UJCS 6(2) (2025)

Unram Journal of Community Service

https://jurnalpasca.unram.ac.id/index.php/UJCS

Utilization of IoT and GIS` for Pest Monitoring and Identification to Enhance Sweet Potato Production in Dryland

Muhammad Zul Qurnain[1*], Barito Noviandi Guna[1], Erwin Irawan[1], Mulyati[1]

[1] Master of Dryland Agriculture Study Program, Postgraduate, University of Mataram, Mataram, Indonesia.

Received: April 29, 2025
Revised: May 28, 2025
Accepted: June 30, 2025
Published: June 30, 2025

Corresponding Author:
M. Zul Qurnain
zulfatepa@gmail.com

DOI: 10.29303/ujcs.v6i2.1069

Abstract: Sweet potato (Ipomoea batatas) is an important food crop with significant economic and social value, particularly in tropical regions. However, its productivity is often affected by pest attacks, which are frequently not detected early due to the limitations of traditional monitoring systems. This study aims to develop a pest monitoring system for sweet potatoes by utilizing Internet of Things (IoT) technology and Geographic Information Systems (GIS). IoT enables real-time monitoring of environmental conditions such as temperature, humidity, and light, while GIS is used to map the spatial distribution of pests. By integrating these two technologies, pest control can be carried out more efficiently, accurately, and environmentally friendly. This system provides early notifications to farmers regarding pest infestations, allowing for quick and effective decision-making in pest management. Additionally, the use of IoTand GIS isexpected to reduce excessive pesticide use andenhance the sustainability of sweet potato production. This article offers an innovative solution for pest management based on spatial-temporal data in dryland agroecosystems.

Keywords: IoT, GIS, Pest Monitoring, Sweet Potato, Precision Agriculture, Pest Control.

Introduction

Sweet potato (Ipomoea batatas) is an important food crop that plays a strategic role in food security, especially in tropical regions including Indonesia. Syamsuri et al., (2022) stated that sweet potato plants provide an alternative source of carbohydrates with economic and social value, especially for small farmers in rural areas. In addition, sweet potato has a high adaptability to changing climatic conditions, making it one of the solutions for food diversification in the era of global climate change. However, sweet potato productivity still fluctuates significantly due to various factors, one of which is pest and disease problems that are often not detected early (Wang et al., 2023).

Sweet potato productivity is affected by microenvironmental conditions and suboptimal land management, as well as the lack of adequate real-time monitoring technology in many traditional farming areas. Factors such as temperature, humidity and light play an important role in plant growth and health, as well as pest development. Manual monitoring that is done sporadically and relies on field experts often experiences delays in pest detection, resulting in less effective control and greater crop losses. New technologies such as the Internet of Things (IoT) are being developed to overcome these limitations through automated and continuous environmental monitoring (Prasetyo et al., 2023).

IoT enables the use of sensors that can record microenvironmental data such as temperature, humidity, and light intensity in real-time that can be sent to a central system for analysis and early warning. Integration with Geographic Information System (GIS) allows spatial mapping of pest distribution so that control can be carried out specifically and focused on the affected locations. The use of this technology is part of the concept of precision agriculture, which emphasizes efficiency and reducing the use of excess pesticides. Thus, IoT and GIS can optimize sweet potato pest management and maintain sustainable production (Chen et al., 2022).

How to Cite:
Qurnain, M. Z., Noviandi Guna, B., Irawan, E., & Mulyati. (2025). Utilization of IoT and GIS` for Pest Monitoring and Identification to Enhance Sweet Potato Production in Dryland. *Unram Journal of Community Service*, *6*(2), 403–408. https://doi.org/10.29303/ujcs.v6i2.1069

One of the main obstacles in sweet potato cultivation is significant pest attacks, especially the armyworm (Spodoptera litura), which attacks the leaves by eating massive leaf tissue to cause heavy defoliation. This negatively affects plant growth and decreases photosynthate accumulation, which has a direct effect on yield (Adekunle et al., 2021). In addition, aphids (Aphis spp., Myzus persicae) are important pests that suck plant juices, causing leaf curling and stunting growth. Aphids also act as vectors of viruses such as Sweet Potato Feathery Mottle Virus (SPFMV), which can significantly reduce production (Dewi & Pratama, 2022).

Other pests such as mites also cause damage by sucking leaf juices, causing leaves to turn silvery and eventually dry out. Leaf mining flies also weaken plants by damaging leaf tissue, thereby reducing photosynthetic ability and increasing plant susceptibility to environmental stress and other diseases (Jia et al., 2023). The damage caused by these pests results in huge economic losses if not effectively addressed.

Monitoring data that is localized and not spatially integrated is also an obstacle in planning effective pest control between regions. The inability to map the distribution of pests causes control to be carried out without considering the proper spatial distribution, so that pest control is less than optimal (Santoso et al., 2022). Therefore, a real-time, integrated, and widely accessible monitoring system is needed to support fast and accurate pest control decision making.

This research offers a solution by integrating IoT technology and GIS to develop a sweet potato pest monitoring system that is adaptive to the characteristics of dryland agroecosystems. The system enables automatic collection of microclimate data, real-time spatial mapping of pest attacks, and analysis of environmental conditions that can support or inhibit pest development.

This research offers a solution by integrating IoT and GIS technologies to develop a sweet potato pest monitoring system that is adaptive to the characteristics of dryland agroecosystems. The system enables automatic collection of microclimate data, real-time spatial mapping of pest attacks, and analysis of environmental conditions that can support or inhibit pest development. The theoretical contribution is to strengthen the scientific foundation of spatial-temporal data-based pest management in the context of agroecosystems. The managerial benefit of this research is to provide an innovative pest monitoring system that can be accessed by farmers, extension workers, and policy makers for quick and targeted decision making. This system is expected to increase sweet potato productivity, reduce losses due to pest attacks, and reduce the use of excessive pesticides so as to support sustainable and environmentally friendly agricultural practices.

Method

This review uses the literature study method by collecting and analyzing literature from scientific journals, books, and research reports related to IoT in dryland sweet potato pest control. Data were collected from Scopus, Google Scholar, and Sinta databases with the keywords "IoT", "pest control", "sweet potato", and "GIS" for the time span of 2020-2025. Relevant and quality literature was selected for critical analysis.

Result and Discussion

Sweet Potato Plant

Sweet potato (Ipomoea batatas) is a tuberous plant that has creeping stems and swollen roots as carbohydrate storage tubers. Its life cycle is generally between 3 to 6 months, depending on the variety and environmental conditions such as temperature and humidity that affect growth. The plant grows optimally in temperatures between 24-30°C and relative humidity of 60-80% and well-drained soil. Sweet potato is very adaptive to various types of soil, but the best growth occurs in soil rich in organic matter and loose texture. The advantages of sweet potato as a strategic food commodity include the content of nutrients such as vitamins A, C, and dietary fiber which are good for human health (Ahmed et al., 2022). Apart from being a food ingredient, sweet potato also has potential as a raw material for bioenergy and functional food, thus increasing its economic value. However, its productivity is vulnerable to pests and diseases that can significantly reduce yields (Sari et al., 2021).

Sweet potatoes contribute greatly to food security, especially in developing countries facing climate change. Food diversification with sweet potatoes adds variety to nutritious food sources and reduces dependence on other staple crops. In addition, sweet potato contains bioactive compounds that are beneficial for health, making it a functional food ingredient (Ahmed et al., 2022). These advantages make sweet potato a multifunctional crop that can improve farmers' economy (Mwanga et al., 2021).

Important Pests of Sweet Potatoes

Major pests in sweet potato crops include Cylas formicarius (tuber borer), Spodoptera litura (leaf caterpillar), and stem borer. Cylas formicarius causes damage to the tubers which can significantly reduce the quality and quantity of the crop. Cylias formicarius is a major pest of sweet potato that causes damage to the tubers. The larvae of this pest burrow into the tubers, resulting in the formation of toxic compounds that make the tubers unconsumable. The damage caused can reduce sweet potato yield by 20-80%, depending on environmental conditions and season (Indriyanti et al., 2021).

Spodoptera litura attacks the leaves, inhibiting the photosynthesis process, resulting in stunted plant growth. Armyworm (Spodoptera litura) is one type of caterpillar that attacks sweet potato leaves. This caterpillar gnaws on the leaves, thus reducing the leaf area that functions for photosynthesis. The damage caused by armyworms can reduce plant growth and tuber yield. Control of this pest is often done by spraying insecticides, although biological methods such as the use of parasitoids can also be effective (Afifah et al., 2022).

Stem borer or Omphisa fuscidentalis is another pest that often attacks sweet potatoes. This pest attacks the stem of sweet potato plants by eating away at the stem tissue, which can cause the plant to become brittle and easily collapse. Damage to the stem also inhibits the flow of nutrients that are important for plant development, which can ultimately reduce crop yields. Control of this pest is generally done by destroying infected plants and using appropriate pesticides (Syahnas et al., 2018). Stem borers damage the plant's water- and nutrient-transporting tissues, causing wilting and death. Variations in the attack of this pest depend on agroecosystem conditions and seasons that affect the pest's life cycle.

Utilization of IoT in Agriculture

The development of Internet of Things (IoT) technology has brought significant changes in the world of agriculture, especially in terms of real-time monitoring and control of plant pests. The main components in agricultural IoT systems include environmental sensors such as DHT22 (for temperature and humidity), LDR light sensors, artificial intelligence (AI)-based cameras, and microcontrollers such as ESP32 and Raspberry Pi which are the data processing centers (Rahayu et al., 2020). Internet of Things (IoT) is a technology that connects devices through internet networks to monitor and control various aspects of the environment automatically. In the context of agriculture, IoT can be used to monitor soil moisture, temperature, pest activity, and crop conditions in real-time (Liu et al., 2025). Various studies have shown that the application of IoT in agriculture, such as smart irrigation systems and soil moisture monitoring, can improve water use efficiency, optimize crop yields, and reduce unnecessary resource use (Walid et al., 2022).

The application of IoT also enables automation of control systems such as automatic activation of pesticide sprays based on the monitoring results of humidity and temperature sensors (Lee et al., 2020). This contributes to improving the effectiveness of pest control without compromising environmental health. In addition, AI camera-based sensors have the ability to accurately identify pest types based on images of plant leaves or stems, thus providing specific data on pest population and distribution. The Internet of Things (IoT) is a technology that allows devices to be interconnected via the internet and transmit data in real-time. In agriculture, IoT has been used to monitor soil conditions, humidity, temperature, and pest activity. IoT enables faster and more precise decision-making in agricultural management (Prayogo et al., 2024). Smart irrigation systems, for example, have been used to efficiently manage water demand by automatically detecting soil moisture and activating watering systems when necessary (Cao & Wachowicz, 2019).

In addition to improving the precision of pest control, IoT also plays an important role in the collection of historical data and agricultural analytics that can be used to predict future seasons and pest attack patterns. In the context of agriculture, IoT can be used to monitor environmental conditions such as soil moisture, temperature, and the presence of pests, all of which have a direct effect on agricultural yields. By using sensors and other connected devices, information about land conditions can be accessed in real-time by farmers, so they can take immediate action to prevent damage or loss of yield. Wahyu et al (2024) conducted an IoT experiment on a smart irrigation system that can regulate water flow based on soil moisture data obtained from soil sensors. This not only saves water usage but also increases agricultural yields by ensuring crops get sufficient water supply.

Utilization of GIS in Agriculture

Geographic Information Systems (GIS) are used to analyze spatial data related to agriculture, such as land mapping, crop distribution, and pest location identification. GIS is very useful in planning and monitoring the development of crops in various locations, as well as for planning the distribution of natural resources more efficiently. GIS enables visualization of spatial data that can be used to design better and more sustainable agricultural strategies (Leeonis et al., 2025).

Geographic Information Systems (GIS) enable the collection, analysis, and visualization of spatial data to understand the relationships between geographic elements in an area. In the agricultural sector, GIS is used to map land conditions, crop distribution, and pest potential and vulnerability. The use of GIS in agriculture helps in making decisions related to land use and natural resource management (Fatmawati et al., 2024). The integration of GIS with other technologies such as IoT allows for more in-depth analysis of the distribution and impact of environmental factors on agricultural yields.

The use of GIS also enables temporal analysis, where pest infestation data is collected and analyzed over a period of time to identify infestation patterns and trends. This makes it easier to predict pest attack seasons and prepare preventive control strategies. The use of GIS in agriculture also includes mapping potential fertile land and that which is prone to natural disasters such as floods or droughts. GIS thus provides much-needed insights for planning more efficient and sustainable land management (Ugliotti et al., 2025).

IoT and GIS Applications in Sweet Potato

The combination of IoT and GIS has been proven effective in increasing agricultural yields, including in sweet potato cultivation. By using IoT sensors to monitor soil conditions and pest activity, and GIS to analyze spatial data, farmers can better manage sweet potato crops (Sari et al., 2024). This technology can help farmers optimize fertilization, irrigation control, and pest management. In addition, the use of IoT and GIS can also increase the resilience of sweet potato crops to climate change and natural disasters, and reduce the use of excessive pesticides.

Pest monitoring using IoT and GIS technology has shown positive results in pest control. By combining IoT sensors that detect pest activity and environmental parameters with spatial analysis performed by GIS, farmers can more easily identify pest locations and take appropriate action. This IoT and GIS-based system can provide immediate notification to farmers regarding potential pest attacks and provide more precise control recommendations (Crismeire et al., 2025).

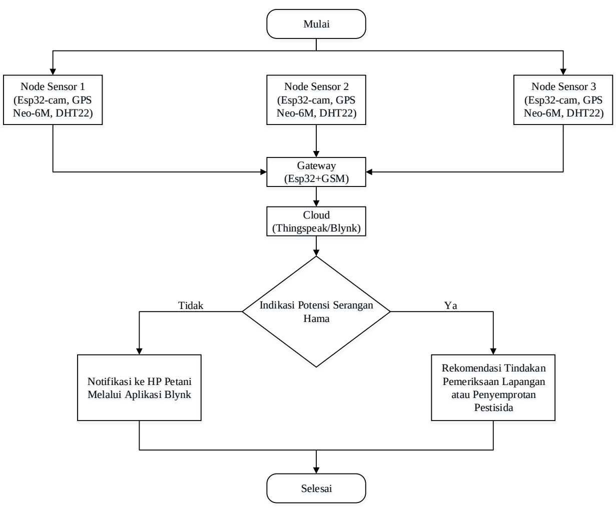

Figure 1. Working System Flowchat

For the workflow that can be described in the control flowchart diagram above can be seen below:

1. Sensor nodes 1, 2, and 3 will send images every specified time alternately to prevent messy data, temperature and humidity along with the location in the form of coordinates will be sent to the gateway (Esp32+GSM).
2. The gateway will receive the image, temperature and humidity, and location of each node in turn. Then the Gateway will send the received data to the Cloud (Tingspeak/Blynk).
3. On the cloud, the data will be stored and then sent to Thingspeak/Blink, then Blynk will send a notification through the phone.
4. The Blynk application will display images, temperature and humidity, and location. If it is seen in the picture that the crop damage exceeds 25%, it will display a notification to the farmer's mobile phone to recommend action to inspect the land or spray. If the damage level is below 25%, there is no recommendation for action. Only Temperature and Humidity, Location and Images of each Sensor Node appear.

Related Research

Various studies have examined the application of IoT in the observation and control of food crop pests such as rice, tomatoes, and soybeans with encouraging results. Wolfert et al.,(2021) reviewed that IoT in agriculture enables real-time data collection and big data analysis that supports pest attack prediction and efficient resource management. In the context of sweet potato, although still relatively rare, several studies have begun to show the great potential of IoT technology in accurately monitoring crop conditions and pest attacks. Research by Putra et al., (2021) emphasized the importance of adapting IoT monitoring systems to different agroecosystem characteristics in order to make pest control more effective and efficient.

In addition, the integration of IoT with GIS is the main focus in developing a precise pest management system. Spatial mapping of IoT monitoring results enables visualization that facilitates precise location-based decision-making and faster control interventions. This is very important to increase crop productivity while reducing the use of excessive pesticides and adversely affecting the environment (Fitriani, 2023).

Technical constraints such as implementation costs, uneven network infrastructure, and farmers' level of understanding of digital technology are still obstacles to the widespread adoption of IoT and GIS in agriculture. Therefore, the technology approach must be adapted to local conditions and supported by a comprehensive education program so that this technology can be applied effectively and sustainably (Rahmawati & Nugroho, 2021). The potential for the development of these technologies is enormous if supported by collaboration between academics, practitioners, and the government to accelerate digital transformation in the agricultural sector.

Conclusion

The use of Internet of Things (IoT) technology integrated with Geographic Information Systems (GIS) has proven to be an effective solution in improving pest monitoring and control in sweet potato crops. By integrating sensors to monitor microclimate parameters such as temperature, humidity, and light intensity, as well as spatial mapping of pest distribution, the system enables real-time monitoring that can provide more accurate and quick information to farmers. The results of this study show that focused pest control based on spatial data can reduce excessive pesticide use and minimize losses caused by pests, especially armyworms (Spodoptera litura), aphids (Aphis spp., Myzus persicae), and stem borers (Omphisa fuscidentalis).

The success of IoT and GIS technologies in pest monitoring can also improve the timeliness of decision-making, allowing farmers to take more targeted control measures and reduce damage to crops. In addition, this technology can increase efficiency in farmland management, resulting in more sustainable and environmentally friendly agriculture. Overall, the integration of IoT and GIS in agricultural systems has great potential to increase sweet potato productivity by minimizing losses due to pests and diseases, as well as supporting agricultural sustainability in areas vulnerable to climate change and pest attacks. The system is also accessible to farmers, extension workers, and policy makers, supporting faster and more targeted decision-making in crop pest and disease management.

Acknowledgments

Thank for the researchers to the Master of Dryland Agriculture, Postgraduate Program, University of Mataram and thank you friends who have helped in completing this writing.

References

Adekunle, A. A., Oladipo, O., & Adebisi, M. A. (2021). Effects of environmental factors on sweet potato production in tropical regions. Agricultural Sciences, 12(4), 500-510.

Afifah, L., Aulia, C. A., Saputro, N. W., Kurniati, A., Maryana, R., Lestari, A., Abadi, S., & Enri, U. (2022). Maize Media Enhance the Conidia Production of Entomopathogenic Fungi Lecanicillium lecanii also Its Effective to Control the Weevil Cylas formicarius (Fabricius) (Coleoptera: Brentidae). Agrivita, 44(3), 513-525. https://doi.org/10.17503/agrivita.v44i3.3605

Ahmed, S., Tariq, M., & Ali, Z. (2022). Nutritional profile and health benefits of sweet potato. Food Chemistry, 384, 13251.

Cao, H., & Wachowicz, M. (2019). The design of an IoT-GIS platform for performing automated analytical tasks. Computers, Environment and Urban Systems, 74, 23-40. https://doi.org/10.1016/j.compenvurbsys.2018.11.004

Chen, J., Li, Y., & Zhang, S. (2022). IoT-enabled pest monitoring system for precision agriculture. Computers and Electronics in Agriculture, 195, 106819.

Crismeire, I., Costa Francisco dos, R. F., & Batista, T. (2025). Application of GIS in the maritime-port sector: A systematic review. Sustainability, 17(8), 3386. https://doi.org/10.3390/su17083386

Dewi, M., & Pratama, A. (2022). Impact of climate change on sweet potato pests and diseases in Indonesia. Journal of Plant Protection Research, 62(1), 77–85.

Fatmawati, F., Qashlim, A., & Kahpi, A. (2024, January). Sistem Informasi Lahan Pertanian Kabupaten Polewali Mandar Berbasis GIS. In Journal Peqguruang: Conference Series (Vol. 5, No. 1, pp. 171-174).

Fitriani, D. (2023). IoT-based pest monitoring for sweet potato agroecosystem. International Journal of Agricultural Engineering, 12(1), 21–32.

Indriyanti, D. R., Wijayanti, D., & Setiati, N. (2021). The effect of Beauveria bassiana on the larvae of Oryctes rhinoceros. Journal of Physics: Conference Series, 1918(5) https://doi.org/10.1088/1742-6596/1918/5/052091

Jia, X., Wang, X., & Liu, M. (2023). Spatial-temporal analysis of pest dynamics using IoT and GIS technologies. Agricultural Systems, 204, 103740.

Lee, S., Park, J., & Kim, H. (2020). Automated pest control system using IoT sensors and machine learning. Sensors, 20(17), 4812.

Leeonis, A. N., Minhaz, F. A., Mazlin, B. M., Halder, B., Chen, K. L., Nuriah, A. M., & Scholz, M. (2025). Importance of Geographic Information System (GIS) Application to Reduce the Impact of Flood Disasters in Malaysia: A Meta-Analysis. Water, 17(2), 181. https://doi.org/10.3390/w17020181

Liu, X., et al.,(2025). BIM, IoT, and GIS integration in construction resource monitoring. Automation in Construction, 174, 106149.

Mwanga, R. O. M., Carey, E. E., & Grüneberg, W. J. (2021). Sweetpotato breeding for food security in sub-Saharan Africa: Recent progress and challenges. Crop Science, 61(3), 1662–1672.

Prasetyo, Y., Suprapto, N., & Wahyuni, S. (2023). IoT based pest monitoring system for smart agriculture. Computers and Electronics in Agriculture, 199, 107182.

Prayogo, Y., Bayu, M. S. Y. I., Indiati, S. W., Sumartini, F. C. I., Ginting, E., Susanto, G. W. A., Harnowo, D., & Mejaya, M. J. (2024). Eco-friendly biopesticide of Beauveria bassiana to control sweet potato weevil Cylas formicarius (Coleoptera: Curculionidae). IOP Conference Series: Earth and Environmental Science, 1312, 012025. https://doi.org/10.1088/1755-1315/1312/1/012025

Putra, F. D., Wahyuni, S., & Santoso, A. B. (2021). IoT applications in pest management in different agroecosystems. Agronomy Journal, 113(1), 456–465.

Rahayu, D., Santika, B., & Wardhani, N. (2020). Development of IoT sensor systems for pest detection in agriculture. Journal of Sensors and Sensor Systems, 9(2), 177–186.

Rahmawati, L., & Nugroho, A. (2021). IoT-based pest monitoring systems for smart agriculture. Procedia Computer Science, 179, 876–883.

Sari, I. P., Novita, A., Al-Khowarizmi, A. K., Ramadhani, F., & Satria, A. (2024). Pemanfaatan Internet of Things (IoT) pada Bidang Pertanian Menggunakan Arduino UnoR3. Blend Sains Jurnal Teknik, 2(4), 337-343.

Sari, P., Ismail, A., & Hadi, S. (2021). Pest and disease management in sweet potato: A review. Journal of Agricultural Science, 13(4), 45-55.

Santoso, B., Wibowo, D., & Fadilah, R. (2022). Precision agriculture and sustainable pest management: a review. Agronomy for Sustainable Development, 42, 18.

Syahnas, F., Bakti, D., Lubis, L., & Rahmawati, N. (2018). Resistance test of several sweet potato genotypes against sweetpotato weevil Cylas formicarius Fabricus (Coleoptera: Curculionidae) in the lowlands. Journal of Agricultural Science, 44(3), 513-525.

Walid, M., Hoiriyah, H., & Fikri, A. (2022). Pengembangan Sistem Irigasi Pertanian Berbasis Internet of Things (IoT). Jurnal Mnemonic, 5(1), 31-38.

Wang, Y., Li, J., & Zhang, F. (2023). Environmental influences on pest outbreaks in sweet potato cultivation. Agriculture, Ecosystems & Environment, 337, 108113.

Wahyu, A., Suryanto, R., & Jatmiko, H. (2024). Pengembangan sistem irigasi cerdas berbasis Internet of Things (IoT) untuk optimasi penggunaan air dalam pertanian. Jurnal Teknologi Pertanian, 32(1), 45-56.

Wolfert, S., Verdouw, C., & Ge, L. (2021). Big data and IoT technologies in agriculture: Challenges and opportunities. Agricultural Systems, 193, 103244

Zhou, S., & Lee, C. (2021). Advancements in integrated pest management for sweet potato: A review. Pest Management Science, 77(3), 1237-1246.