IoT Based Farmers' Smart Technology, Case Study: Rwanda Meteorology Agency, Kayonza District

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Abstract

A prior research done indicates that there is various challenges farmers face including unpredictable weather conditions affecting farmers' yields, slow flow of information from the agronomist and meteo Rwanda to the farmers, regionalized weather information, data provided by meteo is hard for farmers to interpret.This project was sponsored by UNDP-Rwanda and organised by Rwanda Meteorology Agency. The aim of this system is to help in fast communication between Rwanda Meteorology Agency, agronomists, famers' facilitators and farmers in meaningful way. The researchers used qualitative methods by conducting an interview with the meteo, agronomist, and farmers. An observation was also used to get first-hand information on the flow of communication betweenmeteo, agronomists, volunteers, farmer facilitators and farmers. Existing Communication was Analyzed andProposed Effiective Kubero Communication Model, which allow faster communication between stakeholders.An Innovative approaches Agile methodology was used to develop a pilot project. A prototype was designed to deliver timely climate related information and predictions to address pressing needs of farmers in climate disaster prone areas. Where farmers will be periodically accessing of clear weather prediction via USSD, together with agronomists' suggestion, so that they can plan a head and a prototype was distributed betweenmeteoRwanda, agronomist, volunteers and farmers for their feedback.Farmers Smart Technology is a three one App, which has Android App, USSD farmer App and Meteo Web App. Agronomist will use Android App to access provincial weather forecast data to provide suggestion to famers. Agronomist can send emergency alert to famers' facilitators. Farmers can retrieve weather forecast data along with agronomist's suggestion in meaningful way using USSD App. Farmers can provide feedback on weather prediction in yes, no or maybe which can help meteorology Agency to improve their prediction. Volunteer will also use USSD App to feed temperatures and rainfall of the day. This Volunteers' data will be accessed by Rwanda Meteorology Agency using Meteo Web App for their approval.The feature that the system provides makes this proposed system an easy to use.

Keywords:*smart technology, farmer, agronomist, meteorology, communication model,weather prediction,Agile methodology, suggestion, Android App, USSD, Web App*

I. INTRODUCTION

Disaster risk is increasing globally, largely due to a growing exposure of people and assets to natural hazards. Between 2006 and 2015, there was an annual average of 376 disasters triggered by natural hazards, affecting about 224 million people and causing over 69,000 deaths annually[1].More specifically, intense climate-related disasters have been on the rise worldwide. Between 1995 and 2015, 90% of disasters were caused by floods, storms, heat waves and other weather-related events. In total, 6,457 weather-related disasters were recorded, claiming 606,000 lives, with an additional 4.1 billion people injured, left homeless or in need of emergency assistance [2].Floods have accounted for the majority of weather-related disasters worldwide, striking in Asia and Africa more than in other continents. Droughts also account for significant disasters, and are associated with widespread agricultural failures, loss of livestock and water shortages. In total, more than one billion people have been affected by droughts in the past 20 years [3].Droughts affect mostly Africa, with 77 droughts recorded in East Africa alone. In particular, droughts put at risk the lives and livelihoods of vulnerable populations such as smallholder farmers, who account for 70 percept of Africa's population and whose agriculture depends on rainfall. This in turn affects the population as a whole considering that smallholders produce about 80 percent of the food in Sub-Saharan Africa.

In Rwanda, water and climate related issues remain a significant impediment to the country's green growth strategy and pose direct risks for vulnerable populations, such as rain dependent smallholder farmers. The country is highly prone to hazards, including drought, landslide, flood, earthquake and windstorms. Over 157,000 people are vulnerable to drought, about 7,500 are vulnerable to landslide and over 5,000 houses are vulnerable to windstorm, while forest and landscape degradation and climate change increase the risk and severity of disaster. In particular, the districts of Kayonza, Gatsibo, Kirehe, Nyagatare, Rwamagana, Ngoma and Bugesera in the Eastern province are likely to experience severe drought. On the other hand, the highlands of the Congo-Nile Ridge in the Western, Southern and Northern provinces are prone to landslide.

Accurate climate and weather information is critical for managing climate related risks such as droughts and floods, early warnings and fast response; however, micro level data is very difficult to collect with traditional meteorological stations. African observation networks are still very sparse and unevenly distributed, and there is not enough data to inform decisions in water management and climate change adaptation. Weather stations in Africa are spread out over large distances, most being found in northern and southern Africa. The lack of communication occurs within countries and the region as a whole, creating data gaps at multiple levels.

In Rwanda, climate related data is collected and analyzed by Meteo under the Ministry of Environment. Meteo's observational network platform contains automatic weather stations but also many manual weather stations. In the manual stations, one staff or volunteer observer per station writes down the record for the day and sends the data as a monthly report by phone or paper form. Thus, the process is slow and leaves room for human error. This can delay early warning mechanisms and in the face of large-scale disaster, prove inefficient to provide first-hand scoping information and moreover lead to loss of data. Meteo and other relevant stakeholders and users of climate information have expressed the need for more targeted and speedy information, especially for disaster risk reduction and agricultural planning.Climate change is one of the biggest challenges hitting the world today [7]. Disaster risk is increasing globally, largely due to a growing exposure of people and assets to natural hazards [8].This pilot project was *focused on Kayonza*, one of the districts identified as most vulnerable to drought in the National Risk Atlas [4].

II. PROBLEM

Farmers indicated that simply knowing the temperature does not help them.Slow flow of information from the agronomist and meteo Rwanda to the farmers.Farmers are not getting relevant weather informationahead of time for them to get ready. Data provided by meteo *is* hard for farmers to interpret.

III. RESEARCH OBJECTIVES

i) To analyze current communication model usedby Meteo, Agronomist, RAB and farmers.
ii) To identify the complexity of communication model.
iii) To design effective communication model
iv) To design and develop functioning prototypes.

IV. RESEARCH QUESTIONS

i) What communication model is being used for communication between Meteo, Agronomist, RAB and farmers?
ii) What are the complexities of communication model?
iii) How to design the effective communication model
iv) How to design and develop functioning prototypes?

V. LITERATURE SURVAY

Disaster Risk Reduction is a conceptual framework that entails minimizing disaster risks by reducing the degree of vulnerability and increasing resilience capacity as well as preventing or limiting the adverse impacts of natural hazards with a sustainable development approach. Acknowledging that there is nothing natural about disasters, but that these can actually be avoided and their impacts minimized, this project is presented as an initiative to collect and disseminate reliable weather and climate data to reduce the vulnerability to climate change and increase the resilience of vulnerable populations to disaster. Rwanda is a country highly prone to disasters such as drought and flood; however, the country faces an on going challenge of collecting timely and accurate data that can help vulnerable populations and decision-makers be better prepared for climate change. Drought affects the population who depend on rain waiter to cultivate and get agricultural products, especially in the Eastern province of the country. In response to this, MIDIMAR developed the National Drought Contingency Plan to ensure that necessary efforts are carried out to mitigate the risk to drought. The plan serves as a tool to support the preparedness, response and recovery intervention in case the country or a given district faces the impact of drought. While the plan contributes to the improvement of early warning systems for drought detection, reporting mechanisms and cross-sector collaboration, the challenge remains getting accurate forecast data for a specific location since the data being used are generalized at the district level [4].In this regard, micro-level climate data becomes very relevant for reducing climate related risks.

Emerging Internet of Things (IoT) technologies have the potential to collect and disseminate more accurate microclimate data. IoT devices such as wireless sensor networks, network-connected weather stations, cameras and smartphones, can be used to collect a vast amount of climate data, which is then stored in the cloud. Such data can then be analysed to compute localized data and recommendations for any specific location. Real-time micro data collection and dissemination can support decision making at the population level (farmers, direct early warning) and the policy planning level (DRM, agricultural planning) to reduce vulnerability to climate change related issues such as drought and flood. For instance, precise real-time information can help manage water in response to drought.

IoT solutions have the potential of being widely implemented in development contexts due to various factors, including a decline in the price of IoT sensors by about 80-90 percent over the past five years; an increasing internet penetration and the falling cost of smartphones; and the increasing support by governments in developing nations towards IoT innovations [5]. Programmers and designers are constantly developing new low-cost IoT applications that can help solve development challenges. Installing more internet enabled weather stations or small-scale IoT devices can contribute to having a denser observational network, which is capable of providing real-time microclimate and weather data. The data collected from IoT technologies can be combined with data collected from Meteo's manual and automated weather stations, improving the weather forecasts. Working closely with Meteo, capacities can be developed to assimilate data from various different sources, including ground and satellite, as well as to improving the forecasting models. Furthermore, applications can be developed to collect feedback from users on site, who may tell whether the forecast was correct or not, helping improve the models and ultimately adding precision to these forecasts.

Based on the data collected from IoT technologies and conventional weather stations, data usage applications can be developed to disseminate the climate data in an effective and understandable way to vulnerable populations and planners, accelerating effective planning and decision-making in agricultural productivity, Early Warning, disaster risk reduction and water resource management in vulnerable areas.

VI. INNOVATION APPROACH AND METHODOLOGY USED

UNDP placed a strong emphasis in using an innovative approach for the IoT for Climate project, integrating innovation throughout the entire project cycle [6] With the support from the Innovation Facility, the project team was encouraged to engage in a process of testing and learning as well as to embrace failure as a necessary step for success. Through a continuous process of empathizing, ideating,prototyping and testing

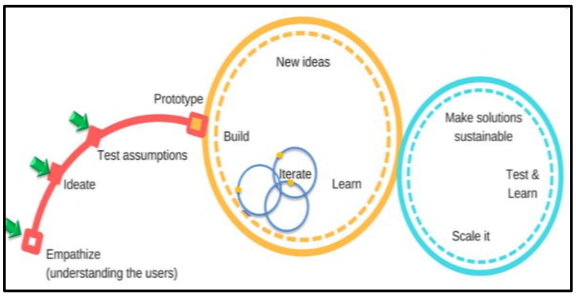


Fig1: Innovation approach used for the IoT for Climate

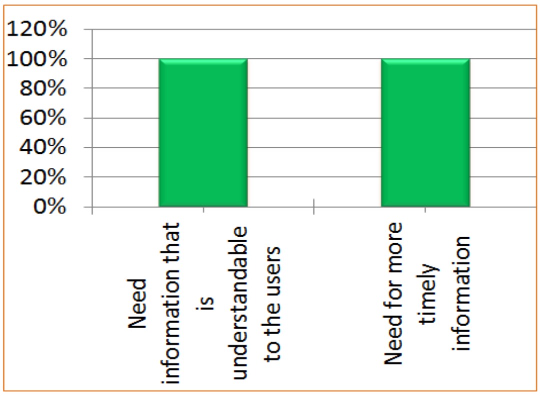
the team was able to gather learning's that are crucial for pivoting and redefining the direction the initiative must take for further scale up. The pilot project was established as a first phase of a broader initiative that aims to leverage the potential of IoT technologies and applications for climate adaptation.

The project focused on a strong **user-centered approach**. Moving away from the notion of "beneficiary", the project focused on understanding the needs of the "users" it was trying to serve. The project also used a **collective innovation approach** by engaging a wide range of stakeholders from the beginning and designing the project in a collective manner. The project further used a **lean start-upapproach**, by which ideas were prototyped and tested continuously. From selecting the site all the way to developing the applications for the end users, there was always a process of testing and learning. Lastly, the project made sure to look at the **scalability and sustainability** of the initiative. As part of the pilot project, partnership workshops were designed to bring together key stakeholders and discuss the next steps IoT for Climate Initiative. This report serves to document strategies for scale up as well as to reflect onthe process of the pilot project so far and explore ways to make the project sustainable.

VII. Findings

Based on in-depth interviews to farmers and agronomists during field visits to Murundi, Ndego and Rwinkwavu Sectors

Table1: Findings



VIII. SOLUTION TO THE PROBLEM

Farmers will be periodically notified of clear weather predictions via USSD/SMS, together with agronomist suggestions, so that they can plan ahead. There are modules is developed as: Android App of Agrnomist and RAB, USSD App of Framer and Web App of Meteo.

IX. TECHNOLOGY USED

There are PHP,HTML, CSS, Jquery, Ajax, Java, Volley Ardroid Library, Afrika'sTalking, and MYSQL ae used.

PHP is used to develop Application Programming Interface (API). It helps to read data from meteo data server.

To develop Android Mobile Application of Agronomists & RAB, Java and Volley Android Library are used.

To develop USSD & SMS Application of Farmers, PHP and Africas'Talking SMS Gateway are used.

Web Application of Meteo is designed and developed usingPHP, Bootstrap3, JavaScrpt/Jquery/AJAX.

DatabaseMySQL is used as Central Database.

X. COMUNICATION MODEL

A. Existing Communication Model

In Existing communication model, information used to travelled through lots of intermediate channel before reaching to farmer that cause delay in information transmission.

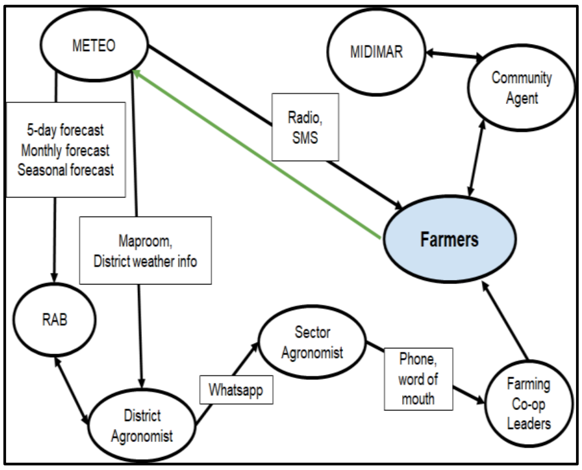


Fig2(A). Existing Meteo Rwanda Communication Model

B. *Proposed KUBERO Communication Model*

This communication model is named **KUBERO**, based on the first two letter of three Authors' name (Kundan, Bensonand Romalice).

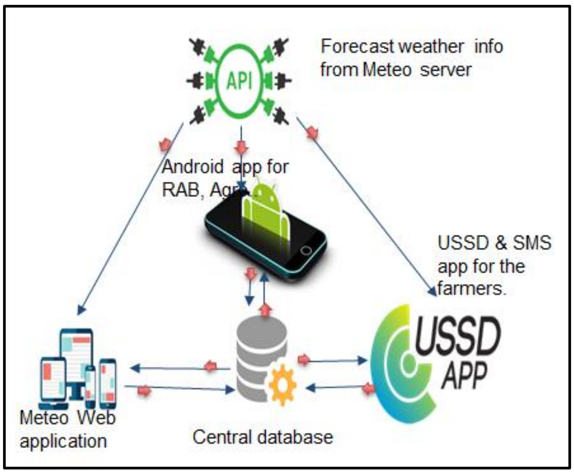


Figure 2(B). Proposed KUBERO Communication Model

Kubero Communication Model, which allow faster communication between stakeholders. Where Predicted weather forecast are pulled from Meteo server through API and availble to Agronomist using Android App. Agronomists' suggestion can be saved on central database which can be pulled any time by Framer using USSD App. Volunteer data is saved on central database which is accessed by Meteo using Web App.

XI. PROPOSED SYSTEM DESIGN

Farmers will be periodically notified of clear weather predictions via USSD/SMS, together with agronomist suggestions, so that they can plan ahead.

A. Screen Shots

The proposed system is being implemented through phase conversion and the following are a sample/prototypeof the ready-made sections of the Framers' Smart Technologydeveloped by the authors

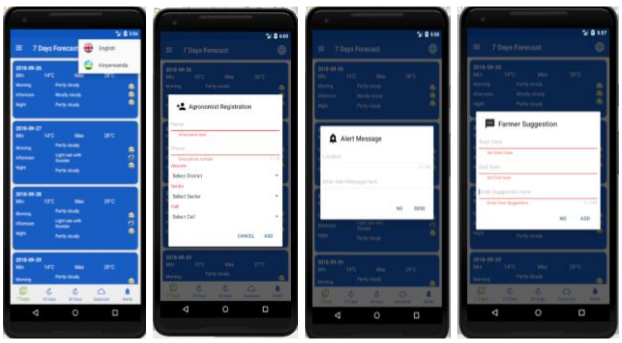


Fig3 (A): Agronomists' Android App Prototype

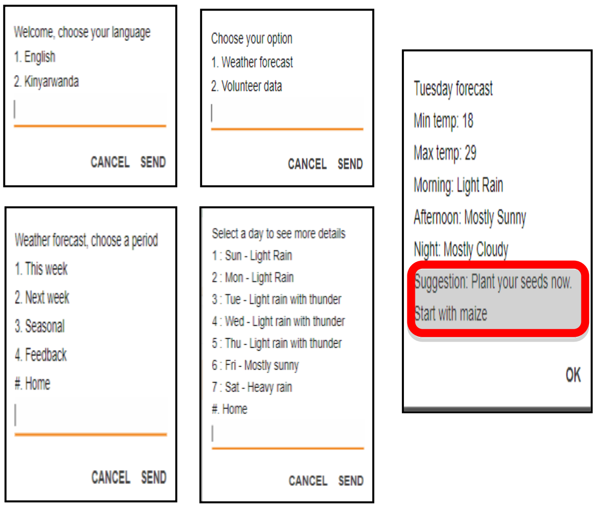


Fig3 (B): Farmers' USSD App Prototype

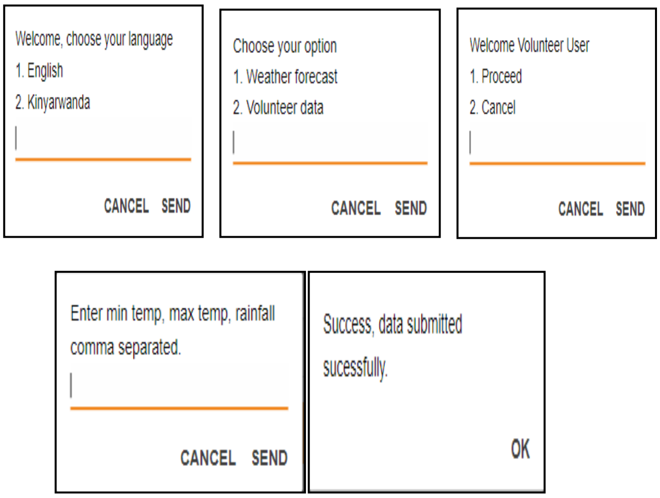


Fig3(C): Volunteers' USSD App Prototypes

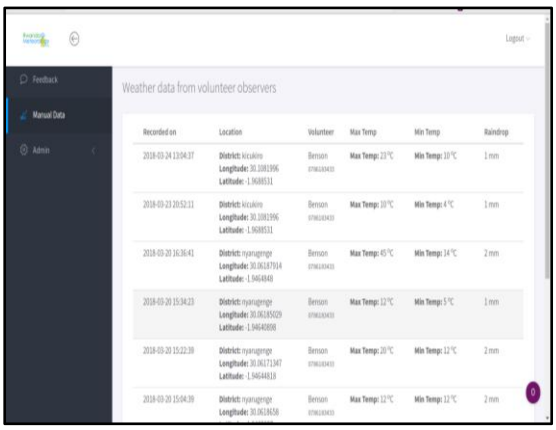


Fig3 (D): Meteo Web App Prototype

XII. STAKEHOLDERS

Wide ranges of stakeholders were involved during the pilot project to ensure that the technologies and applications are relevant and meet the needs of the user.

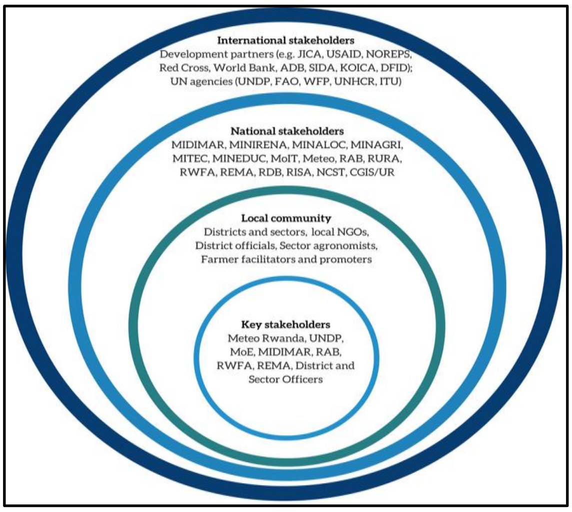


Fig 4: Stakeholder, Source: UNDP

XIII. GUIDELINES FOR SCALE UP

The pilot phase focused on testing different components along the IoT for climate value chain. Based on the learning's from Phase One, some guidelines are suggested for the scale up of this initiative and outputs and activities are proposed for the next phase.

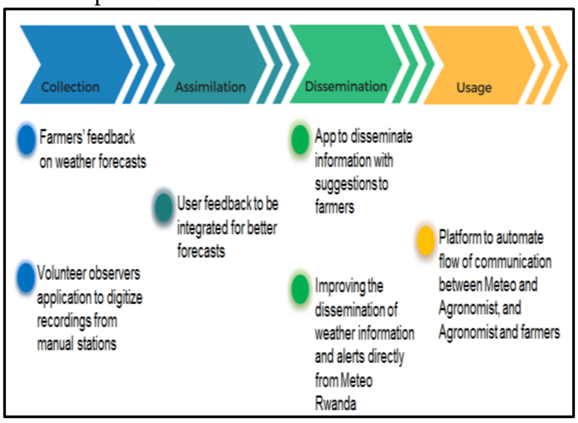


Fig5: GUIDELINES FOR SCALE UP

XIV. CONCLUSION

Problem was identified. Exiting communication model was Analyzed andProposed Effective Kubero Communication Model, which Allow agronomists & meteo provide value to the predicted data and faster communication between meteo, agronomists and farmers.The prototype was developed using Innovative approaches Agile methodology and handed over to stakeholders to use and give the feedbacks for further improvement.

XV. FUTURE ENHANCEMENT

Continuous enhancement of the system to continuously suit the end users' and stakeholders always needs.So Virtual agronomist, Android Mobile App for Farmer, Two way communication between Farmer and Agronomist, Natural Language processing and Real time Chat room for agronomists has been suggested.

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