



Empowering Affordable and Open IoT Solutions for Local Adaptation in Africa

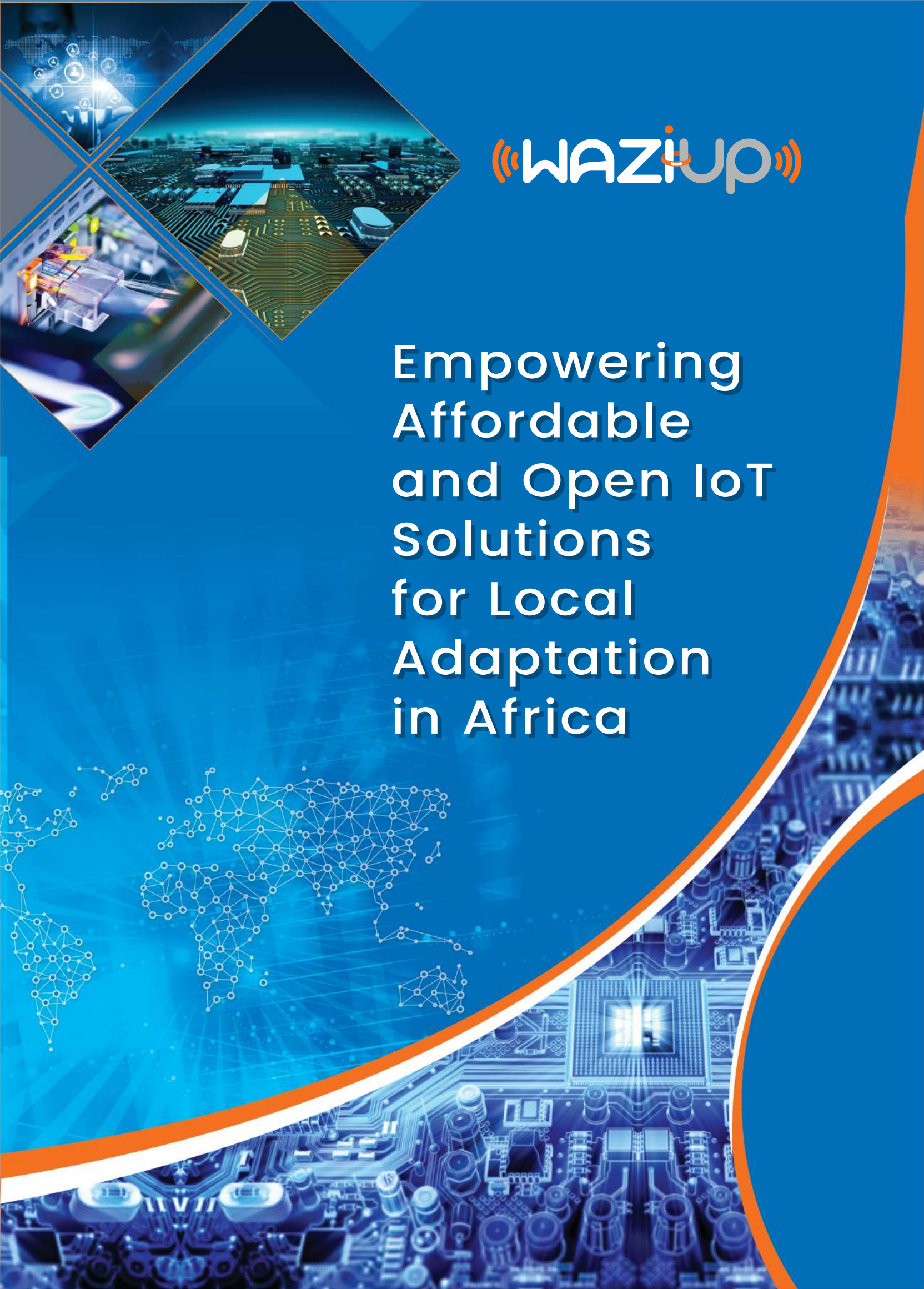


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Introduction

Fostering IoT solutions for sustainable development in Africa

The first leg of our journey takes us to the African continent, in particular to the Sub-Saharan countries. In this developing part of the world there are many initiatives led by many NGOs, as well as public and private organisations with humanitarian objectives. They all have in common an interest and commitment towards accelerating the speed at which African countries can develop due to innovation and new technologies that improve people's' lives while sustaining the economy.

The EU took part in this via the Joint Africa-EU Strategy; agreed upon as far back as December 2007, it is an overarching long-term framework for Africa-EU relations. The Strategy was adopted with a number of actions, one of which resulted more recently in funding opportunities for joint projects within the H2020 Horizon framework program.

In this report we place our magnifying glass over two related projects WAZIUP and WAZIHUB. WAZIUP, which started in 2016 and finished recently, laid the foundations for the implementation of an IoT-based open platform, mostly based on existing assets, which were the result of previously funded EU collaborations and were immersed in the African context. WAZIHUB started in 2018 and aims to exploit these assets through integration with home-grown innovation-related activities, until 2021.

This introduction is organised in two sections highlighting first the lessons

learned with specific reference to technology deployment and second, illustrating the paths taken to foster home-grown innovation in the context of the presented EU-Africa projects.

“Project execution exposed us to many deployment challenges” explains Abdur Rahim, the project coordinator of both initiatives as the first phase nears its conclusion.

Through WAZIUP we implemented a low-cost infrastructure for deploying IoT in developing countries.

— Abdur Rahim

Considering 70% of the world's population live in developing countries, working to address real daily life problems in these contexts is quite stimulating. Rather than keeping it in the labs of participating partners, we deployed it in real application domains, common across many African countries' rural areas, such as livestock farming, precision agriculture, logistics and storage as well as fresh water management.”

The WAZIUP project proposes a Do-It-Yourself (DIY) approach to problem solving, providing a list of hardware and IoT components to be used as well as tutorials to empower the locals to easily and quickly create solutions to the problems they face in their daily activities. Due to its low-cost and wide coverage, IoT allows unique opportunities for social inclusion and innovation.

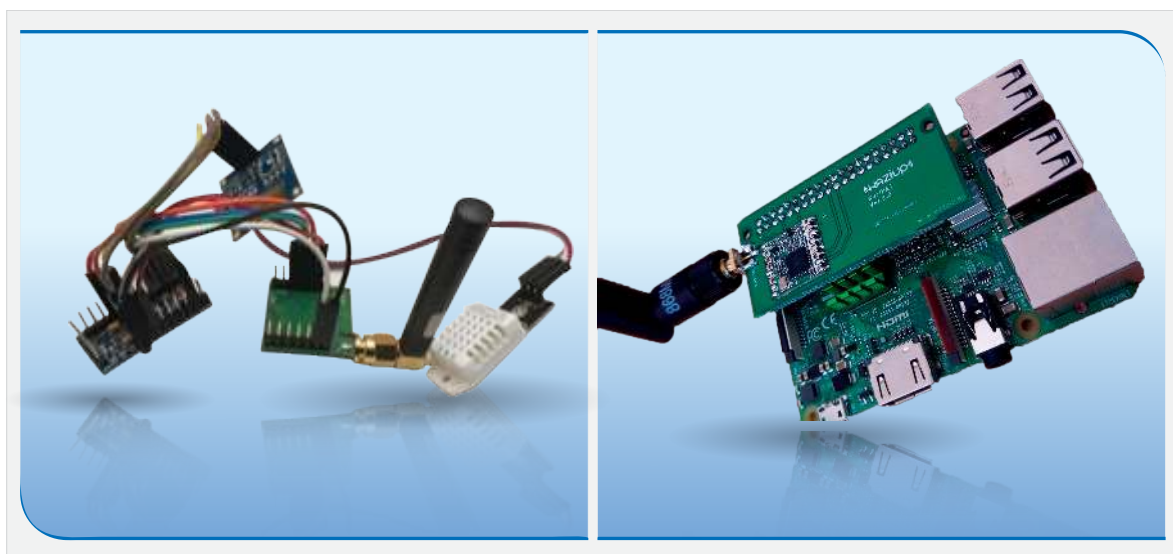
“For WAZIUP, we shared through Github the integration software package as well as a collection of supporting material, such as different types of tutorials and videos. We provided ready-to-use code templates and comprehensive step-by-step guidelines on how one can assemble full IoT solutions with locally available hardware.

To date these online tools have reached 100K people both within and outside Africa

— Congduc Pham

adds Congduc Pham, who leads the WAZIUP WP2 on “Open IoT Sensing and Communication Platform”.

On the hardware front, Arduinos (for connecting sensors to a widely available microprocessor) and Raspberry Pis (for implementing low-cost IoT gateways yet benefiting from an open and very powerful Linux-based platform) have been proposed together with Semtech’s LoRa (Long Range) low cost and energy efficient radio communication technology.



An IoT node and gateway

“Besides the need for cost-effective solutions (people’s average daily earnings is about 2 Euros, which demands for low-cost and affordable technology), another major hurdle against adoption is the internet infrastructure: WAZIUP’s main focus is on rural applications and many of the targeted regions don’t have internet connectivity. Thanks to LoRa, we could access the sensors deployed in the fields within a 10Km radius from the gateway. In order to push the data back to the WAZIUP cloud we used a 3G router where

this was an option but we also had to engineer alternative solutions using GSM connection, SMS or USSD.

In some cases, pushing data back to the cloud is not an option at all: use of SMS or USSD can quickly become expensive. In some cases, there was no reliable cellular connectivity at all. To extend the reach of LoRa (originally designed for star topologies) we also developed some LoRa relay points and added local processing and edge computing capability.”

Many of the IoT applications in rural areas, such as irrigation, fish farming, cattle monitoring, etc, do not need to push data in real-time, back to the cloud. If well engineered, sensing and actuation can be implemented in a loop that doesn't require internet connectivity. Hence, the only way to create reliable solutions is to bring the edge computing concept to the gateway level, breaking long established models, widely adopted in developed countries simply because internet connectivity is a given. The contextual background of developing countries imposes different design choices, requires alternative thinking and much higher adaptation degrees than what one would consider otherwise.

“Another peculiar feature of WAZIUP solutions was to use single channel LoRa communication” recalls Abdur Rahim. “There are many reasons for considering the single channel compared to multi-channel LoRaWAN”.

First of all a single channel gateway is 10 times cheaper than an entry-level LoRaWAN gateway.

— Congduc Pham

As most of the applications do not need high duty cycle (one measurement every 20 mins is sufficient for instance). Hence, with single channel we can still connect hundredth of devices which is much more than what most of applications require. In addition, LoRa is much simpler to deploy than LoRaWAN as it doesn't need backend connectivity to the Network Server and customized frequency plan can be used. This simplicity does not give up on data security as encryption can be enabled.” Congduc Pham said.

“Such approaches enabled us to successfully deploy application use-cases in many different countries and in different domains. Precision irrigation systems are piloted in 9 fields in four African countries (Senegal, Ghana, Togo and Burkina-Faso). Fish farming applications, which measure pond water quality real-time (i.e. oxygen level, PH and water temperature) are also piloted in 9 fish ponds in four different countries. Livestock management solutions are used for monitoring real-time position and health of the cattle as well as to prevent cattle rustling. These solutions are deployed by three firms in two countries whereas the deployment of cost-effective mini-weather stations has been adopted in four countries.

“One would think Africa is not yet ready for IoT. However, with technologies moving very fast, especially in the low-cost and wide-coverage part of the spectrum, things have changed rapidly in the last 4 years. Initially, one could see the activities were limited to gathering awareness, attending workshops and events. Today, many African industries and entrepreneurs are now concretely working with IoT solutions, as the pilot experience in these projects shows.”

But, to ensure success, one has to be aware of the perks and the hurdles of the African environment. So far we have illustrated with few examples how the peculiar background typical of rural areas in developing countries can influence the design of IoT solutions, requiring a different mind-set and an altogether different approach to problem solving. Technology, however, is only part of the solution.

In order to ensure that solutions can sustain a growing economy, one has to take advantage of so-called “home-grown alternatives”. In fact, there is a trend aiming to redesign the existing expensive solutions available in developed countries and remake them in a highly cost-effective manner for the African market, using local resources, low-cost hardware derived from electronics waste etc.

Leveraging on WAZIUP technology inheritance WAZIHUB took on this challenge. This project in fact is meant to foster the creation of startups, to develop IoT regional ecosystems, to target capacity building for IoT-based solutions in local communities involving local actors.

WAZIHUB plans to empower African IoT innovation “Made in Africa” and “by Africa” engaging the local innovation hubs, makers’ hubs and accelerators across 20 countries in Africa. The hubs will operate in local setting but at the same time will be connected with WAZIHUB African-wide ecosystem. These innovation hubs will create new business with the local communities for local needs, sharing best practices and inspiring entrepreneurs with appealing and locally validated business models.

To foster IoT adoption in Africa we need to engage more and more young people as well as policy makers.

— *Abdur Rahim*

Abdur Rahim reports that “to foster IoT adoption in Africa we need to engage more and more young people as well as policy makers. It is also for these reasons that within the WAZIHUB project we plan

to engage much more with so called “techhubs” which drive the innovation movement in Africa. There are different types of techhubs in Africa with mixed business models as well as activities. These innovation spaces gather most of the innovation and technology tools for local young people to tinker with. The main vision of the program is to offer innovation opportunities to potential entrepreneurs and create an IoT ecosystem sustained by one platform. For this model to work, we plan to offer both easy access to cutting-edge IoT technology, and supporting tools to create businesses and innovative solutions.

In particular we plan to partner with the techhubs and offer them WAZIUP IoT technology catalysts and capacity building training. Once the hub participants become knowledgeable on the technology, they can themselves organize bootcamps and start-up events for local developers and entrepreneurs, giving them the opportunity to do hands-on training and rapid prototyping of IoT applications using WAZIUP technology components. It is planned that the best ideas will be selected and incubated for a minimum of 6 months. It is expected that this model will also foster collaboration amongst different hubs with the aim of sharing the IoT best practices. We strongly believe that following this innovation path will help techhubs create successful spin-offs and contribute to the sustainability of the whole initiative also from a business point of view.

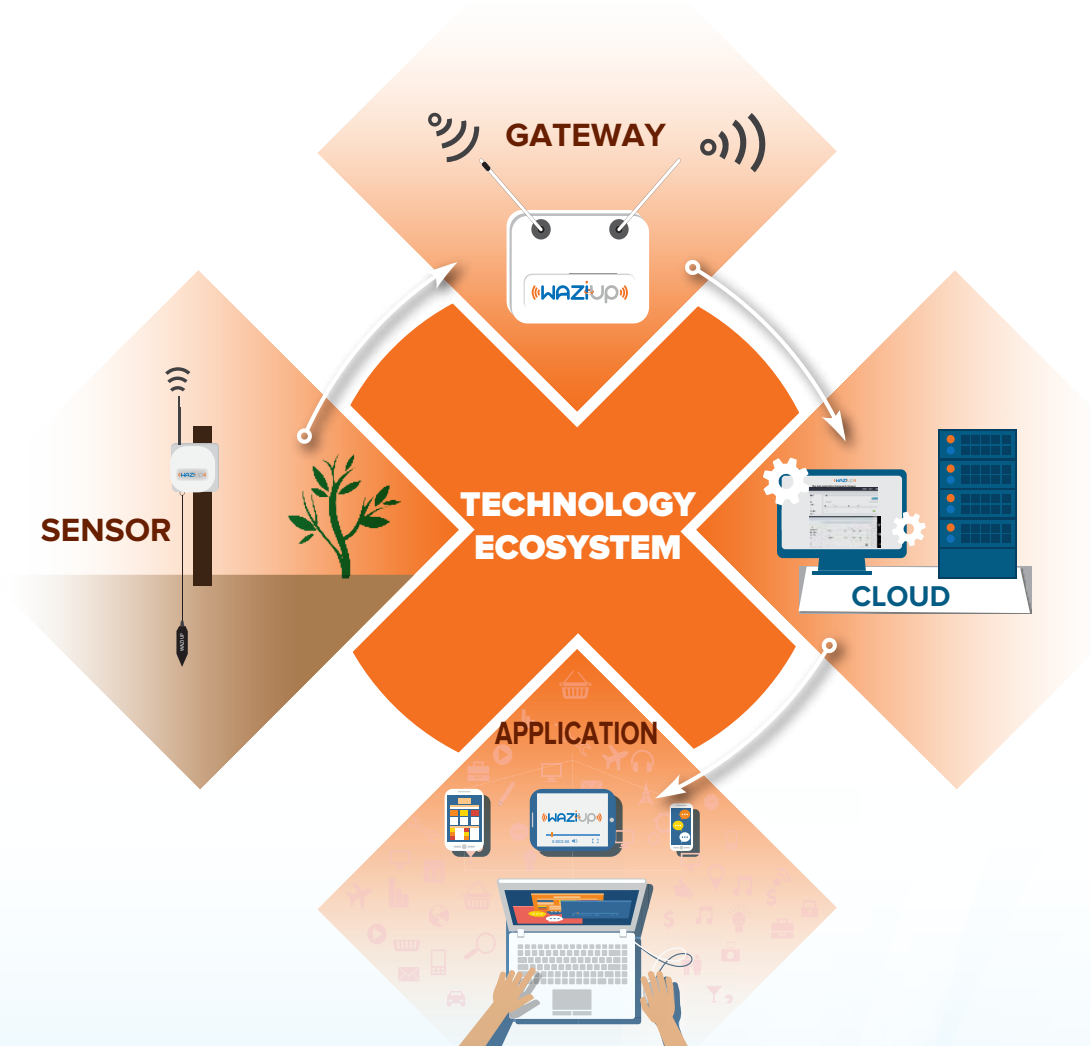
More information and details on the described projects can be found through the websites of the mentioned projects, via social media channels.

WAZIUP technology ecosystem

WAZIUP developed complete end-to-end IoT Open technology ecosystem.

WAZIUP core solutions are:

- IoT LoRa Devices based on open source hardware arduino
- WAZIGATE: IoT LoRa Gateway platform based on Raspberry-pi and which includes the Gateway software framework
- WAZICloud: IoT Cloud Platform with open dashboard and Open API for IoT application development
- WAZIFARM: Farming application platform for advanced farming data analytic and visualization platform





Open and modular hardware platform

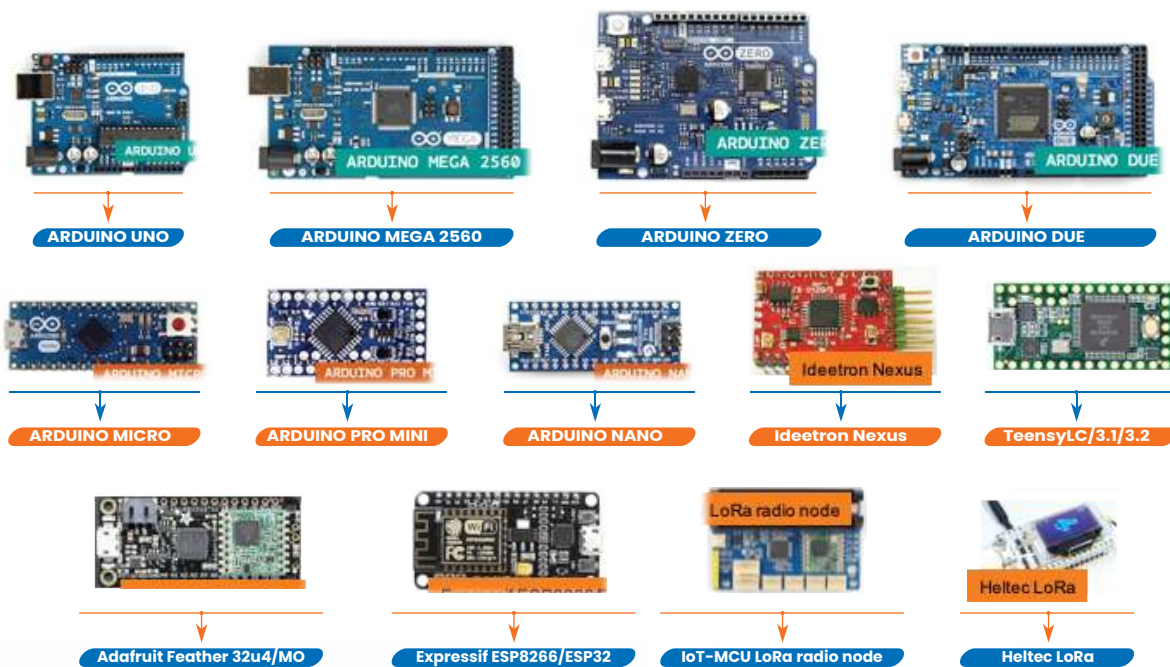
IoT LoRa device

“From the very beginning of the WAZIUP project the main objective was to use open and low-cost hardware platforms to maximize technology appropriation local innovation. The world-wide availability of low-cost, open-source hardware platforms such as Arduino-like boards is clearly an opportunity for building low-cost IoT devices from consumer market components. In addition to the cost argument such mass-market board greatly benefits from the support of a world-wide and active community of developers. It must be kept in mind that software can sometime be more important than hardware because developing drivers and specific libraries is

a very hard and time-consuming task.” Congduc Pham said.

The core Arduino board ecosystem consists in large form boards (UNO, MEGA, ZERO, DUE) and small form boards (MICRO/MINI, PRO MINI, NANO). Large boards are suitable for testing and first step prototyping while small boards can be used for higher integrated prototypes, close to final product.

Many Arduino-compatible boards from various makers are also supported to provide a large choice of development and integration possibilities.



More to come...



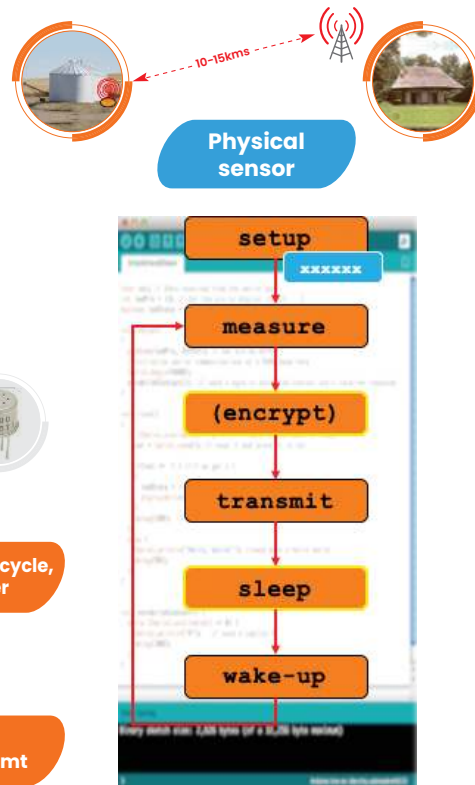
LoRa radios that our library already supports



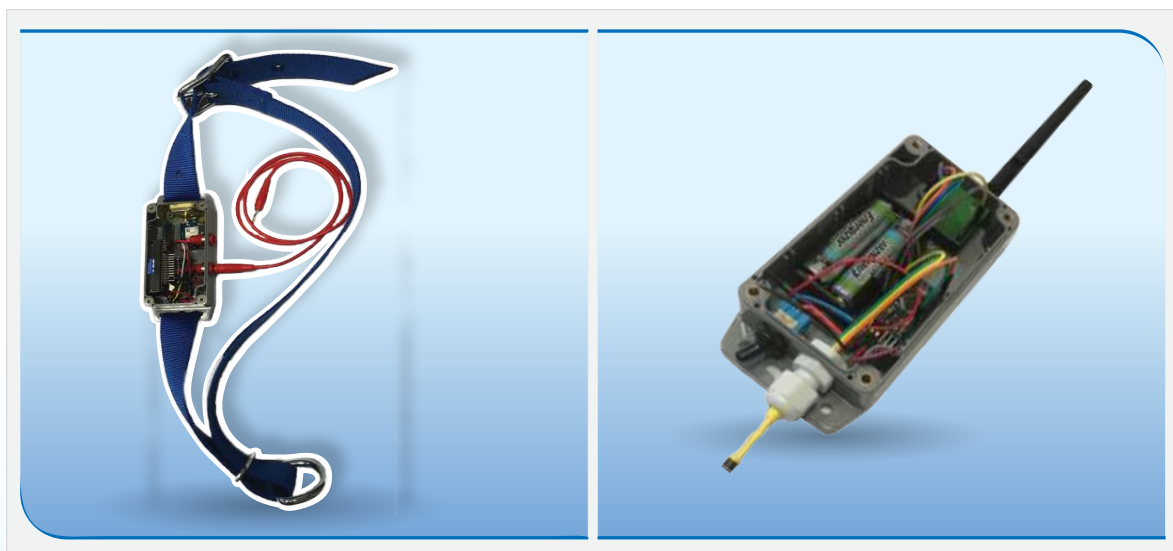
Long-Range communication library

A small form factor board like the Arduino Pro Mini (18mmx33mm) based on an ATmega328 microcontroller offers an excellent price/performance/energy tradeoff and can provide a low-cost platform for generic sensing IoT with LoRa long-range transmission capability for a total of less than 10 euro!

Leveraging the digital divide and fostering IoT innovation in Africa mean providing generic hardware platform and ready-to-use code templates. In WAZIUP, we provide both and most of complex operations such as data encryption, low-power management and long-range transmissions are already taking care by software building blocks.



Such platform can be used as the first step towards integration into a prototyping product.



Cattle collar IoT

IoT LoRa gateway

The gateway is the central element in LoRa IoT networks and will collect all data sent by deployed LoRa IoT devices. It is the unique point where Internet connectivity should be provided in order to push data to various cloud platforms.

The single-channel LoRa gateway based on the well-known Raspberry PI offers incredible cost/performance tradeoffs in addition to a high level of versatility. Again, we designed the WAZIUP LoRa gateway with maximum appropriation and flexibility properties in mind. Also, adapted for deployment in rural and remote areas, the

WAZIUP LoRa gateway can easily work without Internet connectivity and still provides data to end-users through its embedded database and web-based visualization module.

Third-parties and developers can use the base distribution with the numerous template scripts to customize and/or add new features to the gateway in a very modular and comprehensive way, using high-level languages such as Python to extend the capability of the gateway according to new needs.

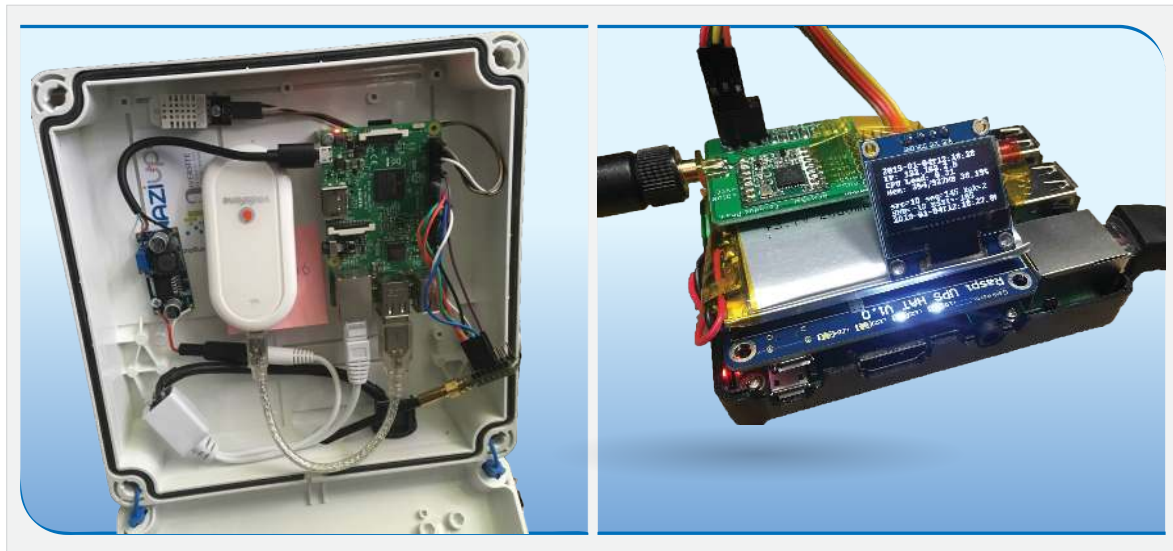
Unlike commercial gateways, the open WAZIUP gateway can be configured to



WAZIUP Gateway Deployment

push data to any cloud systems at the same. A large variety of data upload methods can be used: HTTP REST, FTP, MQTT or even SMS!

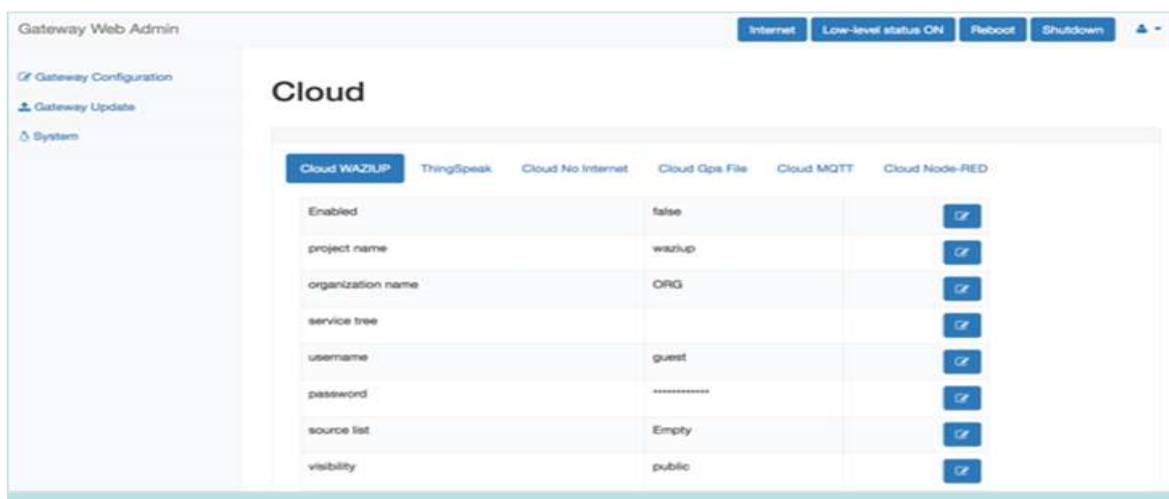
Many tutorials and video are available to learn how to build the WAZIUP LoRa gateway and add advanced features such as Power-over-Ethernet, antennas, UPS system, solar panel powering, cellular Internet connectivity, small OLED screen, in-case temperature sensor,...



Gateway remote configuration panel

The base distribution of the WAZIUP LoRa gateway also provides an embedded intuitive web administration interface that can also be customized by third-parties! We really wanted to offer a great

framework for quickly deploying an operational LoRa IoT network. For instance, in most pilot sites, less than 15 minutes are needed to setup a complete IoT infrastructure!



“In WAZIUP we enable low-cost IoT but we did not want to decrease the level of functionalities. Our gateway offers more functionalities than commercial gateways thanks to its open and modular design.” Congduc Pham said.

“The gateway can easily be customized to host dedicated end-user applications such as the real-time GPS collar localization application developed for Cattle Rustling prevention that can even be used on-the-go by nomadic shepherds” Congduc Pham added. More details on the Cattle Rustling application is presented later.

WAZIUP software platform

IoT cloud platform

The WAZIUP offers the secure, modular and open platform to develop enterprise IoT applications. It integrates with the software and hardware components needs for an entrepreneur, developer and industries to develop customized full stack end-to-end IoT applications with limited resources and efforts. Using our platform, you'll have everything you need to for your application:

- Remote connection of the sensors and actuator,
- Manage your network of sensors and devices,
- Manage the users and their privacy
- Send, receive, collect, store and analyze the data they generate
- Turn that data into actionable insights, in real time
- Using SMS or mobile application for notification

Core features

WAZIUP is an IoT platform that allows you to create and deploy your IoT applications both in the Cloud and on the IoT edge computing gateway. WAZIUP offers "out-of-box" complete solutions from sensors nodes to applications. WAZIUP is particularly adapted to tough conditions, for example for low power and long distance applications.

- Simply and easy to deploy the applications (create, push and run)

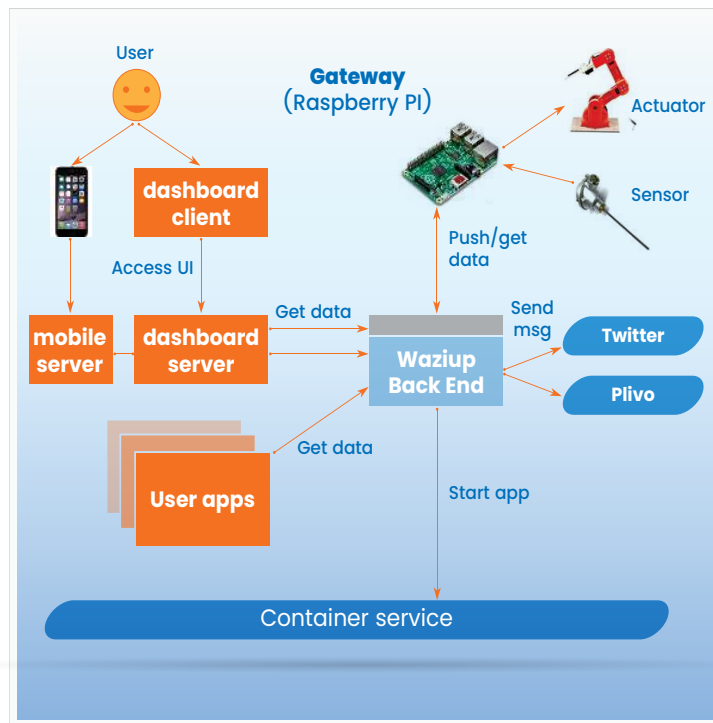
- Ready to use dashboard to manage the users and devices
- Offer customized sensors nodes and Gateway solutions
- Long Range and low power IoT communication
- The platform can handle unreliable and intermittent internet connection
- WAZIUP offers very low cost hardware as well as application development solutions
- Multiple fall-back communication options (3G, Wifi)
- User centric interface design (SME, voice call, mobile app and web app)

The Waziup platform is a Cloud service for managing and analysing IoT data. The website www.waziup.io gives the complete platform user manual and reference manual. That includes an update on the components architecture, the security aspects, the data models, the new dashboard, the new API and finally the validation procedures and results. The API of Waziup is documented online at <http://www.waziup.io/documentation/api/>.

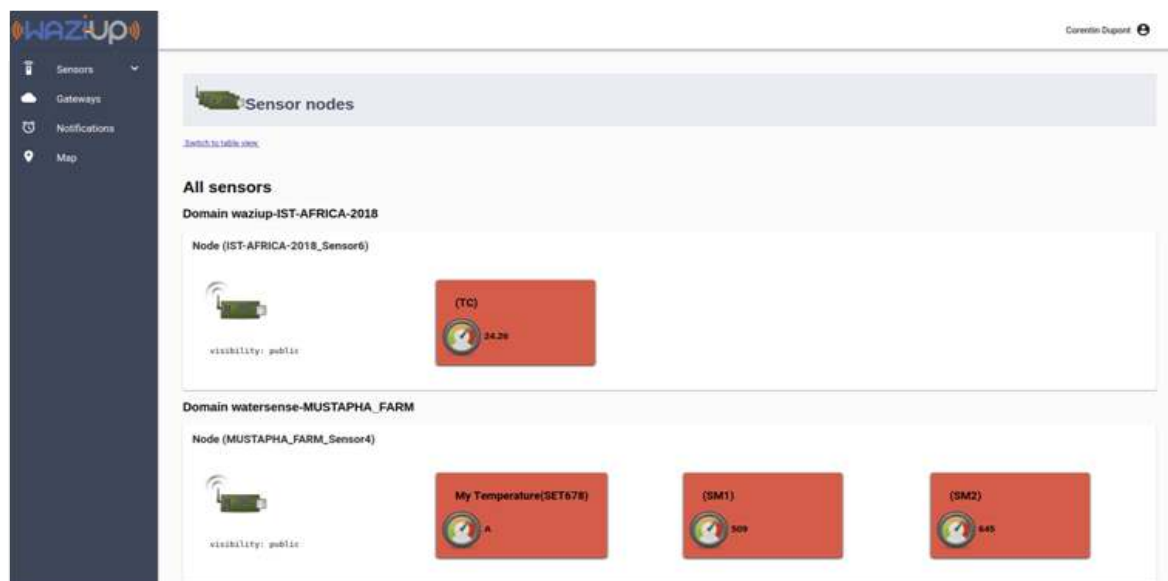
The main component of Waziup is called the back-end. It consists of a number of sub-components, each delivering a set of features. The external world is talking to the back-end through the Waziup API.

The back end is run as a collection of containers on a “container service” (for example Amazon ECS). The Waziup dashboard and mobile app are parts of the Waziup front-end. They fetch data from the Waziup back-end and display it to the User. The user apps, once started, are also communicating with the Waziup back-end through its API.

Those applications expose their own specialized API to the user. For example, a fish farming app will perform specific elaboration on the sensor data, in order to present it to the farmers. Finally, the back end communicates with social networks such as Twitter and Plivo in order to send messages.



Waziup Cloud environment



WAZIUP Dashboard

WAZIUP IoT dashboard is developed for adding and tracking sensors and measurements. It serves as a platform for keeping up to date with the sensors that are added by the user.

One can add sensors with their respective measurements and location. A historical chart and notification can be found for each measurement.

WAZIFARM - Analytic and visualization platform

WAZIFARM is an application platform for various farming sectors. End-users of different domains can benefit from several features of WAZIFARM in order to have a fully-fledged visualization application and analytics dashboard. This tool is free to use for development of applications. It is fully integrated with WAZIUP cloud platform. For instance, a developer, or an entrepreneur can use this tool for rapid development of farming application. Within few hours, you can develop your own farming applications dashboard.

WAZIFARM provides a modern technical solution for agriculture farms, leveraging Internet of Things, and Data Analytics to provide insights to farmers, and

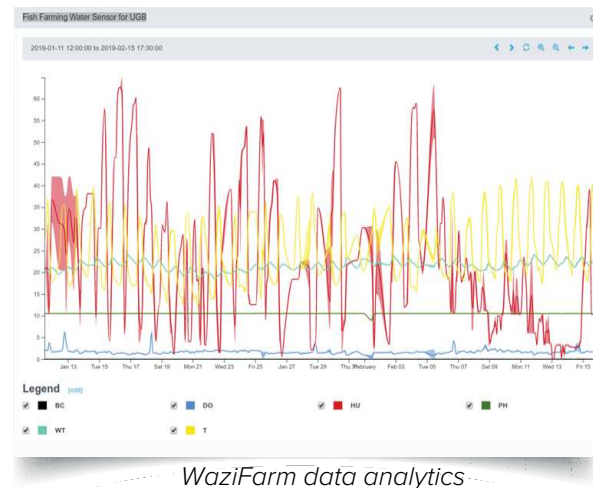
agronomist to make important decisions such as when irrigate their farms, pest management, etc. WAZIFARM provides many customized visualization templates for various use cases. In addition, it allows end-users to perform various data analytics on their data to take insightful decisions.

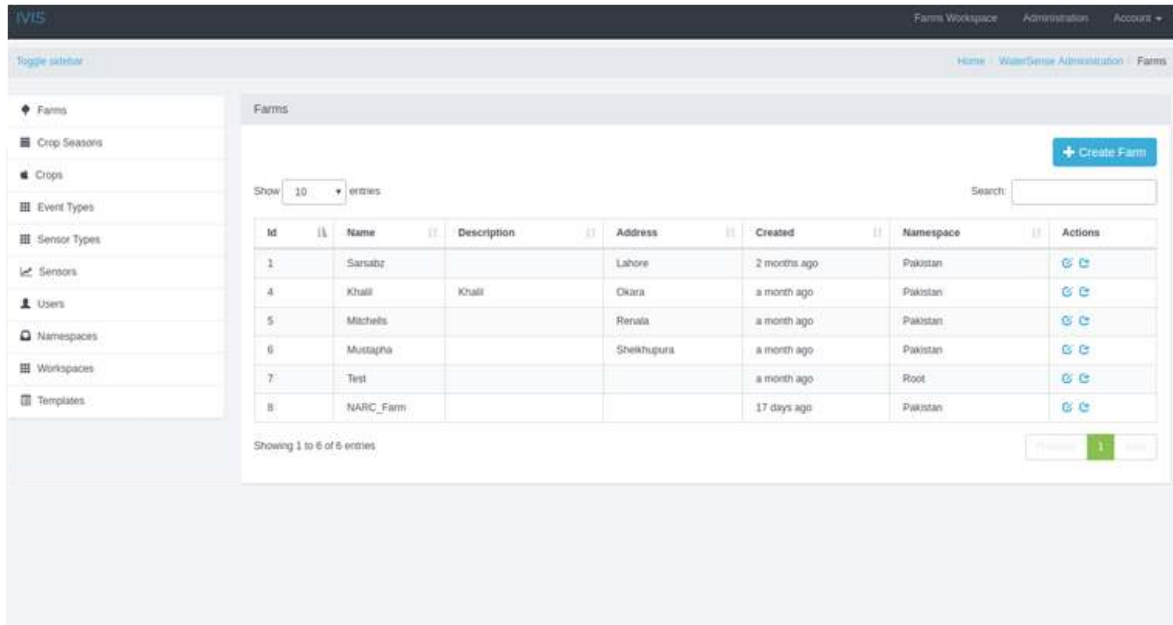
Embedded Visualization and Analytics is another important feature of WAZIFARM in which it allows end-users with their own dashboard application to benefit from data visualization, and analytics of WAZIFARM.

For instance, the following figure illustrates visualization of sensors data for a fish farming sensor in Senegal.

The major features of current WAZIFARM are as the following:

- Application can be scaled to support different administrative domains with different users, etc. This feature allows global admin (master) in cooperation with local admins (admins of administrative domains) to create users, and application resources (farms, sensors, etc.) and manage them with full security and transparency. So, if an application should be marketed in different domains (countries, companies), it can be easily configured, and used.
- Advanced data visualization: WAZIFARM allows definition of customized visualization templates for different use cases. Here, global admin, and local admins can create customized visualization templates for end-users (farmers, advisors), and share with them. End-users just would need to provide how they would like their graphs, and visualizations be and provide to admins.





WaziFarm dashboard

WAZIFARM has been used to support three MVPs of WAZIUP namely, agriculture (crop farming), fish farming, and weather station. It gives farmers a tool in order to take important decisions wisely such as irrigation of a farm, water treatment of a fish pond, or protection of an agriculture farm due to severe weather conditions.

Using WAZIFARM tools, you will have everything you need for your farming application. You will be able to:

- Develop advanced visualization and analytic applications
- Have remote management of the IoT devices
- Manage farm inputs, weather condition, and weather forecast, and feeding practices
- Manage your farming schedule and tasks
- Manage the notification and recommendation for farmers
- Manage costs, and quantity of reports for your farming business
- Creation and management of farming schedules, resources and entity
- Usage of the visualization template which can be customized the
- A developer or entrepreneur can create its own application workspaces, and information panels

Mobile deployment assistant

The idea of the deployment assistant is to guide the engineering team when installing sensors. Indeed, deploying and undeploying sensors is a complex task, that was often performed in an uncontrolled way. Hence WAZIUP developed an application that will guide the user in the deployment process, and guarantee a better result in terms of sensing and actuating.

The application will collect metadata information about the sensors deployed:

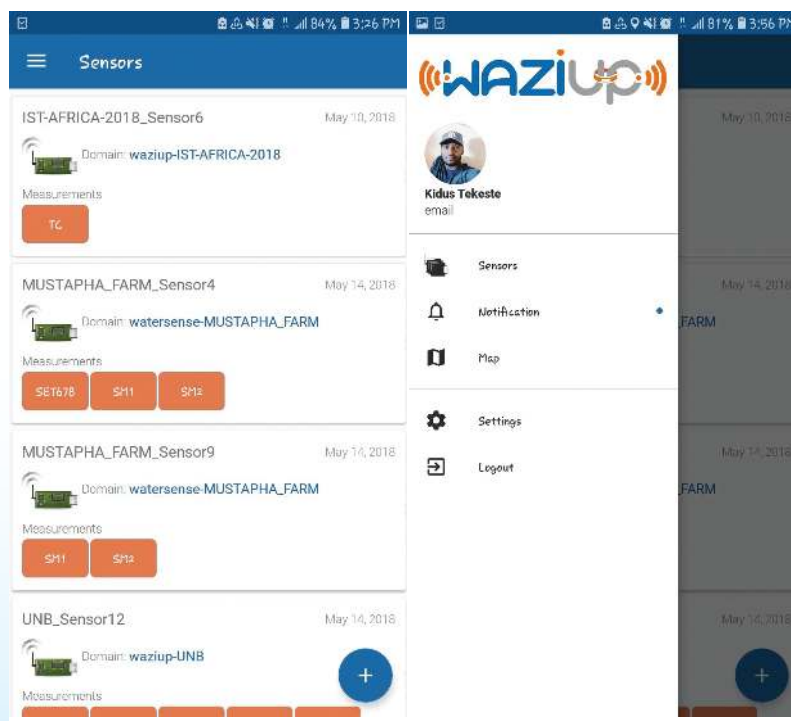
- Sensor details (name, owner, domain and gateway ID, deployment status, measurements details and last values)
- Geo-localization of the sensor
- Setting of the ownership

When selling/distributing gateways and sensor nodes, they could come with a barcode/QR code. The deployment team will then use the deployment assistant to

scan the bar codes. This would permit to do the pairing more easily.

The list of features that will be developed are:

- Login to the application
- See my sensor list
- See a particular sensor status: sensor ID, name, owner, domain and gateway ID, deployment status, measurements details and last values
- Register a new sensor: ID, sensor name, owner, domain and gateway ID
- Register measurements: type and unit of measurement
- Deploy a sensor
- Undeploy a sensor
- Geolocalize a deployed sensor
- Scan a QR code to ease the sensor registration.
- Calibrate the sensor



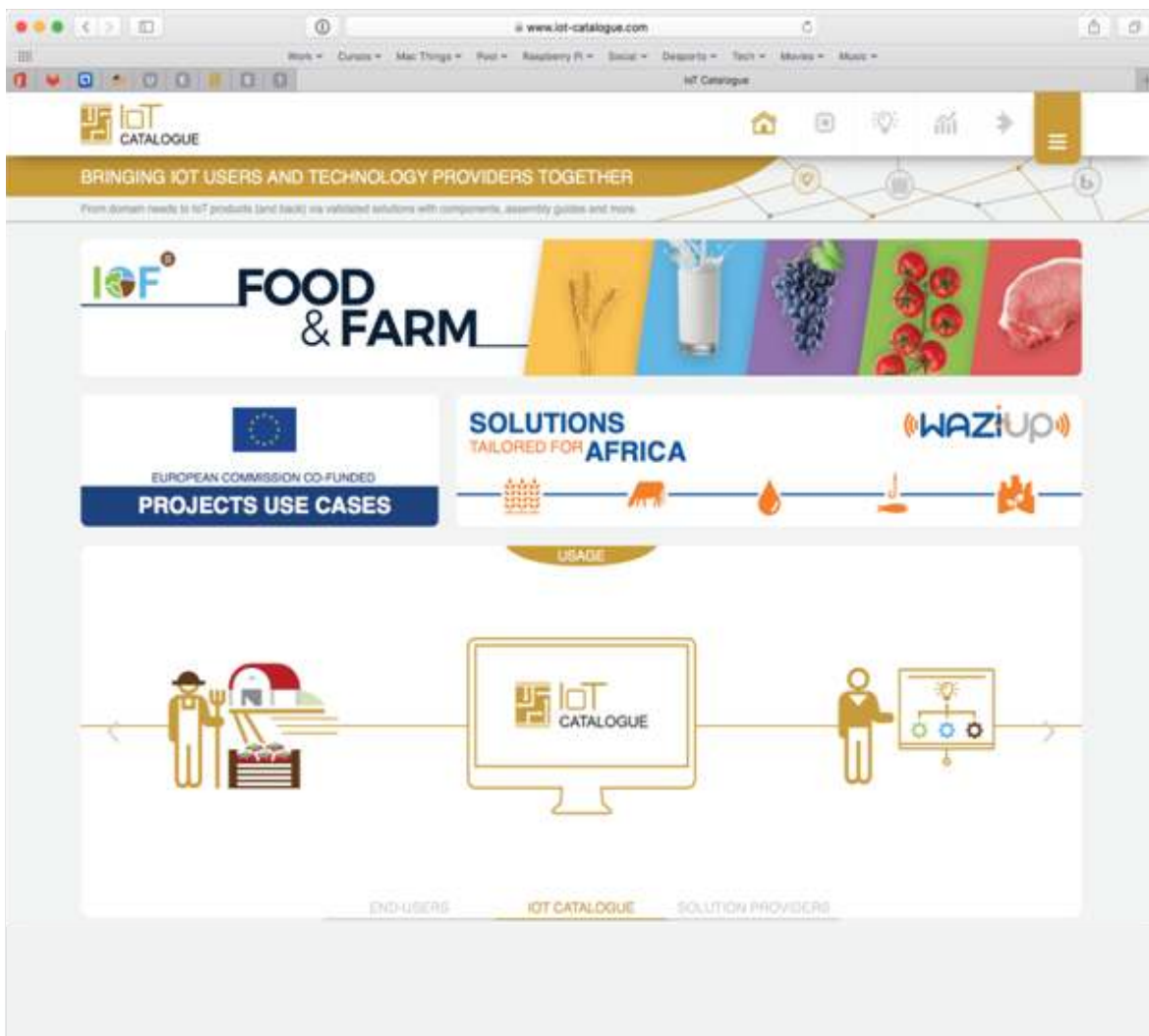
Mobile deployment assistant



IoT catalogue

The 'IoT Catalogue' is a web-based catalogue and decision-support tool for solutions of the Internet-of-Things (IoT). The 'IoT Catalogue' targets especially developers/integrators of IoT systems

addressing questions such as: What IoT solutions exist for a given problem? What components compose a given IoT solution? What is their cost? Where to buy them from? Etc.



IoT catalogue welcome page

The 'IoT Catalogue' helps in the process of identifying and selecting a group of suitable components that combined work as an IoT solution (able to process, store and transmit data) to a problem defined by

the user. The solutions can present different costs and complexity levels ranging from integrated elements to compositions of components.



WAZIUP MVPs solutions and piloting

The minimum viable product (MVP) concept consists of a product with a minimum of features to satisfy end-users, and to provide feedback for future product development.

The following MVPs in WAZIUP incorporate core features defined at the beginning of the project.

- Soil moisture sensor for agriculture,
- Weather station
- GPS-based cattle collars for cattle rustling,
- buoy device for fish farming,

The above MVPs are deployed in several pilot farms.

The below is the list of pilot partners in WAZIUP and their countries:

- UGB (Senegal)
- CIMEL (Senegal)
- Ndiawdoune (Senegal)
- ANIDA (Senegal)
- DKC Farm (Ghana)
- Ghana School (Ghana)
- Kita farm (Ghana)
- Kumah Farm (Ghana)
- Lazarus Farm (Ghana)
- KNUST Fish Farm (Ghana)
- Peace & Love Vegetable Farm (Ghana)
- Nasso site (Burkina Faso)
- Comoé dam (Burkina Faso)
- Nasso Site (Burkina Faso)
- Woelab (Urbanatic Gardens - Small Urban Farm) (Togo)



MVP deployments

Agriculture MVP

The WAZIUP soil moisture sensor is an ideal solution for farmers who want to optimize water consumption and improve crop yield of their businesses. It measures in real-time the accurate soil water content in the field and notifies the farmer about irrigation decisions.

Soil sensor hardware leverages a customized designed PCB. PCB boards combined to capacitive soil moisture sensors and waterproof boxes are carefully integrated to allow easy deployment and maintenance. The overall

box itself measures real-time accurate soil water content, and is highly cost-effective and easy to install and maintain. The electronics is placed in a watertight box to protect it from dust and water. The device is powered by 4 AA batteries, and can be connected to a mini-solar panel. We have designed and developed a set of soil moisture devices for pilot partners.

The soil moisture sensors are deployed in 7 farms in four countries, in total 25 sensor devices are deployed in vegetable, cereal and banana farms.



MVP deployments

Weather station MVP

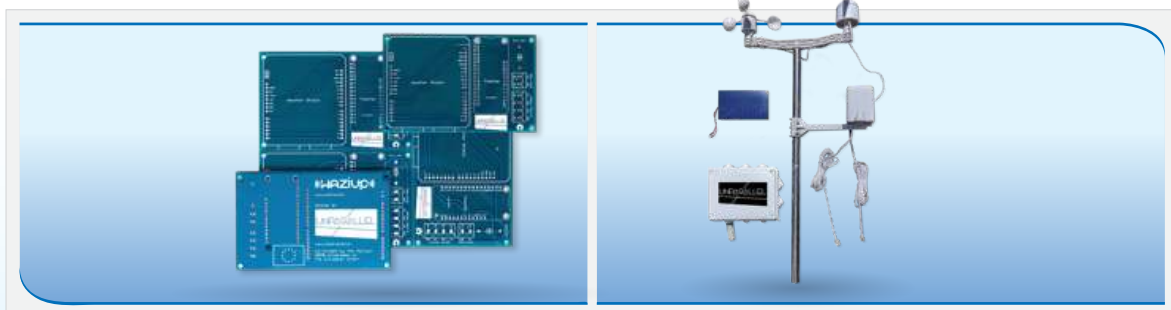
The Weather Station MVP is based in a use case that's dealing with meteorological data which is obtained through the measurement of weather parameters. In the first place it was necessary to identify all the parameters that are useful to the farmers. Then based on this information, the suitable sensors

have to be chosen then deployed in the selected field site. The weather data which will be useful for the farmers are obtained through the measurement of parameters identified on the table. Each parameter corresponds to a physical characteristic of the environment.

Weather Measurements	
Parameter	Unit
Atmospheric Temperature	Degrees Celsius (°C)
Relative humidity	Percentage (%)
Wind Speed	Kilometres per hour (k/h)
Wind Direction	Degree (°)
Barometric Pressure	Hectopascals (hPa)
Precipitation	Millimeters (mm)

The challenge here was to be able to gather data from the surrounding area and then make it available to the WAZIUP cloud. The transmission is carried out by the LoRa bi-directional communication, representing a low cost technologic long range communication. Also challenging is to provide a final sensor node as a light and scalable solution with low energy dependencies.

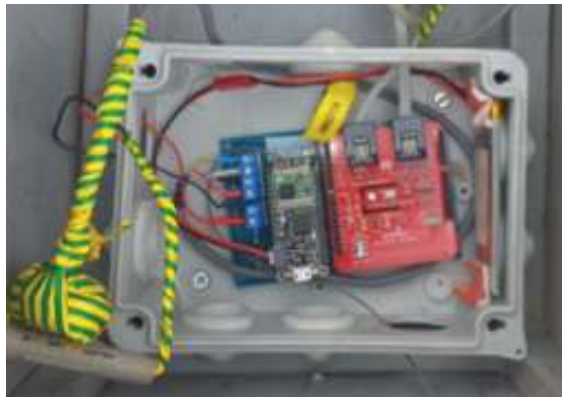
Nowadays there are many advanced and well-integrated weather stations. However, they were discarded for use in WAZIUP due to the need of having an IoT solution that could be qualified as "low-cost" and with built-in LoRa radio. So, and in order to decrease costs, we decided to use several low-cost components and integrate them to provide a WAZIUP Weather Station.



Weather station prototypes

The WAZIUP Weather Station was developed using low-cost hardware that is able to measure Temperature, Humidity, Atmospheric Pressure, Wind Direction, Wind Speed, Wind Gust and Amount of Rain. The Weather Station uses LoRa communication technology in order to send the acquired weather data to a LoRa

receiver (e.g. Gateway). The Weather Station can also be assembled with a Solar Panel mount that will make the system self-sustained in power. The Weather Station assembly guide, technical guide and solar panel deployment guide are openly available at <https://github.com/Waziup/WAZIUP-WeatherStation>.



Weather station deployment



Deployed weather station in UGB

Fish farming MVP

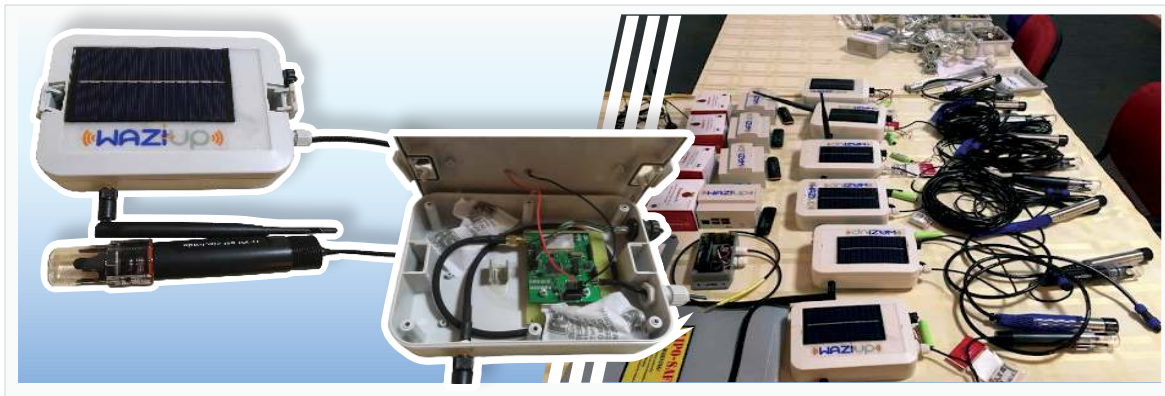
The fish farming MVP is developed to measure the water quality for the fish pond. The solutions are deployed in 7 pilot sites in Senegal, Ghana and Burkina-Faso.

The final version of the fish farming prototype is now enclosed in a box that has to be fixed near to fish pond. The box is comprised of an ATmega1824 microcontroller, a LoRa module of Semtech family SX1272/1276 and a 3.6V battery. The box is powered by a photovoltaic panel. The sensors used are: h-101 pH electrode for the pH

measurement and LDO sensors for DO measurement. The pictures illustrate the inside and the outside views of the equipment, and the device with the solar panel and LoRa antenna.

The gateway is a raspberry based board equipped with a LoRa Modtronix inAir9 module. The gateway has to be connected to Internet through Ethernet cable or by a 3G dongle connection key.

The figure below illustrates an inside view of the gateway.



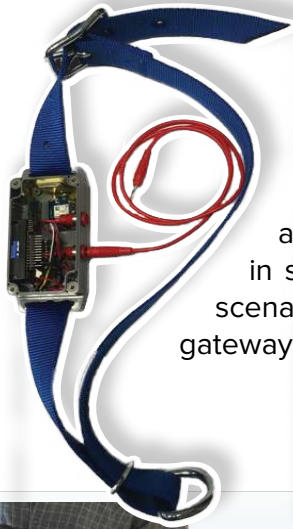
Fish farming sensors



Fish farming sensor deployment

Cattle rustling MVP

The WAZIUP collar for cattle rustling application is depicted below. It embeds a GPS receiver to be able to periodically send GPS position of the collar device.



Such GPS positions can be pushed to the WAZIUP data platform for visualization as any other IoT applications. However, we developed an additional specific end-user application that does not require Internet connectivity to be used in standalone and/or nomadic scenario. An example of nomadic scenario is illustrated below where both cattle collars and the gateway are mobile.



Cattle collar application

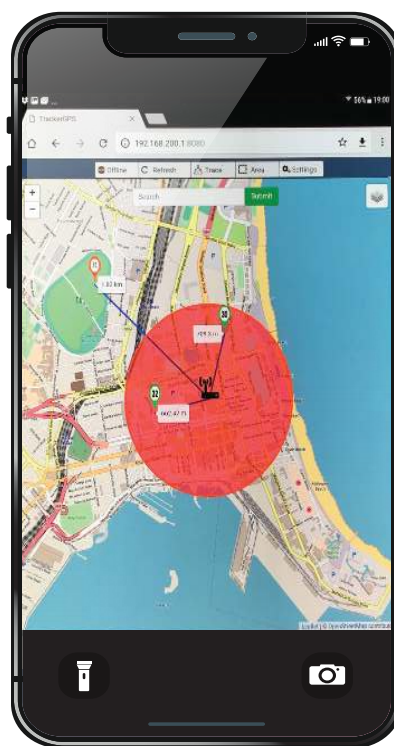
The gateway is powered by a USB battery pack and has a USB GPS connected that periodically updates the gateway's position. Collar positions are received by the gateway which stores these position data into the local database. Then, a dedicated web interface displays the position of collar devices relatively to the

gateway's position. The end-user can use a smartphone or a tablet to connect to the gateway's WiFi in order to run the web interface with a regular web browser. It is possible to define an alert area to better show which collar devices are out of the allowed range as illustrated below.

The main features of the cattle collar web applications are summarized below:

- visualization of collars' GPS position relatively to the gateway's position
- fast visualization of each collar device's distance to the gateway
- direct access to each collar device GPS and last received transmission data
- definition of a safe zone where collar devices will be displayed in green
- definition of a maximum time window for the last GPS reception from a collar device: those collars that exceed the time window will be displayed in black
- can work offline with no Internet connection in which case the background map is not displayed, unless a map is downloaded on the gateway beforehand. In any case, the distance indication, as well as safe area indication, are still available

Here is a link to a short demo video of the collar web interface: <https://youtu.be/meFDav1SLPI>

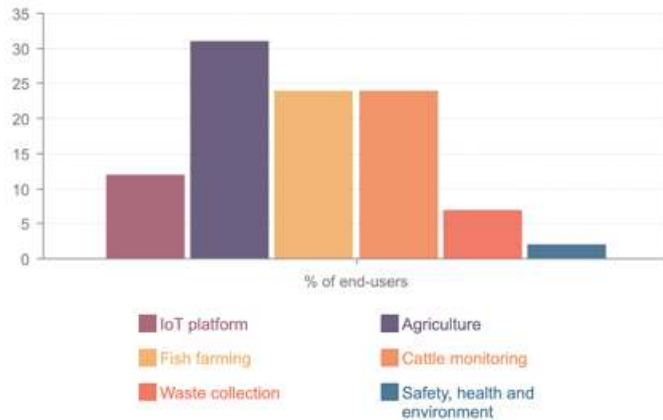


cattle location on mobile phone

MVPs impact analysis

	Sensors		Gateway	
	2018	2019	2018	2019
Agriculture	9	25	8	12
Fish farming	3	6		
Cattle	2	5		
	14	36		

Almost 20% of the responding users concern the IoT platform, with safety, health, environment and waste collection. More than 30% for agriculture and 24% for fish farming and cattle monitoring. This confirms the early choice made on the at the initial stage of the project about collecting and reporting users' preferences on specific areas and use cases. In order to assess impact analysis, some visits have been made in different areas, to meet breeders and farmers. The objectives were to check how cattle rustling affects these people in different places, and their feedback about the features of the devices proposed by MVP leaders in WAZIUP. The picture shows some moments of the visit to breeders in Fatick by CTIC's team .



Percentage of end-users in the different IoT applications



Visit performed by CTIC to meet cattle breeders in the region of Fatick

Another element is the fact that the problem of cattle monitoring might be seen differently depending on the locality. For example, by interviewing breeders from Saint-Louis, around UGB, in the north of Senegal, it has been seen that most of the farms there are familial and so, are managed differently than in Fatick which is located in the center of Senegal. The requirements for breeders to increase their production is less in the

north, contrasting with the center. This is due to the fact that most of the times, cattle in the north move more in free pasture sites, with shepherds around, usually hired by owners, to control the herd. A clear confrontation between physical monitoring of cattle (with shepherds around) and collars deployment on cattle' neck with a little bit of uncertainty leads to diverse feedbacks that were all collected.

WAZIUP entrepreneur ecosystem building and business spin-off

While tackling challenges which are specific to the rural ecosystem, WAZIUP also engages the flourishing ICT ecosystem in those countries by fostering new tools and good practices, entrepreneurs, developers and start-ups. The WAZIUP platform is open for those who are willing to participate in the project and be part of the community. WAZIUP provide them with a mature platform, as well as tools and standards that are inexpensive, easy and relevant.

WAZIHACKS

WAZIHACKS were one of the most efficient way to engage the developer as well as entrepreneurs. The event is organized partnership or co-located with innovation hub. It was 3-4 days event in which the entrepreneurs were asked to

WAZIUP use tools in order to engage the developer, entrepreneurs and startups, innovation users.

- WAZIHack, Wazihacks, also called Hackatons are one of the ways to engagement. It is 3-4 days hand-on training on IoT rapid prototyping
- IoT Club, is an activities of popularization of IoT in Africa. It aims to create some local basis of IoT by using the African fablabs network.
- Training and workshop, a 1 day training and workshop for developer and entrepreneurs

prototype their innovation idea during the course of the event. WAZIUP organized 8 Boothcamp Hackathon in different countries in Africa. A short list of the ideas came out at the event are mentioned in the table.



Developers and entrepreneurs during WAZIHACK

Teams	Ideas
ADEYEBA (INCUBATEUR CONNECTÉ)	Connected incubator which allows to check (control) the brooding of eggs automatically
ELEVUP	Connecting feeding dishes and water troughs of the hens to allow the aviculturists to make a follow-up of the used resources
URBANATIC	Take advantage of abandoned spaces in urban areas to turn them into gardens where fruits and vegetables will be cultivated
SCOPE	Connected waste bin that sends a signal once full so an agent can come pick it up
AGRILOG	Marketplace app where people can acquire food collected from farmers and delivered to consumers
AQUATECH	Water quality monitoring and leakage system: solving water issues from source to household
SOIL COMPANIONS	Checking of the various minerals in the soil
THE BIOTEAM	Provide integrated energy solution to farmers in an environmentally friendly and socially accepted technology
ECOSAFE	Drainage monitoring system using IoT
AFI GREENHOUSE FARMS	To build a Greenhouse aimed at decreasing the importation of vegetables from other countries to Ghana
NETFARM HUB	Farmer base network that makes no room for crop lost and also bridges industrial
OAT/KITA MUSHROOM COMPANY LIMITED	Fresh and processed mushroom production
AGRO WORLD COMPANY LIMITED	They have 2 products Morifert organic fertilizer and Moritech soil management device
GOVERNORS CORPORATION	Husbandry management and regular vaccination
SCI BUSINESS CENTER	promote the quality health of people through neem organic products (pesticides and medicine)



WaziHacks



WaziHacks

IoT Clubs

The WAZIUP African #IoTclubs is an original activities of popularization of IoT in Africa. It aims to create some local basis for the european project Waziup by using the African fablabs network. Clubs incubated by partners offer a surrounding for discovering, sensibilisation and experimentation on the issues and potential of IoT.

The #IoTClubs appear as relays for WAZIUP, preparatory to its next moves. For this purpose, #IoTclubs put ressources, infrastructures and WAZIUP platform as a priority in their effort to vulgarize IoT. The African program Waziup is led by woeLab who incubates the first Waziup / #IoTClubs. IoT club is organized in four countries Togo, Benin, Ivory-Coast and Burkina-Faso



WAZIUP/ #IoTClub launching in Cotonou



WAZIUP/ #IoTClub launching in Abidjan

Training and workshops

In the course of the project, WAZIUP organized regular training and workshop for the students, developer, entrepreneurs. In total WAZIUP organized more than 50 training and workshop. The training was not limited only the partners countries but African as well as Asian countries.



WAZIUP presented at ENSA Safi, Morocco
IoT starter kit successfully deployed on March 13th, 2018



WAZIUP presented at IRD/UMMISCO/University Yaoundé, Cameroon
IoT starter kit successfully deployed at IRD on March 19th, 2018



WAZIUP/ #IoTClub launching in Cotonou



ITU General Secretary visits our stand at ITU Telecom World in Durban

WAZIUP partnership

WAZIUP has established several cooperations with are each one an important relay of exploitation. Each partner has taken on board WAZIUP

potential both with WAZIUP MVP results but more broadly with the overall potential of developing products and applications with IoT and big data approaches.



WAZIUP non-profit organization

WAZIUP e.V is register in Dresden as a no-profit organisation. The association is highly technology driven.

The goals of this WAZIUP e.V

- The WAZIUP e.V. is to promote science, research and innovation towards the 17 goals of SDG 2030 identified by the United Nation Agenda, to be achieved by 2030. The WAZIUP e.V. is committed in promoting and advancing the modern and deep digital technologies developed in two EU research project H2020 WAZIUP and H2020 WAZIHUB to to realize the agenda SDG2030 contribute.
- WAZIUP e.V. will mobilize the technologies developed by H2020 WAZIUP and WAZIHUB as well as further development of the relevant technologies through research and development in collaborate with the partners and members. WAZIUP e.V. intention is to manage the open source software and hardware tools and technology developed in both, the H2020 WAZIUP and the H2020 WAZIHUB EU co-founded research projects. The purpose is further development, adaptation and integration of these tools and technologies in order to serve for the increasing evolutionary needs for sustainable development.
- WAZIUP e.V also involved promotion and support of technology transfer and innovation (e.g. entrepreneurship, start-ups, innovation services and solutions) of the scientific, technical and application oriented which directly contribute towards SDG 2030 objective. The WAZIUP e.V objective also to engage large number of communities of young developer, entrepreneurs including women entrepreneurs, industries and public bodies who will be potential users of our technologies and tools of WAZIUP e.V. The WAZIUP e.V. will also conduct innovation oriented capacity building training and professional development for young students, developer, entrepreneurs as well as supporting startup ideas.
- The technology developed by WAZIUP e.V will be open source so that large communities and users can use it, “royalty free use” unless specific cases where the technologies are developed together with a partner where partners have certain constraint or IP right from funding bodies/agencies.
- The WAZIUP e.V. major focus is on the developing and emerging countries but not excluding other world regions.

WAZIHUB - A future way forward

WAZIHUB means the Open HUB (the creation of Open IoT HUB for local IoT adaptation). The main KPI of the WAZIHUB is to create startups, to develop IoT regional local ecosystem, IoT capacity building for local communities and actors. The following figure shows the main KPIs of the program.

WAZIHUB will also further improve and adapt WAZIUP technology mainly to

development kit, capability of large-scale deployment IoT smart village reference infrastructure and multi-cloud infrastructure and robust real-life testing facilities. This last part is not in the scope of the WAZIUP project. In addition, the WAZUHUB will offer the “Open IoT data” for the users for new data-driven services creation (prediction, forecasting, analysis the system and situations).



The WAZIHUB plan to empower African IoT innovation “Made in Africa” and “by Africa”. In order to achieve the goal, the WAZIHUB plan is to engage the local innovation hubs, maker’s hubs, and accelerator across 20 countries in Africa.

The hub will operate in local setting but at the same time connected with WAZIHUB African-wide ecosystem. These innovation hubs will create new business with the local communities for local need.

WAZIUP social media



<https://www.youtube.com/channel/UCGbGcMnBxiJG6Q29LyuKOJQ>



<https://twitter.com/waziupiot>



<https://www.facebook.com/loT-Clubs-174884616217149/>



<https://www.linkedin.com/groups/8156933>

GitHub

<https://github.com/Waziup>



www.waziup.eu



<http://www.waziup.io/>

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