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Development of a LoRa Wireless Sensor Network to Estimate Agricultural Risk

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How this presentations is organized

Motivation → Objective → Materials and Methods → Results and Discussion → Conclusions

Motivation

- **Agribusiness** is an important pillar of the Brazilian economy encompassing several areas and in it the use of automation has increased significantly, specially in precision and decision-making agriculture;

- The **new technologies embedded** in agricultural machinery, the development of **low-cost sensors based wireless network** and their connection has proved to be useful in the field:

  - based on the data generated by such sensor's devices, **computational techniques and statistics** to extract useful information **for farmers**;

  - More recently the **Internet-of-Things (IoT)** has been playing a key role in the **Agriculture 4.0.**

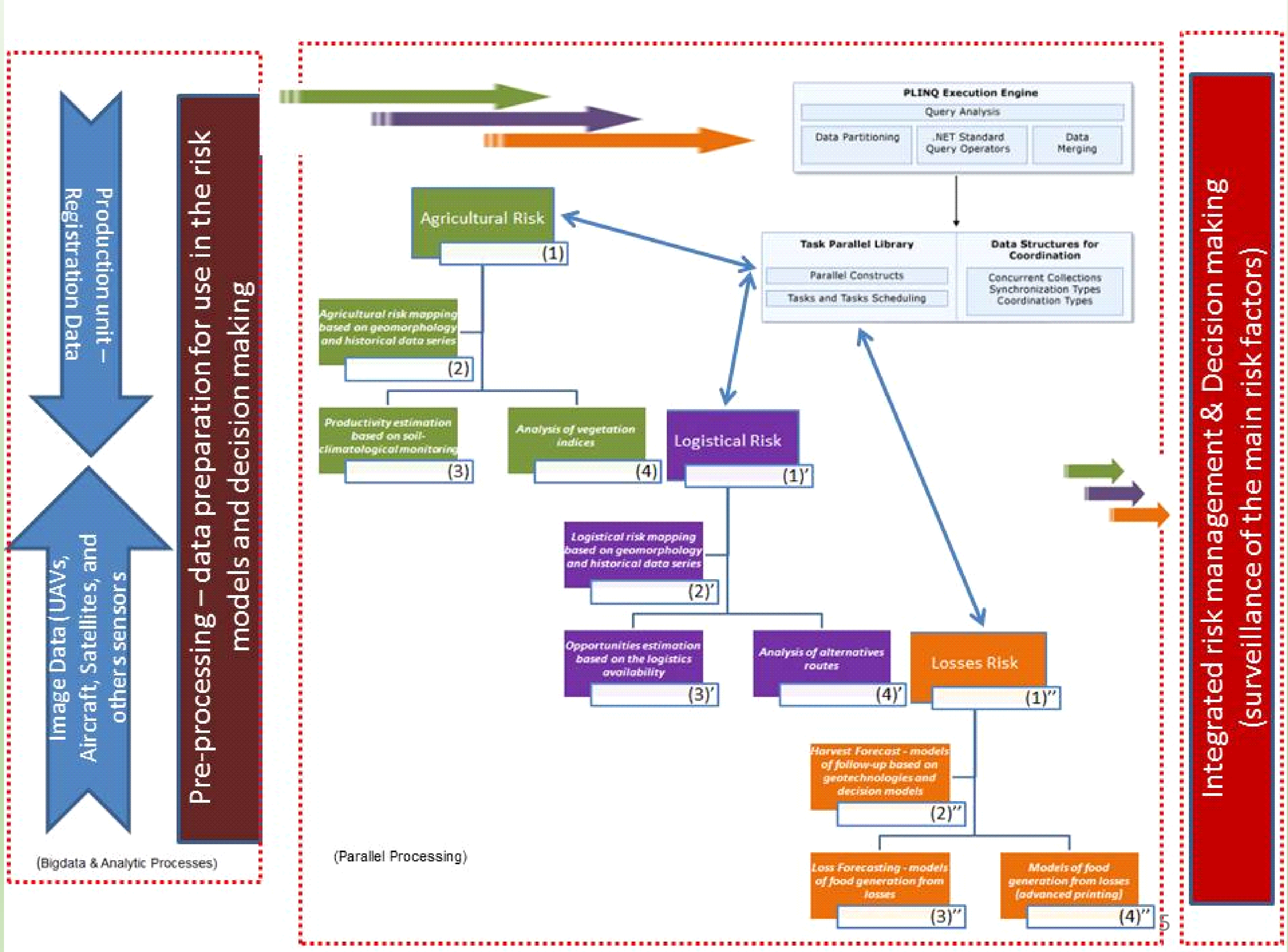
Motivation

- Several types of sensors can be used for continuously measuring a great amount of data, assisted by wireless networks and cloud computing to develop models for field conditions evaluation, while providing values to farmers;
- Application for sensors in agriculture to measure soil characteristics, such as **pH**, **nutrient content**, **temperature**, and **moisture**, among other variables of interest;
- The results of soil evaluation are important for obtaining a more precise scenario for planting, as well as for higher performance and quality.

A framework related to the use of geo-technologies and embedded support decision systems for agricultural risk management has being developing…

- Use of this framework to exploit smart sensors to evaluate Soil Quality (SQ)

- SQ is one of the factors that influence agricultural risk. It can influence the productivity indexes of crops



Motivation

- Different protocols for data communication have been observed in the literature;
- In such context, LoRaWAN protocol can enable implementation for long-range networks avoiding the use of conventional cellular networks, whose coverage in Brazil in rural areas is still not ideal.

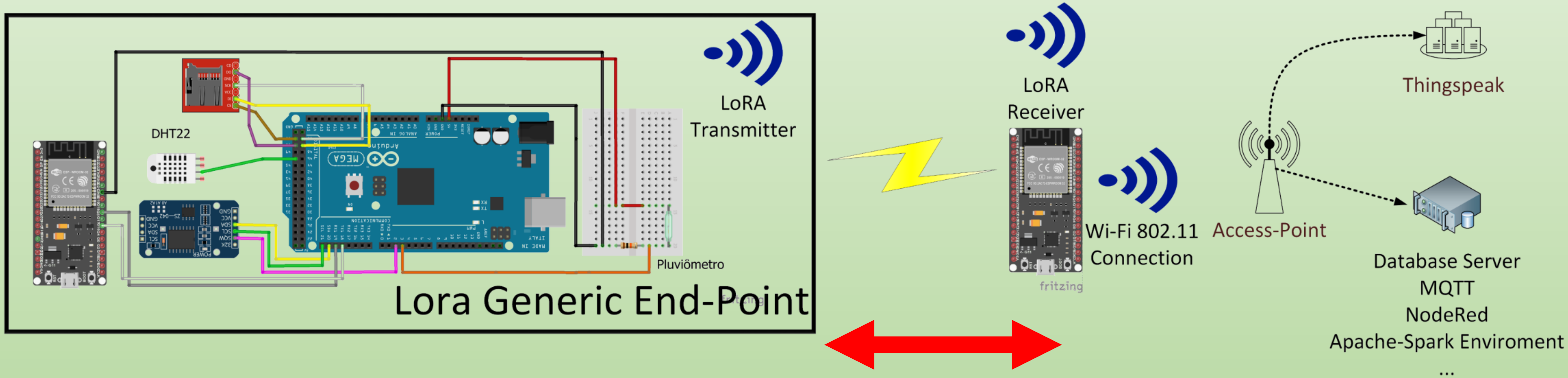
Objective

As part of a broader project in which the development of agricultural-risk analysis tools based on data from different sources is being developed, this study presents a new approach of both climatical and soil data collector system based on a wireless network, which is intended to be one of those data-sources to support decision making in agricultural risk.

Material and Methods

- Hardware device based on **Arduino Mega 2560**, **Heltec Wi-Fi Lora 32**
  - Sensors are connected to Arduino which sends data to Heltec module
  - Both boards exchange information through their serial ports
- Data were also received using another Heltec Wi-Fi LoRa 32 module
- This module receives, organizes and transmits data to remote servers
  - **ThingSpeak** - an IoT platform that enables Realtime aggregation, visualization, and analysis of data flows in the cloud
  - **Dedicated server** - data were also inserted into a **Mosquitto, NodeRed**, and **Postgres-based** platform, which will be integrated in a high-performance architecture using Apache-Spark to treat and process data through a risk calculation algorithm

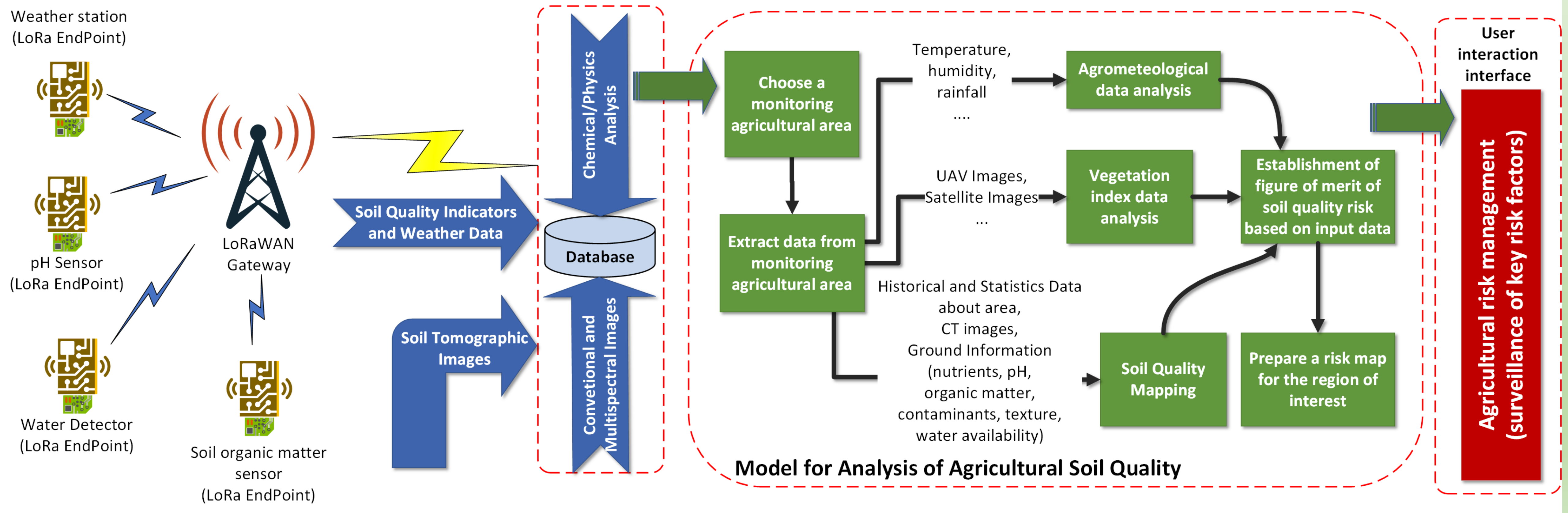
Material and Methods



Receiver Wi-Fi LoRa module was positioned 500 meters away playing the role of a gateway

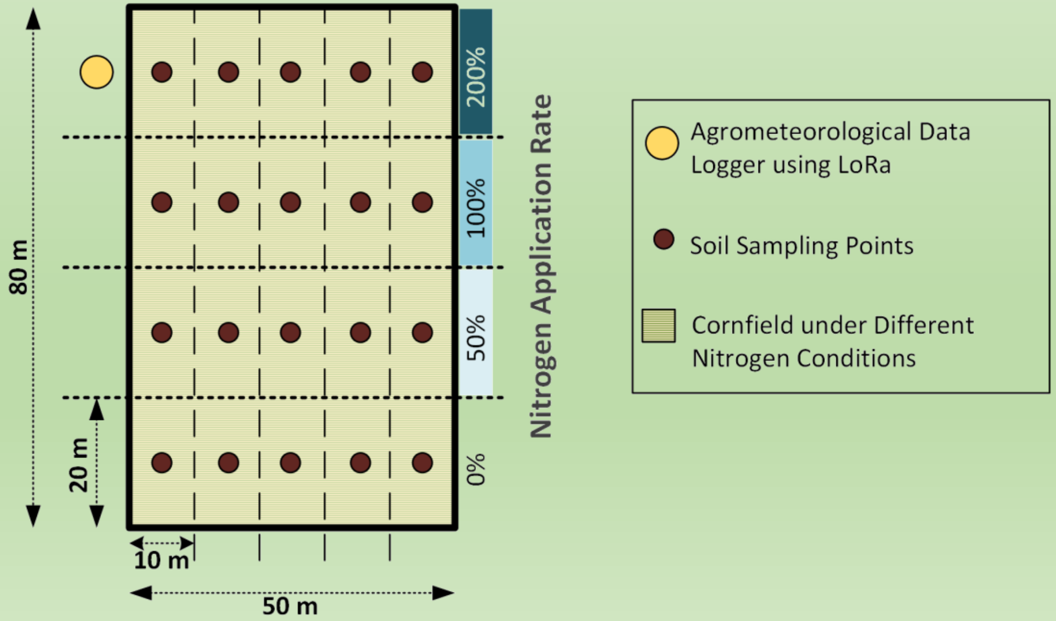
Material and Methods

Basic architecture developed for soil quality risk analysis with model components, the LoRa structure and the used protocol for wireless agricultural data communication.



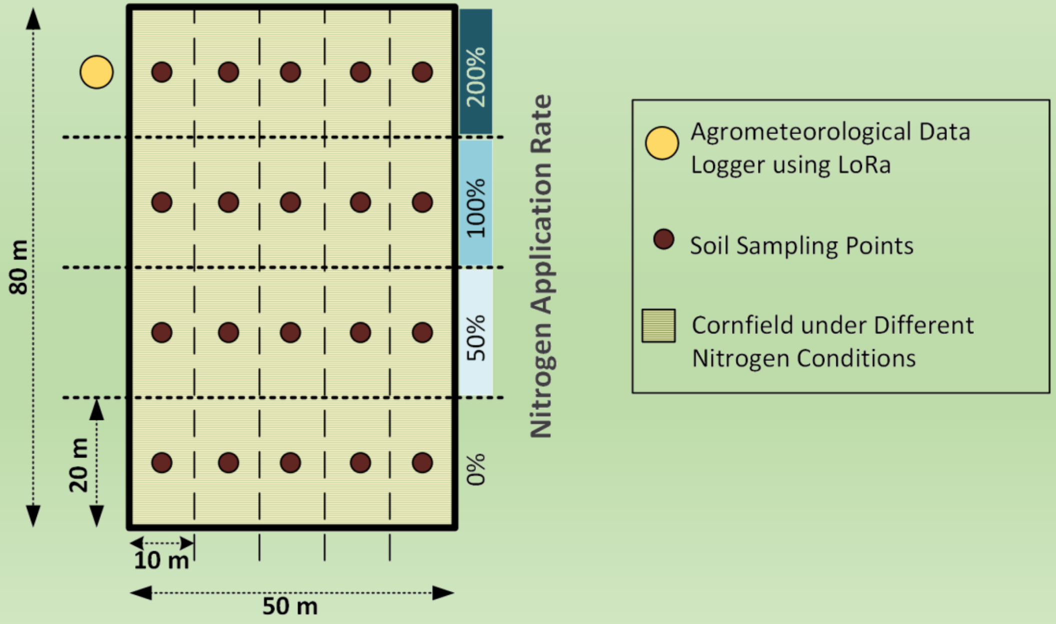
Material and Methods

- The collector system was installed inside a reserved area of the National Precision Agriculture Reference Laboratory from the Embrapa Agricultural Instrumentation (São Carlos – SP – Brazil).
- The agricultural area was about 80 by 50 meters, having corn (*Zea mays.*) planted throughout its extension and soil received different amounts of Nitrogen (N).



Material and Methods

- The collector system has allowed to obtain climate data over a prescribed experimental period, i.e., to improve the accuracy of the agricultural risk model.
- The objective was to integrate those pieces of information into an agricultural-risk analysis model.



Material and Methods (LoRa and LoRaWAN)

- LoRa (long-range) is a patented modulation technology for wireless communications acquired by Semtech Corporation in 2012;

- A remarkable advantage of LoRa is the high sensitivity of its sensor and the great capacity of its communication link, allowing long-range transmissions

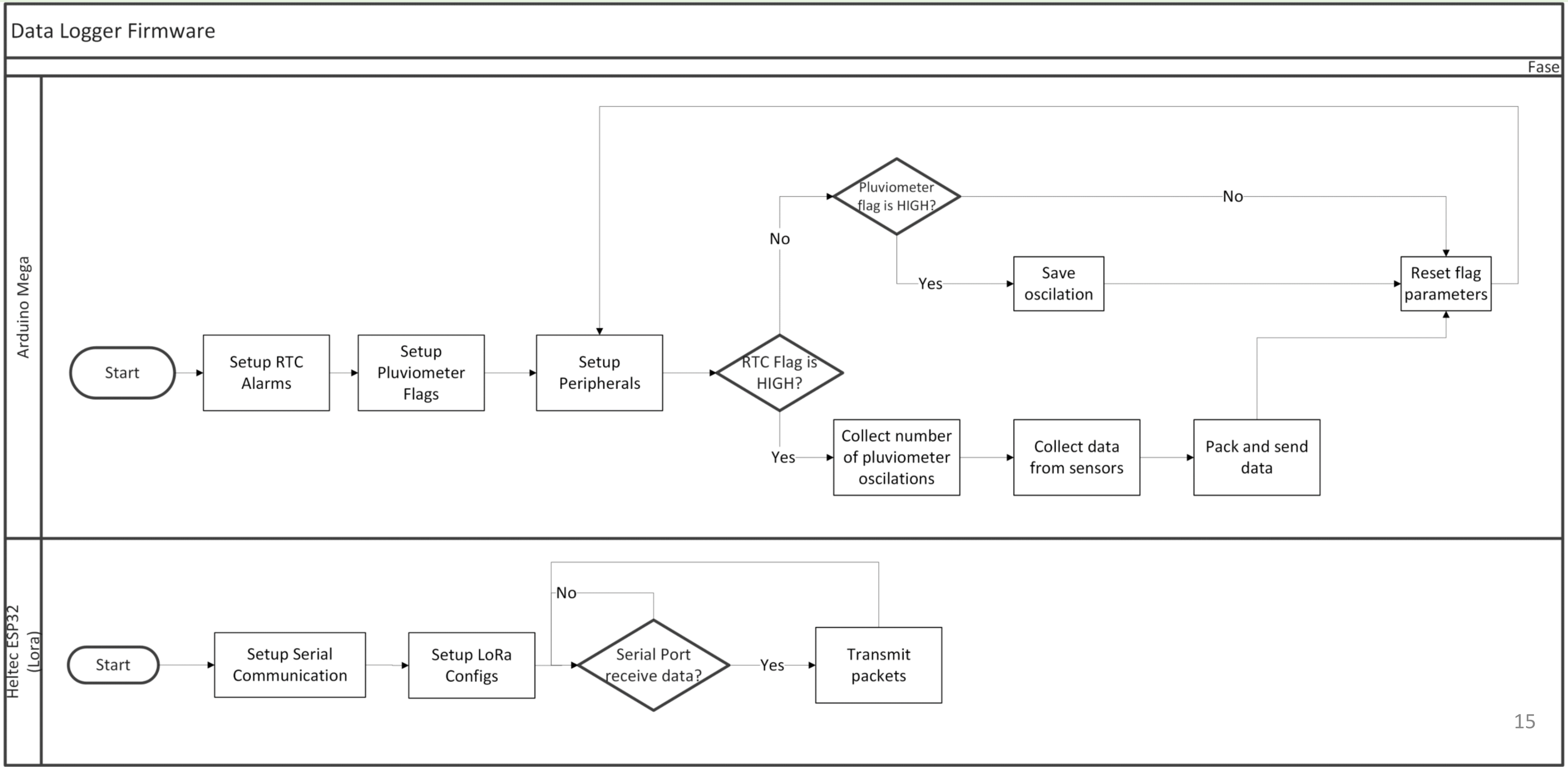
- The LoRaWAN is the most popular protocol for wide area networks and it is, fundamentally, a network protocol designed with a special focus on battery-powered devices, as they are the most commonly used devices with LoRa.

Material and Methods (Evaluation in relation to ZigBee and Wi-Fi technologies)

MAIN CHARACTERISTICS OF THE TECHNOLOGIES ZIGBEE, WI-FI , AND LORA [26]–[28]

Indicator	Wireless Network's Technologies		
	ZigBee	**Wi-Fi**	**LoRa**
Range Average	up to 100m	up to 250m	up to 15 km
Power Consumption	52 mA	251mA	20 mA
Baund Rate	up to 250 Kbps	3 Mbps up to 866 Mbps	up to 50 Kbps
Robustness	High	Medium	High
Network topology	mesh	start, mesh	star-of-stars, mesh

Materials and Methods (Structure of the collector station firmware)



Results and discussion

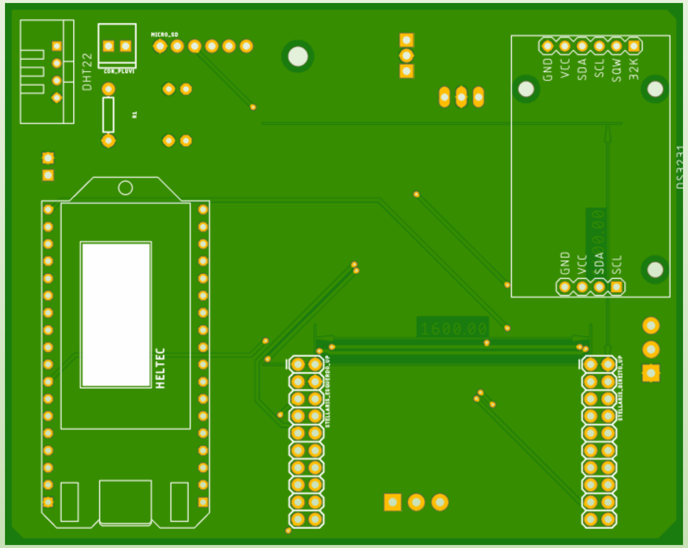
- The growing stage of the maze crop, for the validation of this development, was defined into a period of time comprised between 60 and 65 days:
  - The complete monitoring of both the time of climate and the soil variables have took from 1440 hours to 1560 hours.
- Evaluation of the LoRa wireless sensor network in a rural environment, wireless networks based on ZigBee (IEEE 802.15.4-based) and Wi-Fi (IEEE 802.11-based) were tested, and LoRa has presented a better performance for agricultural purposes:
  - The total energy consumption [kWh] and the range distance [m] have also been evaluated, as well as other parameters of interest.

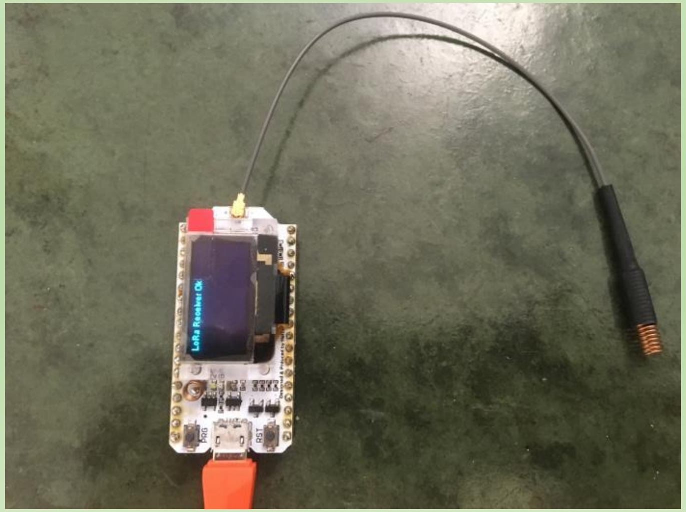
Results and discussion

- For the maize cultivation monitoring time of 1560 hours a consumption **equal to 0.16 kWh** for the platform based on LoRa was observed.
- For the ZigBee and Wi-Fi the consumptions of **0.40 kWh** and **1.95 kWh** were respectively observed.
- In such a context, the LoRa technology was observed to be **150** times superior to ZigBee and **60** times superior to Wi-Fi use.

Results and discussion

Prototype and implementation





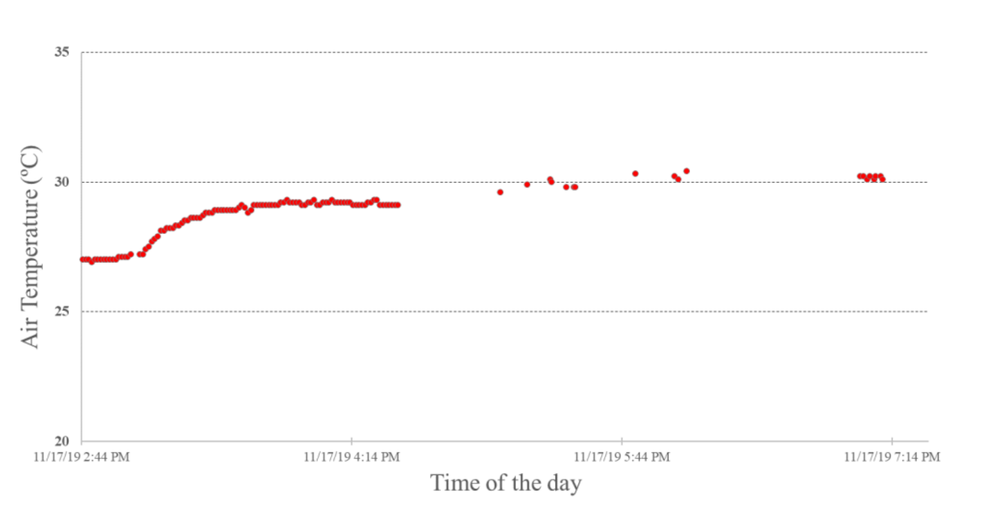
LoRaReceiverColetor.ino

```
Serial.println("\"");

Serial.print("IP ");
Serial.println(WiFi.localIP());
// bufferMsg = WiFi.localIP().toString() ;
//display.drawString(0, 12, bufferMsg);
Serial.println("LoRa Receiver");

pinMode(DISPLAY_RST_PIN,OUTPUT); //RST do oled
pinMode(25,OUTPUT);
digitalWrite(DISPLAY_RST_PIN, LOW); // resetao OLED
delay(50);
digitalWrite(DISPLAY_RST_PIN, HIGH); // enquanto o OLED estiver ligado, GPIO16 deve estar HIGH
display.init(); //inicializa o display
display.flipScreenVertically();
display.setFont(ArialMT_Plain_10); //configura a fonte para um tamanho maior

display.clear(); //apaga todo o conteúdo da tela do display
display.drawString(0, 0, "Starting LoRa");
display.display(); //mostra o conteúdo na tela
delay(1000);

// Iniciamos a comunicação SPI
SPI.begin(LORA_SCK_PIN, LORA_MISO_PIN, LORA_MOSI_PIN, LORA_SS_PIN);
// Setamos os pinos do lora
LoRa.setPins(LORA_SS_PIN, LORA_RST_PIN, LORA_DI00_PIN);
if (!LoRa.begin(433E6)) {
  Serial.println("Starting LoRa failed!");
  while (1);
```

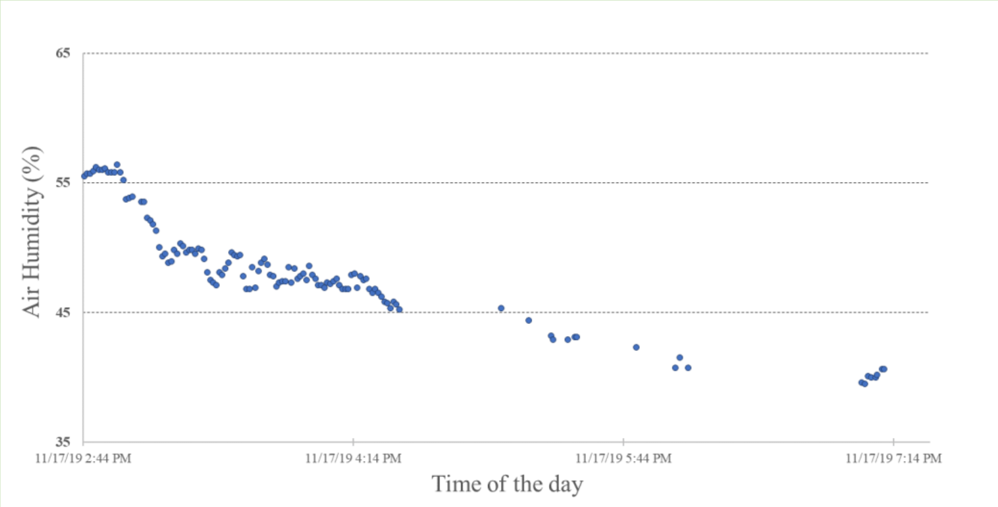
Results and discussion

Transmission to ThingSpeak service

- Experimental tests have allowed recording data into ThingSpeak, which could be analyzed using its tools.



- The charts present an example for a period of 12 hours of data related to the temporal series for air humidity and air temperature in the agricultural area.



Conclusions

- In this present study it has been shown the use of LoRa wireless network for agricultural application, i.e., related to risk analysis.
- The use of a LoRa network has been proved to be suitable for agricultural application, with special interest for soil quality risk analysis.
- The development of a wireless sensor network based on LoRa made it possible to transmit long range and operating agricultural data at low power consumption, which is promising for decision support in the rural environment.
- The development of the wireless network based on Lora minimized the limitations regarding the availability of energy sources and the difficulty of accessing the internet in rural areas, which required seeking customization for Realtime operation considering variables of climate and soil which can bring impacts to soil quality during agricultural planting.

Future Works

Future works will consider not only the implementation of embedded smart sensors to allow measurements of pH and soil organic-matter values, but also the development of algorithms structured using Apache-Spark to operate the model for agricultural soil quality risk analysis

Main References

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Acknowledgments

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Please, contact us either if you have some doubt or even you would like to know more about the results.

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Thank you for your attention!