# A cost-efficient smart solution for small-scale farmers: a multidisciplinary approach

José A. Brenes[1], Freddy Soto[2], Gabriela Marín[3]

[1] Research Center for Communication and Information Technologies (CITIC), University of Costa Rica
San José 11501, Costa Rica
joseantonio.brenes@ucr.ac.cr

[2] Fabio Baudrit Moreno Agricultural Experimental Station (EEAFBM), University of Costa Rica
Alajuela 20102, Costa Rica
freddy.sotobravo@ucr.ac.cr

[3] Research Center for Communication and Information Technologies (CITIC), University of Costa Rica
San José 11501, Costa Rica
gabriela.marin@ucr.ac.cr

**Abstract**

In the near years, the world population will have to deal with a big problem: to produce the food required to satisfy its increasing demand. It is imperative to support farmers to find a solution. In this regard, the information and communication technologies (ICT) sector can help by creating technology which supports agriculture processes to increase the crop production and to reduce the resources consumption.

In this paper, we present a cost-efficient solution for small scale farmers. Our platform helps the farmers in the decision-making process by using data recollected from crops and by controlling fertigation. Using it, farmers can be more efficient and waste fewer resources.

## 1 Introduction

One of the biggest problems society will have to deal in the future is related to the lack of food required to feed people around the world. According to the World Economic Forum, by the year 2050, the world population will reach 9.8 billion people, and they will demand approximately 70% more food than they consume today [1].

To respond to increasing global problems, the United Nations developed the Sustainable Development Goals (SDG) [2]. They represent the walkthrough nations have to follow to guarantee a better and more sustainable future. To achieve the SDG is necessary to involve the participation of information and communication technologies (ICT) sector to achieve these goals and to provide solutions that support agricultural processes in all the crop stages.

The vertiginous growth on the creation and development of ICT has shown to be very useful. Internet of Things (IoT) technology involves the communication between machines and devices connected to the Internet in a manner that they can interact each other and at the same time, and they can produce data accessible to users remotely [3]. On the other hand, artificial intelligence techniques such as big data, neural networks, and agent-based experimentation, among others; enable new opportunities on data analytics and how to use these data to improve the process of making decisions.

Taking the advantages of these technologies, smart farming or smart agriculture can be defined as the combination of context-aware computing and wireless sensors and actuators networks [4], to use the data retrieved from the crops, to support the decision-making process. The final goal is to increase productivity and reduce resource consumption.

Currently, agriculture is benefiting by platforms developed to support agricultural processes using emergent technologies. An example is the development of multiple solutions based on wireless sensor networks which are deployed directly in the crops, in which the data is collected automatically and served to the users in real-time [3,5-6].

A lot of researchers have directed their efforts on the creation of decision support systems that help farmers in different crop phases. Some of these efforts help with fertigation, climate control, or pest identification, and control inside the greenhouses. Some other efforts seek to support the farmer in the early stages of the agriculture process by defining the better crop to cultivate according to the climate or soil conditions [7].
Nowadays, smart agriculture is an active field of research. However, many of the work done and solutions produced are not reaching the small farmer. Some proposals are no more than that. They remain on labs. Several systems developed do not include all the necessary elements or characteristics to deploy them massively. Furthermore, not all farmers have the means to acquire commercial platforms and systems, causing that technology do not reach the productive sector.
What we want to achieve with our platform is just that. Our goal is to create a cost-effective solution that can be acquired by the farmers directly. A platform that can be delivered massively to improve the conditions of small-scale farmers. We pretend to support the farmers with the deployment and the management of the platform in the first months to maximize their benefits.

## 2 Our research context

To create a cost-effective solution, we have been working based on a multidisciplinary effort. The project has envisioned by researchers working on the Fabio Baudrit Moreno Agricultural Experimental Station (EEAFBM) of the University of Costa Rica. This experimental station has an extension of 53.6 hectares, and it is located in the San José neighborhood of Alajuela. The experimental station has a greenhouse dedicated to research in protected environments.
Our interdisciplinary team is composed of researchers on Physics from Center for Research in Atomic, Nuclear and Molecular Sciences (CICANUM) and Laboratory for Atmospheric Research and Planetary Physics School (LIAP), computer scientists from Research Center for Communication and Information Technologies (CITIC), and agronomists from the experimental station. Joining efforts, we have been working in the creation of a platform that maximizes the crop production by the monitoring, control, and decision-making support.

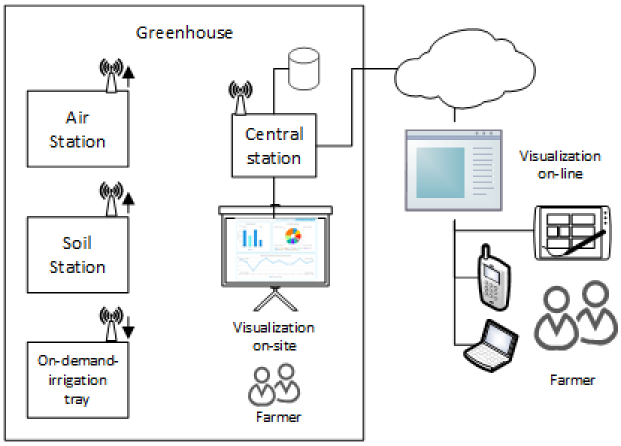


Figure 1: General overview of the solution

## 3 Our proposal

Figure 1 shows a general overview of the platform, the components, and how they interact. The solution is composed of two monitoring stations (marked with an arrow pointing up), a control station (marked with an arrow pointing down), and two visualization systems.
We created the platform using open-hardware low-cost components, looking for cost reduction. The

platform also uses LoRaWAN[1] wireless communication and is energy-efficient due to the use of solar energy.

Currently, we have created two monitoring stations to measure the variables listed in Table 1. The monitoring stations capture and store data in a database. Besides, the system also serves the data to the Internet through an MQTT[2] server. That allows using several systems to visualize the data in real-time.

Table 1: Variables measured by the stations

| Station | Variable measured |
|---|---|
| Climate/Air | Air temperature |
| | Atmospheric pressure |
| | Visible and infrared radiation |
| | Relative humidity |
| | $CO_2$ concentration |
| | VOC gas resistance |
| Soil | Soil temperature |
| | Soil humidity |

For data visualization, we have used two platforms. First, it is necessary to present the data to the farmer on-site, i.e., near to the crop, the place where the farmer spends most of his time. For that, we placed a screen in a laboratory next to the greenhouse and showed the data through a Grafana[3] dashboard in real-time (Figure 2).

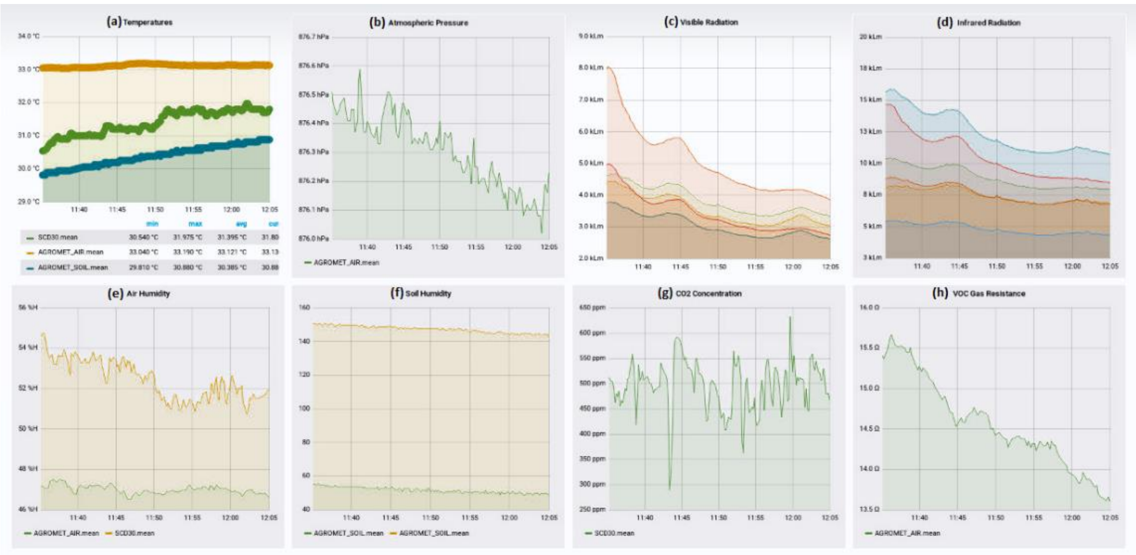


Figure 2: Data visualization on-site. From up to down, left to right: (a) Temperature. (b) Atmospheric pressure. (c) Visible radiation. (d) Infrared radiation. (e) Relative humidity. (f) Soil humidity. (g) $CO_2$ concentration. (h) VOC gas resistance.

Second, we thought that it will be helpful for the farmer to have access to the data from any place. For that reason, we have created a web-based application where the farmer can query data.

For the greenhouse control, we are using an irrigation-on-demand tray created by us to manage the fertigation. That tray uses droppers, soil humidity sensors and a rain gauge to irrigate according to soil

[1] https://lora-alliance.org/about-lorawan
[2] http://mqtt.org/
[3] https://grafana.com/

humidity and drained water.
It is important to mention that we give the farmer the option to apply fertigation manually if s/he considers that. The latter permits the farmers to keep control of the crop and to make more accurate decisions according to his/her expertise, which will enhance the production.

## 4 Conclusions

We have created a cost-efficient smart farming solution for small-scale agriculturists. Currently, the platform created is in an experimental phase. We are testing it with tomato and sweet pepper crops. So far, the platform enables more accurate decision-making based on data retrieved from the crops directly. Now, we are working on a new version of the platform allowing control from a web application. Furthermore, we are working on an automated decision-making version based on data analysis and applying agronomists criteria.

## 5 Acknowledgments

This work was partially supported by the Research Center for Communication and Information Technologies (CITIC), the Fabio Baudrit Moreno Agricultural Experimental Station (EEAFBM), the Center for Research in Atomic, Nuclear and Molecular Sciences (CICANUM) and the Laboratory for Atmospheric Research and Planetary Physics School (LIAP) at the University of Costa Rica. Research Project No. 736-B8-016.

## References

[1] World Economic Forum. (2019). Shaping the Future of Food. Geneva, Suiza: World Economic Forum Official Website. Recuperado de https://www.weforum.org/system-initiatives/shaping-the-future-of-food-security-and-agriculture

[2] United Nations. (2019). Sustainable Development Goals. Roma, Italia: Food and Agriculture Organization of the United Nations. Recuperado de http://www.fao.org/sustainable-development-goals/en/

[3] a G. P. Colucci, M. Poletti, R. Stefanelli, and D. Trinchero, "Internet of Things as a means to improve agricultural sustainability," 2017 IEEE Biomedical Circuits and Systems Conference (BioCAS), Torino, 2017, pp. 1-4. doi: 10.1109/BIOCAS.2017.8325182

[4] Rehman, Aqeel-ur. (2015). Smart Agriculture: An Approach towards Better Agriculture Management. 10.4172/978-1-63278-023-2-024.

[5] Shi, X., An, X., Zhao, Q., Liu, H., Xia, L., Sun, X., & Guo, Y. (2019). State-of-the-art internet of things in protected agriculture. Sensors (Basel, Switzerland), 19(8) doi:10.3390/s19081833

[6] Gómez-Chabla R., Real-Avilés K., Morán C., Grijalva P., Recalde T. (2019) IoT Applications in Agriculture: A Systematic Literature Review. In: Valencia-García R., Alcaraz-Mármol G., Cioppo-Morstadt J., Vera-Lucio N., Bucaram-Leverone M. (eds) ICT for Agriculture and Environment. CITAMA2019 2019. Advances in Intelligent Systems and Computing, vol 901. Springer, Cham

[7] R. A. Cárdenas Tamayo, M. G. Lugo Ibarra, and J. A. García Macías, "Better crop management with decision support systems based on wireless sensor networks," 2010 7th International Conference on Electrical Engineering Computing Science and Automatic Control, Tuxtla Gutierrez, 2010, pp. 412-417. doi: 10.1109/ICEEE.2010.5608629