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VV Sumanth Kumar
National Academy of Agricultural Research Management, Hyderabad, India

V Mani Chandana
National Academy of Agricultural Research Management, Hyderabad, India

Corresponding Author:
VV Sumanth Kumar
National Academy of Agricultural Research Management, Hyderabad, India

A reviewed study on the IoT based smart irrigation system for the betterment of the agriculture system

VV Sumanth Kumar and V Mani Chandana

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Abstract
One of the most pressing challenges for sustainable development is the increasing global population and the resulting food shortage. Smart farming, powered by artificial intelligence (AI) and the Internet of Things (IoT), offers a potential solution to feed the projected 10 billion people by 2050. With their high interoperability, advanced sensors, and cutting-edge technologies, AI and IoT have become essential components for smart farming practices. Drought is the most severe threat to agricultural output today, affecting almost all farming regions worldwide. Sustainable agriculture aims to increase water production and conservation to address this issue. Effective water management is crucial, especially in water-scarce areas, as agriculture consumes a significant amount of water. Traditional irrigation methods are water-intensive and result in substantial water wastage. To combat this, intelligent irrigation systems powered by machine learning and IoT are desperately needed to automate the process with minimal human effort, thereby reducing water waste. Modern agriculture requires the adoption of networking technologies, and IoT represents a crucial step towards the next stage of agricultural growth and development. IoT is a multidisciplinary concept encompassing various technologies, application areas, device capabilities, and operational techniques, often described as a new wave of ICT advancements. This article examines the potential of an IoT-powered smart irrigation system to improve agriculture by optimizing water usage and addressing water scarcity issues.

Keywords: Agriculture System, Internet of Things, Machine Learning, Food Shortage, Smart Farming, Water Adaptation, Etc.

Introduction
India's economy is mostly rooted on agriculture, but the country's storm is rapidly changing. Currently, groundwater levels, hybrid breeding, and fertilisation quality are all decreasing. In India, the population is growing at a rapid rate, and the need for food is growing as well. Our economy is heavily reliant on the agricultural industry. Horticulture relies heavily on water. As a result, effective water management of freshwater resources is of paramount importance. In order to save water and increase product output, it is necessary to use effective water system techniques. Things become self-aware and able to communicate with one other because to advances in technology. It is now possible to give everyday objects, such as appliances and household items, the ability to think for themselves through the Internet of Things (IoT). With the aid of Artificial Intelligence (AI) algorithms, sensors gather actual atmospheric data and analyse it so that gadgets may act more intelligently.

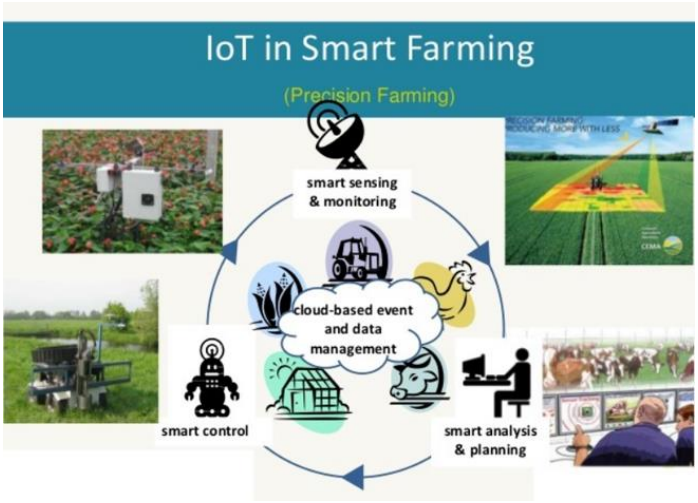

Fig 1: IoT in Smart Farming

Devices with software and sensors, data centres, and machines are all part of the Internet of Things (IoT) system, which aims to gather and share data between them. IoT's major goal is to improve machine-to-machine communication and make the best judgments possible, but without the need for human intervention. Home security, manufacturing, healthcare, automated transportation, and agriculture are just a few examples of how the Internet of Things (IoT) has changed several activities. Precision farming, smart crop monitoring, soil quality, smart irrigation systems, and many other subdomains of contemporary agriculture use the Internet of Things (IoT) effectively. A well-designed irrigation system is a must in precision agriculture. Smart irrigation decision support system (SIDSS) employs sensors in the field to monitor soil parameters, weather and climatic conditions, and crop conditions in order to make irrigation decisions.

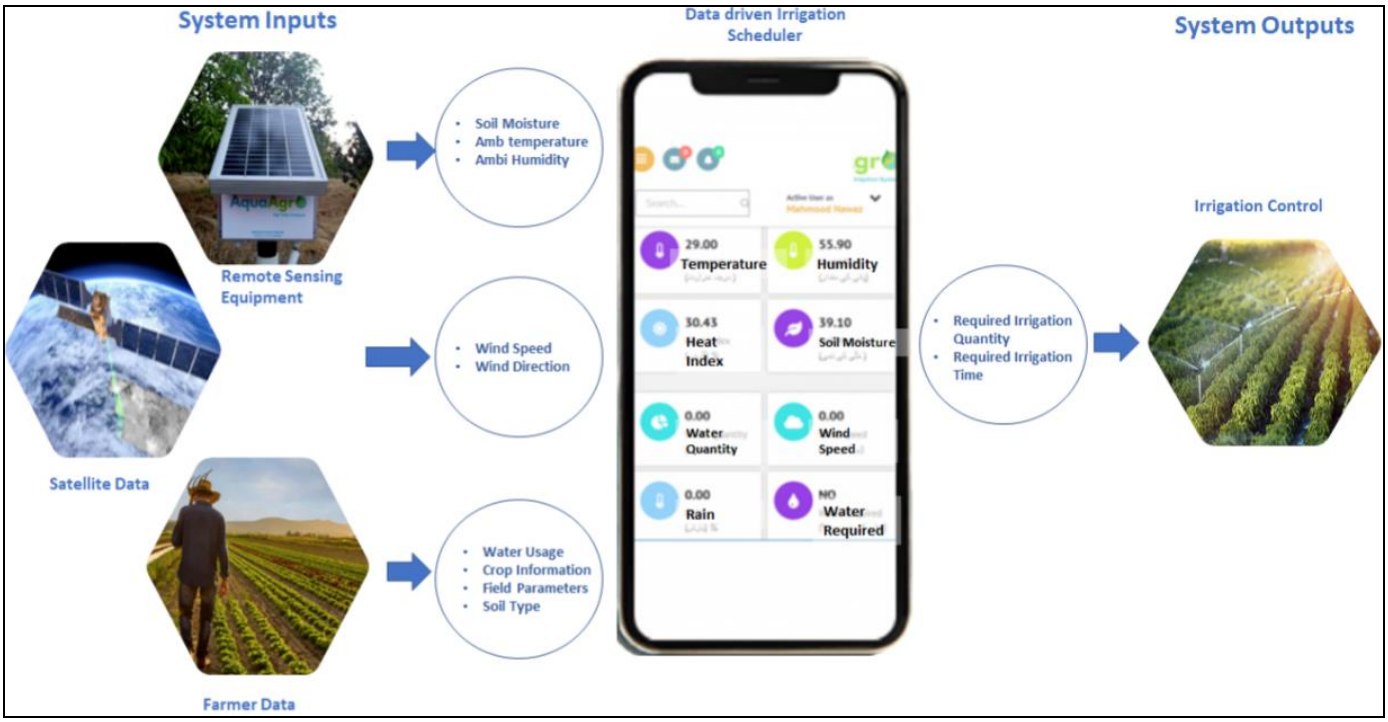

Fig 2: Overall architecture of agriculture-based DSS

IOT Based Smart Irrigation System for the Betterment of the Agriculture System

Rawal (2017) [22] offers an irrigation system that automatically waters the required soil moisture content while monitoring and maintaining it. ATMEGA328P on Arduino Uno platform is utilised as the control unit. Soil moisture sensors are used in this system to provide precise readings of soil moisture. To prevent excess or under-irrigation, this number allows the system to utilise the correct amount of water. Sprinklers' status is sent to farmers through IOT. Using a GSM-GPRS SIM900A modem, a farmer may verify the status of the sprinklers at any given moment by accessing a website that displays information from the sensors. A Thing Speak channel receives sensor information and generates graphs for further investigation. In the end, the researchers found that they had created a system to monitor soil moisture levels, and the project had offered a chance to examine the already used methods, their benefits and limitations. One of farming's most time-consuming tasks, irrigation, might be automated with the use of the system's sprinkler on/off controls based on soil moisture levels. Farming is one of the most water-intensive industries. Soil moisture sensors are used by the system to ensure that the soil is neither over- or under-irrigated, hence preventing crop damage. Using a website, the farm owner can keep an eye on the process. Through this experiment, it can be inferred that IOT and automation may have a significant impact on farming. As a result, the system has the potential to alleviate some of the drawbacks of the current, time-consuming, and labor-intensive irrigation procedure.

Sandeep Kumar *et al.* (2018) [20] An entirely mechanical water structure is the primary goal of this article. As a result of this, the water system architecture is able to monitor and regulate all of its various operations with ease. The moisture content determines whether or not the framework valves are activated or deactivated. A correspondence interface is also provided by the framework. The framework's collected data may be transferred to a third party for additional examination. Using this framework, it is possible to reduce the amount of labour and water required for production, hence increasing the overall benefit. Using the camera, we may look over the area and make an MMS to send to the rancher. We can uncover the plant's

ailment by installing the sensor at the plant's underlying foundations, and we can recommend composts to the rancher based on our findings.

Dr. J. Jegathesh Amalraj *et al.* (2019) [4] Today, it is possible to merge advances in order to save costs and increase the efficiency with which resources are used. Farmers now use a manual technique of irrigation control and water their fields at a certain time each year. As a result of these systems, large amounts of water are lost. Irrigation is difficult in arid locations since there is less rainfall. The optimal use of water in the smart agriculture system ensures greater yield. The use of environmental factors to automate the irrigation control process is required. It is possible to automate irrigation with the aid of contemporary technology and reap the benefits of increased output, reduced water use, and reduced soil erosion, among other things.

S. Vinod Kumar *et al.* (2020) [19] IoT-based smart irrigation has been examined in this article. The Internet of Things (IoT) platform can substitute for the lack of agricultural labour in irrigation. Internet of Things (IoT) platform sensors and wireless communication systems have been used to gather numerous metrics, such as soil moisture and temperature, humidity and pH. (WSN). "An extensive quantity of freshwater was saved using micro-irrigation, which the researchers determined to be the most effective means of reducing water usage." Humankind's role in agriculture should be eliminated as soon as possible and replaced by automated systems. Accordingly, this paper provides an overview of the various moisture and RH sensors that may be used in irrigation, as well as the depth at which they can be placed and the wireless communication devices that can be used to communicate with them. The soil moisture sensor calibration technique was also documented. According to the case studies cited in the article, IoT-based smart irrigation may be used in the future. Using IoT-based precision irrigation systems, farmers may have the best of both worlds in terms of accuracy, economy, human labour savings and environmental protection in their self-sufficient farming operations. Despite the numerous advantages of IoT in agriculture, their adaptation in the field is limited by the appropriate operation of sensors and internet access.

Md. Mehedi Islam *et al.* (2020) [17] The primary goal of this project is to use cutting-edge technology to enhance present agricultural practises and modernise the conventional agriculture system. Smart agriculture relies heavily on the Internet of Things (IoT). As far as agriculture is concerned, the initiative would assist smallholders at the ground level to use smart irrigation. Which deliver better irrigation service for less money and with fewer labour. Internet of Things (IoT) sensors may provide farmers with information about their farms and automate watering as a result of this. Temperature, humidity, pH, and water level in the agricultural field are all monitored by sensors in this study Sending data wirelessly from sensors to a Web server database is the method of choice. A smart phone or computer linked to the internet may be used to control these activities, and rain conditions are also taken into consideration. Smart agriculture will be implemented by connecting sensors to the IFTT and IFTT apps as well as Wi-Fi and the raspberry pi. The goal of this study was to devise a water-saving system that was adaptable, cost-effective, easy to customise, and most significantly, portable. It's a well-built device that's also compact. Using the Internet of Things, this water level monitoring system may be implemented with ease (IoT). The monitoring of water levels in several sectors, including oil and automotive, has become more important in recent years. With our smart technology, we are able to analyse the tanks' utilisation and also identify leaks. This project may be expanded in the future by adding more quality sensors and the like. That can tell you which soils need less fertiliser, how to utilise compost, and what kind of fertiliser you need to use for each of those soil types.

Iqbal Singh *et al.* (2020) [8] It is the goal of this study to provide a broad overview of IOT technologies and agricultural applications by comparing them to those of previous research publications. The irrigation system's hardware was a major focus of the research. This study focuses on the most important aspects and gaps. As a result of the research, it was decided that a better system should be developed, and that the improvement should not just be in paper work, but should be based on real field situations. These methods may be more effective and dependable in most field conditions if we focus on answers to the difficulties faced by farmers. Despite the numerous benefits of an IOT-based irrigation system, the research found that there are still a few areas in which it has to be improved. Analyzing revealed the following issues:

- **Rain sensor:** The rain is detected by this sensor. On the basis of resistance, it functions. Rain sensors have a big drawback in that they only operate when it rains. Normal watering procedures are followed every day. This sensor can't tell you when it's going to rain or how much it's going to rain. Sometimes harvesting and irrigation are done at the same time because of this problem. This may actually harm the crops rather than save them. We may claim that the rain sensor has to be improved to be able to identify when it's going to rain sooner rather than later. We may stop the irrigation system manually so that we can utilise the rainwater at the right moment. As a result, rain sensors are less necessary than weather predictions.
- **Electricity Problem:** The major problem faced by the farmers is electricity. There is no time for the regular supply of electricity. It comes only maximum 8 hours. This is the one-third of the whole day.
- **Maintenance:** Underneath the ground, these sensors are installed. As a result of their poor maintenance, these sensors began to malfunction over time. Sensors may potentially be affected by rust. The sensors and other equipment in the fields might be damaged by animals.
- Farmers have received no formal training to help them progress their careers in this industry. Many farmers aren't aware of the need of prepping their equipment before using it. "Neither the government nor the private sector has arranged a workshop for the advancement of their expertise." Because of this, farmers should ensure that their IOT-based irrigation systems are properly trained. They should be able to identify and fix minor-to-moderate issues.
- A considerable amount of money is required in order to link up with the IOT-based farm system. It's not difficult for wealthy farmers to stay on top of their schedules. Small farmers, on the other hand, are unable to afford these high-priced machines. Because of the low groundwater levels in several parts of India, for example. A much powerful submersible motor is needed for this task. Consequently, high-wattage solar panels are required to supply this need.
- In rural areas network problem is the big issue. Many projects are not completed due to the problem of Network in Rural areas.

Laura García *et al.* (2020) [14] summarises the current status of smart irrigation systems. Water amount and quality, soil qualities, and weather conditions are all factors that are taken

into account when designing irrigation systems, which we then monitor. Wireless technologies and nodes that are most often used are highlighted. Last but not least, we'll talk about the obstacles and best practises for sensor-based irrigation systems deployment. According to the findings of the research, water management is critical in nations with limited water resources. This has ramifications for agriculture, which consumes a significant portion of the nation's water supply. Global warming has led to the consideration of water management methods to assure the availability of water for agricultural production and consumption. As a result, water conservation studies for irrigation have grown in popularity over time. An overview of current IoT irrigation systems for agriculture has been presented in this research. We've compiled a list of the most frequently measured water quality, soil, and weather variables. For irrigation of crops, we have identified the most often used nodes in IoT and WSN systems and the most popular wireless technologies. "We also spoke about how IoT solutions for irrigation and agricultural management are now being implemented." For irrigation management, we've proposed a four-layer design. In the future, we want to use the suggested architecture to create an irrigation system that checks the quality of the water before it is used for irrigation.

Mohamed *et al.* (2021) [5] Data collection, transmission, storage, analysis, and appropriate solutions are the subject of this study from 2019 to 2021, which examines novel ways to smart farming (SF). Smart systems rely on the Internet of Things (IoT) since it links sensors to carry out a variety of fundamental functions. In order to keep track of such things as water level, irrigation efficiency, climate, and other variables, the smart irrigation system included a variety of sensors. On the basis of controls and sensors, together with certain mathematical relationships, smart irrigation may be described as 'smart.' Unmanned aerial vehicles and robots can be used to perform a variety of tasks, such as harvesting, seedling detection, irrigation and spraying of agricultural pesticides in real-time using IoT technology, artificial intelligence (AI), deep learning (DL), machine learning (ML), and wireless communications. Using a 5G mobile network allows for up to 20 Gbps data transmission and can connect a huge number of devices per square kilometre, which is critical in the development of smart systems. Smart farming in impoverished nations has several problems, yet this study identified various smart farming methods. Smart Decision Support Systems (SDSS) in developing nations may also aid with real-time analysis, mapping, and decision-making in regards to soil properties. Finally, greater government and private sector assistance for small farms and smart agriculture is required in emerging nations.

Haque *et al.* (2021) [7] In Bangladesh, this article suggests a smart agricultural system based on AI and IoT. According to this study, conventional farming and irrigation techniques should be replaced with smart farming, which encourages responsible leadership to maintain sustainable agriculture. I think it adds to the literature on smart farming in various ways. One of the most important contributions of this work is that it provides a non-Western perspective on AI, IoT, and smart farming. This highlights the actions of responsible leadership in Bangladesh's agricultural sector and underlines the requirement for sustainable smart farming. Third, this article serves as a starting point for future empirical investigations on the use of AI and IoT to implement smart farming. Finally, this article will serve as a guide for Bangladeshi policymakers who want to implement smart farming in a developing country. The overarching assumption is that Bangladesh's agriculture will be more sustainable if AI and IoT-based technologies are used in conjunction with smart farming and responsible leadership. Developing a long-term and sustainable climate is a task that goes beyond the mere use of conventional agricultural practises. With our suggested AI and IoT based smart farming allowing responsible leadership, we believe that we can realise and encourage smart farming with future innovation and efficiency.'.

Maged Mohammed, Khaled Riad and Nashi Alqahtani (2021) [15] Improve irrigation management of date palms in dry places by using cloud IoT technology to operate current subsurface irrigation systems. An automated controlled subsurface irrigation system (CSIS) was devised, built and tested to meet this purpose. Using an autonomous sensor network, the CSIS measures the volumetric water content of the soil and other environmental variables in the research area on-the-fly. Consequently, we used the Thing Speak cloud platform to host sensor readings and deliver commands to the IoT devices while also doing algorithmic analysis, visualising live data in real time. The CSIS validated that sensor-based irrigation scheduling (S-BIS) is more efficient than time-based irrigation scheduling for autonomously watering date palm plants (T-BIS). As a result of the S-BIS, water was delivered to the date palm's functional root zone at at the right timing and volume. When compared to typical surface irrigation, the CSIS S-BIS and T-BIS lowered irrigation water use by 64.1% and 61.2 percent, respectively (TSI). For CSIS using the S-BIS technique, CSIS using the T-BIS method, and TSI, the total yearly irrigation water applied was 21, 04, 22, 76, and 58.71 m3 palm1. S-BIS (1.783 kg m3) and T-BIS (1.44 kg m3) approaches at the CSIS greatly outperformed the TSI (0.531 kg m3) in terms of water productivity. Because of this, compared to the T-BIS approach, CSIS with S-BIS method retained volumetric water content in root zone around field capacity. Date palm irrigation in dry places is well-suited to the designed CSIS with S-BIS approach, which has a beneficial influence on irrigation water management and increases date palm fruit output.

Comparative analysis on previous reviews

The table below shows the comparative analysis on the works of the previous studies done on the subject of the IoT based smart irrigation system for the betterment of the agriculture system.

Autor(s)	Year	Methodology	Remarks
Kavan and G, *et al.*	2016 [10]	ARM Processor, GSM.	The trickle water system framework utilizing GSM and ARM processor gives a continuous criticism control module which screens and controls every one of the exercises of dribble water system framework proficiently. The framework valves are turned ON or OFF consequently relying on the dampness content. This will likewise give the productive data in regards to the dirt pH and soil supplements like nitrogen alongside the best possible proposals.
John R. DeLa *et al.*	2017	MATLAB Neural Network	By utilizing Neural Network in advancing the water utilization in the brilliant ranch by joining it to the proposed Smart Farm Automated Irrigation System

			(SFAIS).
Ravi Kishore Kodali *et al*	2017	MQTT protocol.	A basic water pump controller, in light of the dirt dampness sensor and utilizing Esp8266 NodeMCU-12E.
Prateek Jain *et al*.	2017	Aurdino microcontroller	It is a small processor core integrated circuit used for automation of interfacing applications For optimizing utilization of water resources and reducing labor cost in agricultural applications.
V. Dharmaraj *et al*.	2018	AI, Robotics	Discussion over AI impact on agriculture in an enhanced way in different sectors that includes the health of the crop, detection of crop yield and diseases, field and water requirement, automated irrigation system, precision farming.
D. Kumari *et al*.	2018	IoT based agricultural production system as GUI visualization software	Management of crop quality is done through working on a complete cycle from sowing to selling. Predicted the behavior of crop activity based on real data.
K. Radha Gowri	2019	IoT, GSM module, WiFi, ZigBee, sensors, WAN	Helpful in labor cost reduction, useful for small landholdings farmers, provides a better agricultural environment to crops than open land cropping. Proposed automated greenhouse control system for crop production under favorable conditions using sensors.
S. S. Mane *et al*.	2019	IoT, AI, Arduino, Sensors, Bluetooth, GSM	Lower and upper limits of soil moisture can be fixed. Proposed cost-effective Automatic Irrigation System with GSM-based on real-time soil moisture content. Recalibration of the system is not required in case of power failure. Status of the pump is used and delivered.
B. Ragavi *et al*.	2020	IoT and AI based 'AGROBOT, Cloud based IoT, Arduino, CAD Programming	Monitors weather conditions, fertilizers & pesticides need, water requirements. Proposed IoT and AI-based 'AGROBOT' for seed sowing mechanism. Reduces labor costs and improves crop yield. By using cloud services, information's sent to the farmers for the live monitoring of the field.
Deepak Sinwar *et al*.	2020	AI, IoT, sensors, cloud computing, solar power, Arduino, Raspberry Pi	Proposed Cloud and Solar Power enabled Hybrid Smart irrigation system (CS-HYSIS). Along with Arduino, Raspberry Pi is used to work on the concept of previous knowledge in the system so that process of irrigation does not stop in case sensor nodes fail. Because of cloud storage, users can access data at any time.

Farmer's stress, reliance on weather forecasts, as well as the expense of human labour may be reduced by employing AI and IoT in agriculture, according to an assessment of the most recent achievements made using these technologies. AI and IoT may be used in agriculture in a variety of ways, according to this article.

Conclusion

Our country's primary source of food is agriculture. More over half of India's workforce is employed in agriculture, which generates 18% of the country's GDP. According to the Indian government, agricultural innovations must meet the requirements listed above, and as a result, evidence of technological exposure and creative implementation strategies are being sought in order to boost production. Agricultural productivity, food security, and variable weather circumstances need innovative approaches. There are a number of factors that contribute to this, including a well-designed irrigation system and contemporary methods in irrigation that assist to maximise yield per drop of water. Over-irrigation is a big issue in the agriculture sector. "Crop quality and productivity are affected, while valuable resources are wasted, as a result of this practise." To combat water logging and salinity, farmers in poor nations tend to over-irrigate. All save the water-intensive crop require simply a sufficient quantity for their growth. Root development is harmed and water security in an area is reduced when too much water is applied. Precision agriculture need a smart irrigation system because we just cannot afford to waste any fresher water. Soil properties, weather and climatic conditions, and crop conditions may all be detected by field-deployed IoT-based smart irrigation systems using sensors. The Internet of Things (IoT) is automating all parts of farming and agricultural processes in order to improve the process. The study's goal is to give an overview of sensors, technologies, and sub-verticals, such as water management and crop management, that have recently been created in the agricultural and farming sectors using IoT. Farmers can maximise yields with little resources, such as water, fertiliser, and seeds, thanks to smart agriculture. In order to better understand their crops, farmers may use sensors to save resources and limit the impact of the environment on crops. Precision agriculture, another term for smart agriculture, is a subset of the former. We may thus infer that the usage of IOT and automation in farming can significantly grow. By making optimal use of water, the system may be a viable solution to the issues associated with irrigation's current manual and labor-intensive procedure. In order for agricultural development to occur, the majority of farmers must adopt the concepts of smart farming and precision agriculture, which are beneficial to agricultural society. In addition, young people must show an interest in the digital age of this new agriculture in order to effectively incorporate the knowledge of old traditional ways and current contemporary technologies to better the entire situation.

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