# Greener IoT: Rainwater Sustainable Green and Vegetable School Gardens

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## Abstract
We describe here our research efforts towards the development and popularization of a prototype for sustainable vegetable gardens automation at schools in Campo Mourão, Paraná, Brazil. Our research is focused on low cost Internet of Things components that can optimize the water use on green and vegetable gardens, especially on public schools, allowing the use of rainwater for irrigation. We also concentrate our efforts in the minimization of the components cost, facilitating the access to the system by schools, and even communities, with budget restrictions. Our initial efforts have showed the feasibility of the project by the development of a complete functional prototype, and its application on a research green garden at our university campus. Next steps include the prototype refinement, and application on selected public schools and communities.

## Author Keywords
IoT; Green and vegetable gardens; Rainwater usage; Public schools; Communities; Budget restrictions.

## ACM Classification Keywords
• **Computer systems organization~Embedded systems**
• **Applied computing~Agriculture**

**Technology innovation allied to balanced diets!**

In Brazil, generally, students from low-income families rely on the free meals provided by public schools during the day. To increase the opportunities to receive good balanced meals, this project concentrates on the green and vegetables production on public schools using low cost technologies and rainwater.

**Water availability**: our choices are directly related to the limited school budgets. With rainwater in abundance, besides the sustainability factor, the automation of the irrigation process brings reduction in the potable water consumption and the costs associated with.

## Our Context

The evolution and growth in the use of mobile platforms with the Internet of Things (IoT) technologies, allied to Cloud Computing and Big Data popularization, poses as a viable way of promoting concepts such as sustainability and quality of life, inherent concepts of our modern society.

Given an IoT scenario, where a set of thousands of intelligent and distributed devices work in a coordinated and interconnected fashion, raising the society's awareness to the benefits of using such technologies as a natural resource management tool is feasible and necessary.

Water is one of the most precious natural resource today. Considering the water distribution, which is certainly uneven across the planet, the rational use of such resource is mandatory nowadays. The sustainable water use relies on the population awareness and, more recently, on the technology enhancements [1]. In this context, water irrigation raises as one important problem in today's society, where the efficient production of food is highly desired.

According to the Brazilian's National Water Agency [2], irrigation in Brazil is responsible for 46% of the water used from hydric resources, and responds for 67% of the total water used in the country. The same agency proposes policies on the water used for irrigation and argue that efficient natural resource usage can bring long-term benefits, which includes the increase in food production, overall production cost reduction, and sustainable natural resources reuse.

Therefore, the options for sustainable water use are always in constant development. This research focuses on the reuse of rainwater to irrigate small vegetable gardens as a way to promote (1) water reuse and sustainability awareness, and (2) IoT technology dissemination on primary schools and small neighborhoods or communities.

## Our Research

We designed and assembled an automated irrigation system that uses a rainwater cistern to irrigate a green and vegetable garden. This project is under development as part of the social interaction between our university and public schools by means of a community project.

Our prototype was developed using an Arduino based platform, the Node MCU, which also includes an ESP8266 Wi-Fi shield onboard. The prototype was designed having as the major goal the component cost minimization. All electronic parts will need a total budget of approximately US$20. If we include the dripping pipes and hoses that take water across the garden, we will need another US$15 to US$20. Although there are more precise sensors, this would increase the overall budget and the results would be roughly the same, since we do not target precise agriculture irrigation. All the selected parts and components are easily available, including the electronics. All listing, assembly schematics and source code are available at our GitHub repository [3]. All documents and codes developed are released under an open source software license.

**Technology to raise public awareness and promote education!**

**Hand-on the results:** Arduino online platforms can be used as a fast way to show practical results to attract attention of children to the programming and technology innovations world. There are plenty free online resources that can be used to this subject.

**Tech innovation**: Although not new, IoT concepts are novelty for students outside the Computer Science area. In elementary schools this could be used as an introductory course to Arduino platforms promoting technology awareness in children.

The prototype is fully functional and, at this point, is under testing at our local vegetable garden in the university, controlled by our research group students. All the green and vegetables produced during experimental phase are distributed for free to the community.

## Technology Dissemination

Although Arduino-based irrigation systems are not new, they are easy projects to replicate, with hands-on and fast results that attract people outside de Computer Science community. Once we finish the testing phase in the university campus, our goal is to replicate the project in selected public elementary schools from Campo Mourão.

The selected schools will be responsible for purchasing the parts to assembly the irrigation device, provide a cistern which can hold the water used for the vegetable garden, and select groups of students that will take part in the project. That is the main reason to keep a low overall budget to replicate the project. Thus, the Arduino was the first choice due to its capacities, flexibility and dissemination in the IoT community, and certainly, the low cost of the parts and sensors.

Our research group will be responsible for the teaching course to introduce the technologies for teachers and children in the target schools. We expect that participant groups assembly their own prototypes thoughout the course. We will primarly focus on the hardware assembly, since the software development would require skills that our participants might not have. At first, we will use our own software in the prototype.

In this context, the fast practical results will serve as leveraging tool to introduce basic, computer science and IoT concepts in elementary schools as a technology dissemination platform. The basic course will be made available online using the Moodle platform. Additionally, we expect that this could help the dissemination of introdutory programming courses in the early shool years, which is rare in Brazilian elementary schools, especially in public schools. Arduino is such a flexible platform that would allow the development of interesting practical applications, using free online tools such as Sketch [4] and ArduBlock [5].

## Gathering and Using Data

Another important part of the project replication in schools is the data gathered. Our prototype keeps records in the ThingSpeak platform. The collected data about soil humidity and temperature might help in the refinement of the irrigation process, providing feedback about the water consumption for different green and vegetables. Teachers in Science classes could use the data to illustrate differences between agricultural cultures. Water cycle, use and reuse awareness could also be explored themes. ThingSpeak is a user-friendly platform, allowing easy data analysis, providing several mechanisms to visualize the data collected. This would serve as proxy to train elementary teachers to use technology to favor experimental classes.

## LATAM CSCW Challenges and Opportunities

Most of our primary challenges here in Brazil are related to budget and bureaucracy. Our research scenario relies, most of the times, on limited reserch budget to develop and to apply the results. Our technology innovation popularization faces problems with bureaucracy.

Nevertheless, research opportunities include raising public awareness on several sustainability topics, including social and environmental aspects of everyday life. The Internet of Things technologies broadened our possibilities, including the smart cities agenda. Our research group has potential interest in efforts towards energy consumption management on IoT devices. This includes several scenarios including urban mobility, environmental monitoring, including green urban areas and pollution levels. In these opportunities, IoT devices are distributed in a large area, performing remotely monitoring tasks.

Additionally, the application of the STEM methodology concepts in the project replication is an extra collaboration opportunity. This could bring students and teachers closer to the project, providing resources for adaptation and overall solution improvement according to restrictions or specific needs.

We also claim that collaboration comes from sharing artifacts and communicating the results. Thus, all of our developed artifacts are released under open licenses: software is released under permissive open source licenses; other artifacts generally use a Creative Commons license. These simple actions allow popularization and collaboration on the project.

## References

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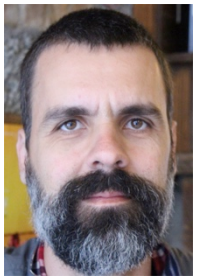
## Short Bio



Ivanilton Polato is a professor at the Federal University of Technology – Paraná. He completed his PhD at the University of São Paulo researching energy consumption analysis on distributed computing platforms. His main interests are related to green computing and energy consumption on computing platforms, including IoT systems; open source programming, repositories and licenses. Recently, he has dedicated efforts towards topics regarding mining software repositories and social platforms such as GitHub.

Willian Rodrigues Barbosa is an undergraduate student at the Federal University of Technology – Paraná, member of this project as developer and collaborator.