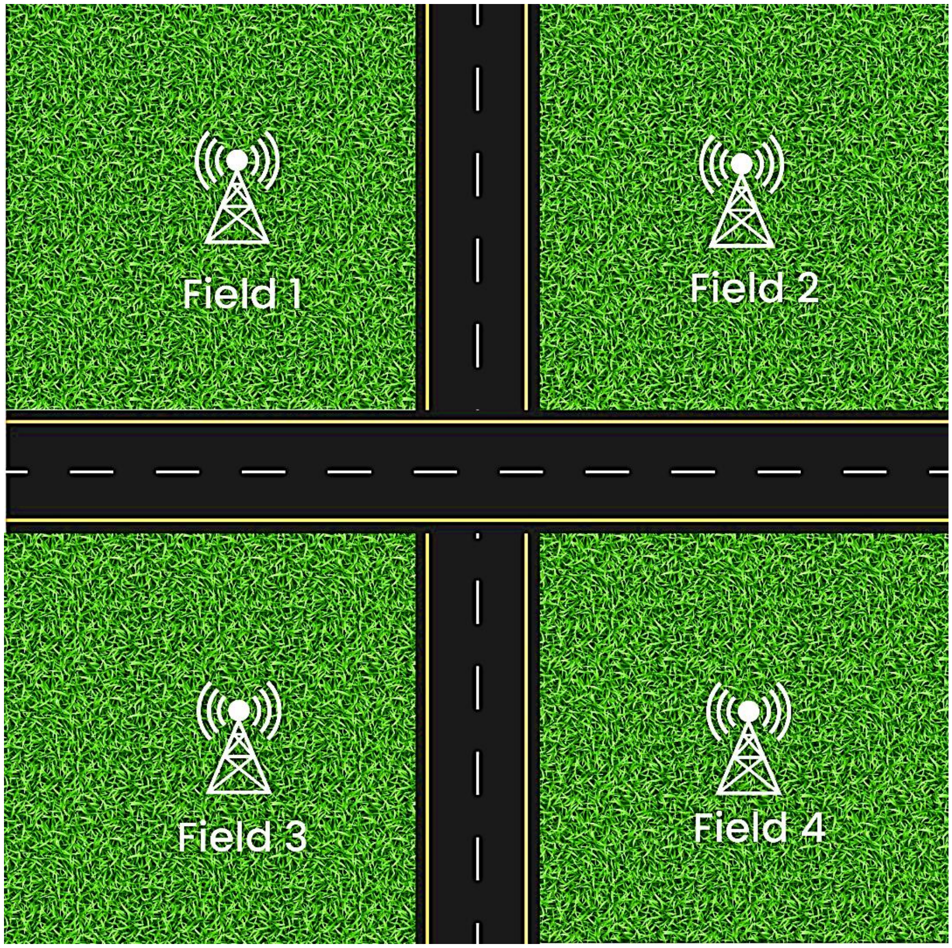

Fig. 2 System setup based on fields

Since crops require different levels of water (Brauman et al., 2013), we divided the farms into fields. Separate devices are used for each area where they plant the same crops. Figure 2 shows how the devices are implemented in each farm field.

Following, we describe the components mentioned above that form our integrated system and the role of each element.

2.1. Arduino Uno

Arduino is open-source computer hardware and software to prototype Internet of Things projects. It is a simplified microcontroller board that uses Arduino IDE to program the board using C language (Modules et al., n.d.). In this project, Arduino Uno is selected as the board on which the sensors are connected.

2.2. Temperature and Humidity Sensor

The DHT11 sensor module is a combination system for sensing humidity and temperature that delivers a calibrated digital output signal. It has a humidity and temperature complex with a calibrated digital signal output. DHT11 delivers excellent reliability and long-term stability, providing us with highly accurate humidity and temperature data (Deeksha Srivastava et al., 2018).

2.3. Soil Moisture Sensor

A soil moisture sensor is an electronic device that measures the volumetric water in the soil. This soil moisture sensor calculates the amount of moisture in the soil based on a feature known as electrical resistance or dielectric constant. Nickel is utilized to make this soil moisture sensor since it has the best conductivity and will not corrode in the soil even when used for a prolonged period. As a result, it has a long useful life (Divya Dhatri P V S et al., 2019).

2.4. Rain Sensor

The rain sensor is used for detecting rain. It can also be used to assess how heavy it is raining. Both digital and analog outputs are available. This module uses an analog output pin to measure the moisture, and when the moisture threshold is exceeded too far, a digital output is sent. The lower output voltage is a function of resistance or water content. On the other hand, a larger resistance, or high output voltage on the analog pin, results from less water (Borhade et al., 2021). This sensor is used to stop the system's functionality if it is raining.

2.5. Relay

A relay is an electrically powered switch with a mechanical switch and an electromagnet (coil) as its major pieces. Relays move low-power voltage controls to conduct high-voltage electric current using the electromagnetic principle (Sadikin et al., 2019). The relay is used between the water pump and Arduino Uno to let the current go through or not, depending on the commands received from the board.

2.6. Water Pump

A 220V water pump motor is a machine that uses mechanical force to transfer water via pipes. Thus, it is employed to provide water to the soil. It is therefore connected to Arduino via the relay module. This device operates according to SMS commands and/or a command from Mobile App received from the farmer's mobile device to an arduino board to irrigate the farm or turn the irrigation process off (Yasin et al., 2019).

2.7. GPRS/GSM Modem

In this research, A GSM modem (SIM900 GSM/GPRS shield), created especially for the Arduino UNO, which can be implemented into many Internet of Things projects, is used. This shield can do everything a typical cell phone can, including sending and receiving SMS text messages, making and receiving phone calls, and connecting to the Internet through GPRS, TCP/IP, and many more. Additionally, the shield is compatible with the quad-band GSM/GPRS network; thus, it may be used almost anywhere in the world (Sialee Leekongxue et al., 2020). Users can use this modem to send and receive data via SMS messages and the Internet.

3. Results and Discussion

The proposed system has been successfully implemented in two farms near Mogadishu, Somalia (Afgooye and Balcad Districts). The irrigation system has successfully irrigated the farms implemented in those Districts mentioned above. The system irrigates the farms using the automatic method or the farmer from the mobile application. The automatic irrigation method irrigates the farm without human interference. This method depends on the level of moisture in the soil. The system automatically irrigates the farm if the soil moisture is below the average (depending on the crop type). The following figure 3 shows the automatic irrigation interface.

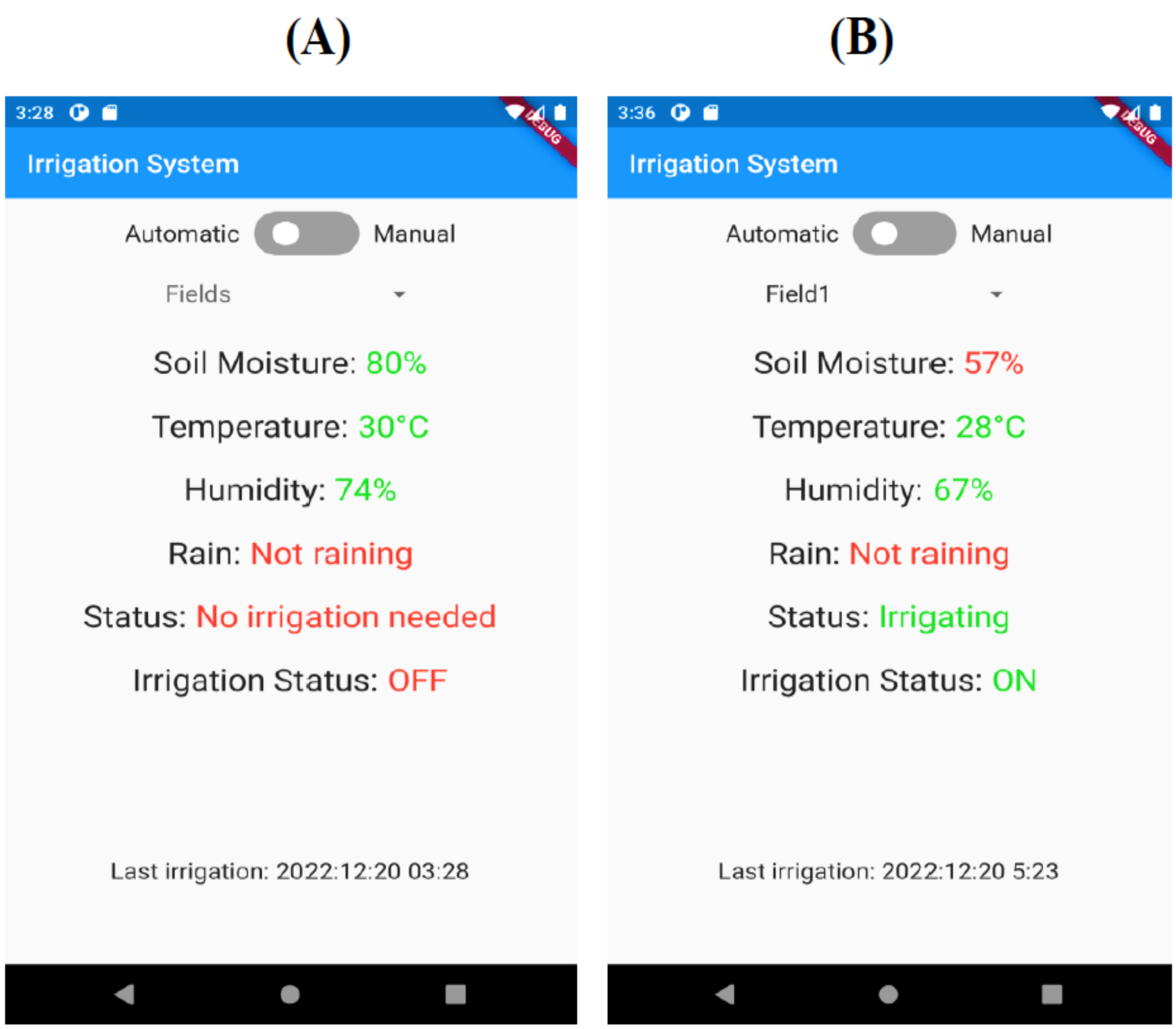

Fig. 3 Automatic irrigation interface. (A) The farm is not irrigated. (B) The farm is irrigated.

Alternatively, the farmer can schedule an irrigation time through the mobile application, and it will send an SMS message with the irrigation status. The farmer irrigates the farm using the mobile application, SMS command, or scheduled irrigation. This method can be used by switching from automatic to manual options in the Mobile application interface. Choosing the manual option, the farmer can irrigate the farm using his mobile application by sending an SMS rather than the system starting the irrigation automatically. When the soil moisture reaches below average, the system notifies the farmer through the mobile application alarm or SMS message to remind the farmer to irrigate the farm. In addition, the system sends an SMS message if it rains to shield the land when the soil moisture is high, and there is no need to allow rainfall.

Following figure 4 shows the mobile application's manual interface.

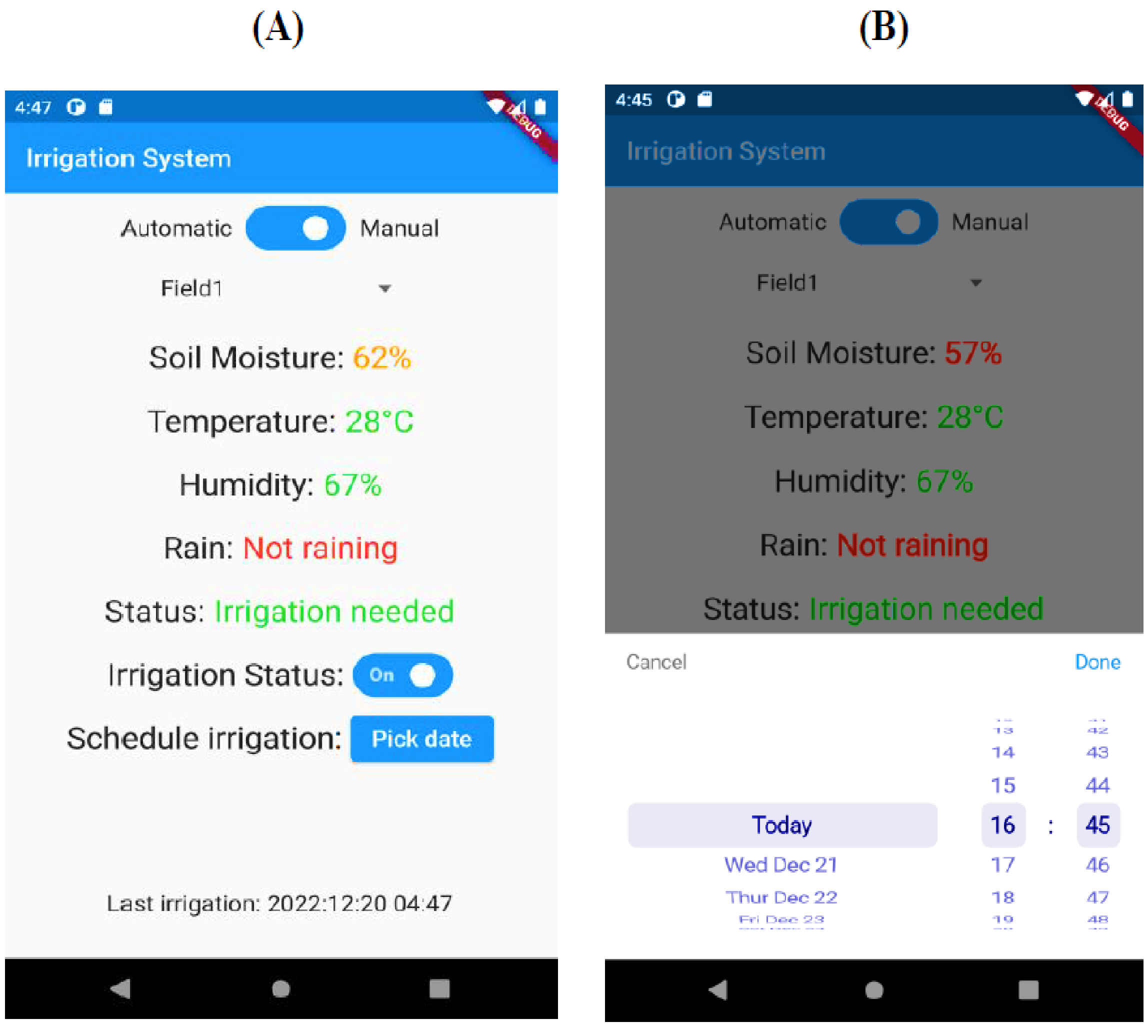

Fig. 4 Manual irrigation interface. (A) The farm is not irrigated. (B) Irrigation schedule interface.

4. Conclusion

This research lies in the development of a real-time, cost-effective solution to address the technological challenges faced by Somali farmers. Using an automated irrigation system with IoT devices, this research offers a practical solution to monitor and control key environmental factors affecting crop growth, such as temperature, humidity, rainfall, and soil moisture. The use of a mobile application interface makes the system user-friendly and accessible to farmers. Moreover, since Somalia faces significant challenges with access to electricity, using a solar panel to power the system makes a sustainable solution. The successful implementation of this system has the potential to significantly improve Somalia's agricultural sector by increasing crop yields and productivity, reducing water waste, and improving the overall efficiency of the irrigation process. This research has practical implications for the development of agriculture in Somalia and can serve as a model for other regions facing similar challenges.

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