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Integration and Implementation of Mobile Based Technology with Weather Forecast For Tanzania Meteorological Agency (Tma)

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Abstract
This study aimed at integrating the TMA's system to mobile technology so as to expand the publication of weather forecast information using the weather application on mobile phones. Surveys show that there is a large number of beneficiaries who are not getting weather updates on time in Wazo Ward. Instead, the majority depend on television to get weather update after news, of which has a number of challenges such that, if it happens no electricity or when you get late to watch the news they do not get weather updates for that particular time. Therefore, this study used the TMA's database using Application Program Interface to integrate to the mobile application.
The study was based on qualitative and quantitative research approaches to guarantee dependability of the findings. For the purpose of this study, the sample size was 30 participants, whereby 23 participants were the beneficiaries for weather forecast information from Wazo Ward, 7 were key informants staff members from TMA. The study used interviews to collect data from the key informants and field surveys to gather facts from staffs and beneficiaries to obtain the information. Data was analyzed quantitatively with the help of the computer program. Statistical Package for Social Science (SPSS) and Microsoft Excel were used to process and present data in the form of graphs and tables. The results indicate that there are factors that hinder the publication of weather forecast information to the beneficiaries in Wazo Ward that are; information does not reach most of beneficiaries instantly because some of beneficiaries do not have television, expensive to send messages to all beneficiaries through mobile phones. The researcher found that, 55% of beneficiaries use television to get weather information and complained this source has its challenges and therefore 80% of beneficiaries preferred to receive weather updates through their mobile phones which they can use it to access weather information through their mobile phones at any time. As a consequence, it was decided to design, implement and test a Weather Mobile Application to expand the publication of weather forecast information and reach most of the beneficiaries with no delay. This study expands the capabilities of publication of weather forecast information in Wazo Ward. More comprehensive studies are still needed to gain more insight of challenges facing TMA and the beneficiaries from the agency in other Wards in Dar Es Salaam and Tanzania at large.

Keywords: Agency ,Beneficiary ,Broadcasting ,Climate ,Climate change ,Geographic information systems ,Global warming ,Integration ,Implementation ,Key Informants ,Meteorological ,Meteorologist ,Mobile application ,Publication ,Prototype ,Remote sensing ,Satellite ,Weather Forecast

1. Introduction
It is now widely recognized that human activities are transforming the global environment. In the first 11 months of 1998, there were major floods in China, Peru, and California, enormous damage from Hurricane Mitch in Central America, record-breaking heat waves in Texas, and extensive drought and fires in Indonesia; weather-related property losses were estimated at over $89 billion, tens of thousands of lives were lost, and hundreds of thousands of people were displaced. This greatly exceeds damage estimates for any other year. The environment was ravaged in many parts of the globe. Many of these losses were caused by weird weather associated with the biggest El Niño on record in 1997–98, and they were probably exacerbated by global warming. The human-induced climate change arising from increasing carbon dioxide and other heat-trapping gasses in the atmosphere. The climate is changing, and human activities are now part of the cause (Kevin E. Trenberth, 2000).

Despite the development of weather prediction and warning systems during the past decades, high impact weather still remains a serious risk involving in various social, health and financial impacts across the borders. For instance, the health impacts of climate variability are, in general, for example, large anomalies in temperature and rainfall in a particular season could cause a number of vector-borne and water-borne epidemics, thereafter the weather could return to normal. Extremes of heat can cause heat exhaustion, cardiovascular disease (heart attacks and strokes) while cold spells can lead to hypothermia and increase morbidity and mortality from cardiovascular disease. Storms, tropical cyclones and extreme rainfall can cause immediate death and injuries, as well as increased risk of water-borne diseases in the medium-term and psychological stress on affected communities in the long-term. Therefore, integrated approach, especially on a local level, will be needed with fully coupled models eventually extending beyond physical impacts to social and economic systems, and decision making (McMichael, 2003).

Different organizations have been formed for weather forecasting around the globe such as the World Meteorological Organization (WMO) which is an intergovernmental organization with a membership of 191 Member States and Territories which was established in 1950 and the World Weather Research Programme (WWRP). The WWRP exists to develop, share and apply knowledge that contributes to societal well-being, principally by helping to manage weather-related risks to safety and property but also by enabling individuals, businesses, and institutions to take advantage of opportunities afforded by weather conditions ((WMO), 2016).

It is essential that communities understand their risks, respect the warning service and know how to react. Education and preparedness programmes play a key role. It is also essential that disaster management plans are in place, well-practiced and tested. The community should be well informed on options for safe behavior, available escape routes, and how best to avoid damage and loss to property (Bonn, 2006). The Met Office is the UK's National Weather Service, which provide the Met Office weather mobile application that help its users to plan their day, with the latest daily weather forecasts and UK National Severe Weather Warnings.

Met Office weather mobile application contain its key features such as Access a seven-day weather forecast, available for many locations across the globe, Get a daily forecast snapshot for your current and saved locations, providing an at-a-glance view of the weather, Personalize your forecasts and see how the weather could affect your day by saving multiple locations, simple and easy to use, get a snapshot of your week or quickly access extra detail when you need it, stay up-to-date with hourly forecasts for the next two days and with three-hourly forecasts available for the next three to seven days, Subscribe to push notifications and receive important alerts for the latest UK severe weather warnings - including snow, strong winds, ice, fog and rain forecasts (Office, 2016).

The extent of the damage caused by a hazard is related not just to its severity, but also to the capacity of people living in disaster prone areas to prepare for and resist it. Efforts to reduce disaster risk have therefore focused, in part, on developing early warning systems such as Forecasting and modelling technology, remote sensing and geographic information systems (GIS) applications, Satellite communication technology and Mobile phone technology to provide timely and effective information that enables people and communities to respond when a disaster hits. For example, *Mobile phone technology in* Asia, with the global spread of mobile phones and networks, this technology is now increasingly used to communicate warnings and coordinate preparation activities particularly SMS alerts for disseminating mass messages. For example, upon detection of p-waves that precede earthquake shaking, Japanese agencies send out SMS alerts to all registered mobile phones in the country (Pearson, 2012). As part of Japan's government, the Japan Meteorological Agency (JMA) deals with Prevention and mitigation of natural disasters, Safety of transportation, Development and prosperity of industry, Improvement of public welfare and focuses its efforts on monitoring the earth's environment and forecasting natural phenomena related to the atmosphere, the oceans and the earth, as well as on conducting research and technical development in related fields ((JMA), 2016).

Furthermore, Africa being one of the regions that risks being most seriously affected. In response to major challenges related to the delivery of weather and climate services in Africa, the African Ministerial Conference on Meteorology (Amcomet) was initiated as a permanent forum where African ministers convene every two years to discuss policy matters related to the development of meteorology and its applications and its contribution to the socio-economic development in Africa. Extreme weather events are known to have serious consequences for human health and are predicted to increase in frequency as a result of climate change (Limin Wang, July 2009).

For example in Kenya, the Kenya Meteorological Department has various functions such as Provision of meteorological and climatological services to agriculture, forestry, water resources management, civil aviation and the private sector including industry, commerce and public utilities for the better exploitation and utilization of natural resources for national development, Provision of meteorological services to shipping in the western Indian Ocean including the issuing of cyclone warnings for the safety of merchant and other ships and Provision of meteorological services to military aviation for the safety of the Kenya Air Force aircraft for national defense, Maintenance of an efficient telecommunications system for rapid collection and dissemination of meteorological information required for national and international use in accordance with the World Meteorological Organization (WMO) and the International Civil Aviation Organization (ICAO) procedures (Department, 2015).

The evolvement of suitable training programmes in all fields of meteorology and other related scientific subjects which are relevant to the development of Kenya and other countries that participate in the Department's training activities, such as the Kenya Meteorological Society (KMS). According to report by the chair of the Kenya Meteorological Society on the activities of the society for the year 2015 (Chair, 2016), he states, there are two publications; the quarterly Journal of Meteorology and Related Sciences (JMRS) and the Bulletin of the Kenya Meteorological Society on Weather and Climate. Although both publications provide resourceful articles which are

beneficial to meteorologists and the general public, In February this year, the Society subscribed to Crossref, a cross linking organization, that provides a platform to register Digital Object Identifiers (DOIs) and enable articles in the KJMRS, Bulletin, Conference proceedings and reports to be cross-referenced. Last year, the Society obtained the ISSN for the electronic KJMRS. The intention is ensuring articles publications are more visible to the scientific community worldwide and have a bigger impact factor.

In Tanzania, National Meteorological Services were provided under the Directorate of Meteorology (DoM) established by Act No. 6 of 1978 after the defuct of East African Meteorological Department. Tanzania Meteorological Agency (TMA) was formed by the Executive Agency Act no. 30 of 1997 under the Ministry of Transport. The Agency came into being on 3rd December 1999. TMA have different functions such as to provide weather, climate services and warnings (e.g. floods or droughts) for the safety of life and property to the general public, to provide weather and climate services to various users including agriculture and food security, to provide weather and climate services to various users including surface transport, Effects of Weather Hazards to Railway infrastructures eg. Kilosa Floods, to provide meteorological services for local and international air navigation on behalf of the United Republic of Tanzania as designated meteorological authority and according to Technical Regulations of the World Meteorological Organization and Annex of the International Civil Aviation Organization, to take part in global exchange of meteorological and related data and products for the safety of humankind and to enhance the understanding of the global atmosphere (Timiza, 2013).

Tanzania Communications Regulatory Authority (TCRA), announced that the number of mobile phone subscribers jumped up by 25% in 2015 to reach 39,800,419 users while the number of internet users rose 52% to reach 17,263,523 which is a good increase as in 2014 there were 31.86 million mobile phone subscribers and 11.35 million internet users due to the launch of cheaper smartphones in the country and the 3G Network infrastructure built (Forums, 2016). The smartphones and the app have become for many of us one of the main ways of accessing information. Therefore, with the advent of mobile computing, you can get updated on the weather forecast anywhere you have a wireless or cellular signal. Since, with Doppler radar, satellite imaging and numerous advances in meteorology, weather forecasts are more reliable than ever. Therefore, using mobile computing technology to publish weather information can be one of the appropriate way to reach more people.

1.2 Problem Statement

Despite the fact that different efforts and methods that are being used to publish weather forecast information to the public (beneficiaries), still there are some challenges one of them being delay. As of these information does not reach out most of the beneficiaries on right given time. That is, not all citizens get exact information at right time from TMA, and some citizens publish wrong information to the public making others get wrong information due to high rate of increased number of internet users which is led by the use of smartphones.

Currently Tanzania Meteorological Agency (TMA) uses Television, Radio, Blogs, Newspapers, journals, mobile phones and social networks such as Facebook, Twitter and YouTube to reach the society to publish weather forecast information. Where by mobile phones are used to send information, advisory or warning to its beneficiaries (in lake zones citizens and farmers) on Severe weather forecasting, that is the Starfish mobile through Vodacom-Tanzania and mFarmer through Tigo-Tanzania which is very expensive since they pay for this service monthly to yearly. The goal of this study is to contribute to TMA by designing and implementing a weather mobile application prototype for smartphones that will enable users access the available local weather forecast from TMA and the beneficiaries would receive instantly updates, hence increasing flow of broadcasting weather forecast information to the public and reaching more people and organizations easily, cheaply and instantly.

1.3 Research Objectives

1.3.1 Main Objective

The main objective of this study is to integrate and implement the weather forecast data for TMA to mobile based technology.

1.3.2 Specific Objectives

1. To identify how TMA, publish its weather forecast data.
2. To investigate factors that hinder publication of TMA weather forecast data.
3. To develop a Weather Mobile Application prototype that expands the publication of TMA weather forecast data.

1.4 Research Questions

From the proposed system in this study the following questions arise:

1. How does TMA publish weather forecast information?
2. What are the factors which hinder TMA in publishing weather forecast information?
3. What prototype (mobile application) can expand TMA's capabilities for publishing current weather forecast information?

1.5 Assumption

The system would help to easily access weather information using mobile application as a result information will be available and the beneficiaries would be able to receive instantly updates. Data would be presented on the mobile phone application and captured from TMA's database for weather forecast with the help of Application Program Interface (API).

1.6 Scope of the study

1.6.1 Geographical scope

The study was conducted at Tanzania Meteorological Agency (TMA) located at Ubungo Plaza, Morogoro road near Ubungo bus terminal in Dar Es Salaam region Tanzania.

1.6.2 Content Scope

The proposed mobile application system covered only weather forecast information for Dar Es Salaam region.

1.6.3 Time Scope
The proposed mobile application system was conducted at TMA for three months from June to late August.

1.7 Significance of the study
With regard to other ways (Televisions, Radios, Magazines) that TMA use to publish its weather forecast information, the findings of the study would enable citizens (users) to get accurate instant weather information available at any time easily, right on their hand devices which they use it frequently, from the authorized agency in Tanzania hence staying safe with their properties.

This study would contribute to widening of TMA approaches of publishing their weather forecast information and reaching more people. Furthermore, beneficiaries would receive instant updates as in case of any emergency or warnings, hence being able to save lives or properties.

This study would also contribute to help the general public users and their properties not to be affected by weather hazards hence government costs would be minimized on helping the victims.

1.8 Operational Definition of Key Terms
Android software development is the process by which new applications are created for the Android operating system.

Agency A governmental or other institution **or** the abstract principle that autonomous beings, agents, are capable of acting by themselves.

Beneficiary is a natural person or other legal entity who receives money or other benefits from a benefactor.

Broadcasting is the distribution of audio and / or video content to a dispersed audience via any electronic mass communications medium, but typically one using the electromagnetic spectrum (radio wave), in a one-to-many model.

Climate refers to the average weather conditions in a place over many years (usually at least 30 years, to account for the range of natural variations from one year to the next).

Climate change is significant change in the Earth's climate. The Earth is currently getting warmer because people are adding heat-trapping greenhouse gases to the atmosphere. The term "global warming" refers to warmer temperatures, while "climate change" refers to the broader set of changes that go along with warmer temperatures, including changes in weather patterns, the oceans, ice and snow, and ecosystems around the world.

Geographic information systems (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

Global warming is an increase in temperature near the surface of the Earth. Global warming has occurred in the distant past as the result of natural causes.

Integration is defined as the process of bringing together the component subsystems into one system and ensuring that the subsystems function together as a system.

Implementation in computer science is a realization of a technical specification or algorithm as a program, software component, or other computer system through computer programming and deployment.

Key Informants are those whose social positions in research setting give them specialist knowledge about other people, processes or happenings that is more extensive, detailed or privileged than ordinary people, and who are therefore particularly valuable sources of information to a researcher, not least in the early stages of a project.

Meteorological is observable phenomena of weather events that are explained by the science of meteorology and can be described and quantified by the variables of Earth's atmosphere that are temperature, air pressure, water vapor, mass flow, and the variations and interactions of those variables, and how they change over time.

Meteorologist is a person who studies processes in the earth's atmosphere that cause weather conditions.

Mobile application is a software application designed to run on mobile devices such as smartphones and tablet computers.

Mobile Technology is the technology used for cellular communication.

Publication is a technical term in legal contexts and especially important in copyright legislation which also involves process of making content available to the general public.

Prototype is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from.

Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on site observation. Remote sensing is used in numerous fields, including geography and most Earth Science disciplines (for example, hydrology, ecology, oceanography, glaciology, geology).

Satellite communication technology is an artificial satellite that relays and amplifies radio telecommunications signals via a transponder, it creates a communication channel between a source transmitter and a receiver at different locations on Earth.

System: as a set of things grouped together and working interactively to achieve a particular task desired.

Weather is a specific event or condition that happens over a period of hours or days. For example, a thunderstorm, a snowstorm, and today's temperature all describe the weather.

Weather Forecast is the application of science and technology to predict the state of the atmosphere for a given location.

Literature Review
2.0 Overview
Different researchers have attempted to solve and suggest approaches that will accelerate the diffusion of publication of weather forecast in Tanzania. This section reviews the existing literature on weather forecast. It critically examines, discuss, and synthesize different documents including books, papers, system documentation and websites with information related to contribution of weather forecast to mobile based technology on weather forecast. The chapter starts with objectives in relation to existing literature, conceptual framework followed by related studies and finally the research gap.

2.1 How weather forecast data is being published
Most end users of forecasts are members of the general public. Thunderstorms can create strong winds and dangerous lightning strikes that can lead to deaths, power outages and widespread hail damage. Heavy snow or rain can bring transportation and commerce to a stand-still, as well as cause flooding in low-lying areas. Excessive heat or

cold waves can sicken or kill those with inadequate utilities, and droughts can impact water usage and destroy vegetation. Several countries employ government agencies to provide forecasts and watches/warnings/advisories to the public in order to protect life and property and maintain commercial interests. Knowledge of what the end user needs from a weather forecast must be taken into account to present the information in a useful and understandable way(Wikipedia, 2016).

Examples include the National Oceanic and Atmospheric Administration's, National Weather Service (NWS) and Environment Canada's Meteorological Service (MSC). Traditionally, newspaper, television, and radio have been the primary outlets for presenting weather forecast information to the public. Increasingly, the internet is being used due to the vast amount of specific information that can be found. In all cases, these outlets update their forecasts on a regular basis as (Palumbo and Herbig, 1998) argued, the typical Internet user of the twentieth century is young, professional, and affluent with higher levels of income and higher education.

According to (Simon Mason, 2015) The over-reliant on climate-dependent sectors of the economy, particularly rain-fed agriculture, and their histories of violence, poverty and weak governance serve to undermine resilience and capacities to respond to climate risks. As (Olson, 2014) suggested, we all rely on these weather forecasts to plan our day-to-day activities. For example, before planning a summer grill out over the weekend, we will check our favorite weather web site to see whether it is going to rain.

2.2 Factors that hinder weather forecast publication of data

Weather forecasts are inherently uncertain, and meteorologists have information about weather forecast uncertainty that is not readily available to most forecast users. Yet effectively communicating forecast uncertainty to nonmeteorologists remains challenging. Many studies such as (John Handmer, 2007), (Rebecca E Morss, 2008) have identified the barriers of capturing uncertainty through numerical probabilistic statement is orthodoxy in risk science and most of science and technology. (Rebecca E Morss, 2008) Claimed there are a wide range of views on the utility of such statements for risk communication, and they are often seen as being central to the failure to generate common understanding about risks between science and non-scientists. The extent to which probability statements are understood is unclear. Some jurisdictions use numerical probabilistic statements on the likelihood of precipitation and variety of qualitative or categorical forecasts are also used.

(John Handmer, 2007)Proclaims, the question logically arises concerning the extent of shared understanding of weather predictions between those making them and those making use of them". He says using numerical probability in weather forecasts communicates the uncertainty inherit in every forecast (and the extent of that uncertainty) on which people can base their decisions. For example, decisions relating to outdoor events, building work, or travel may be influenced by a forecast that there is a 60% chance of rain. The study was set up to examine the use of probabilistic weather forecasts and related issues in communicating weather information, and they examined the following questions:

Do people prefer probabilistic statements? Do they have same understanding of them as forecasters? Does it make any difference anyway do people make decisions based on forecasters? What about alternatives to numerical probability statements? (John Handmer, 2007) Report showed given a choice of verbal, numerical or both, 61.1% of responders to the US surveys collated by Bussum indicated a preference for a numerical forecast (Saviers and van Bussum, 1999). Regardless of their preferences in terms of how weather forecasts are conveyed. Expressions of a chance are generally imprecise and open to interpretation. When a chance is expressed numerically (for example as a probability percentage), it becomes more precise.

2.3 Role of Mobile phones to Weather forecast Agency

Many studies such as (Caine ADorward, 2016), and (Daniele Tricarico, 2016) have identified various roles of Mobile phones in weather forecasting information. According to (Caine ADorward, 2016), Mobile phones are increasingly being used to provide smallholder farmers with agricultural and related information. There is currently great interest in their scope to communicate climate and weather information. Farmers consistently identify demand for weather information and whilst ICTs may be one way of delivering this at scale there are concerns that this should not be seen as a panacea. This focused principally on Sub Saharan Africa but included some examples from India. Despite numerous initiatives few have developed fully beyond the pilot stage and few have been evaluated. An important challenge is how to meet farmers' needs for location specific, timely and relevant information in economically sustainable ways.

More widely there are challenges in achieving successful business models and potential conflicts between initiatives driven by mobile network operators and public goals. The study identified areas of considerable potential which include: the use of increasingly available mobile data connections to ensure locally relevant content is available to farmers in timely fashion (including both historical climate information and forecasts), development of participatory decision making tools to enable farmers to interpret information for their own contexts and consider implications and management options, use of visual applications and participatory video on mobile devices to enhance learning and advisory services for farmers, the potential for increased feedback between farmers and service providers as well as increased knowledge sharing between farmers provided by the use of social media (Caine ADorward, 2016).

Furthermore (Daniele Tricarico, 2016) argued that, smallholder farmers in the developing world need to adapt to changing climate conditions. For the provision of weather forecasts, however, farmers rely on national meteorological agencies with low capacity and obsolete technologies. Over 60% of national meteorological agencies, the vast majority in emerging markets, are significantly challenged with respect to their core infrastructure (observational networks, forecasting systems and telecommunications). To improve weather services, there is a need for greater engagement and collaboration of different stakeholders, including government and transnational organizations with global weather data (e.g. the European Centre for Medium Range Weather Forecasts,

and the US National Center for Environmental Prediction), commercial weather forecasting companies (e.g. MeteoGroup, StormGeo, Foreca, Ignitia), and international research institutions and NGOs with open data.

In addition (Daniele Tricarico, 2016) suggested, there is a need of greater engagement of all distributors of weather forecasts, primarily Mobile Network Operator (MNOs) and Value Added Services (VAS) providers delivering weather forecasts to smallholder farmers on their mobile phones. As the only ecosystem players that can scale mobile agriculture services, MNOs can play a pivotal role in catalyzing investment, including from donors, and drive forward innovation in weather services.

2.3 Conceptual frame work

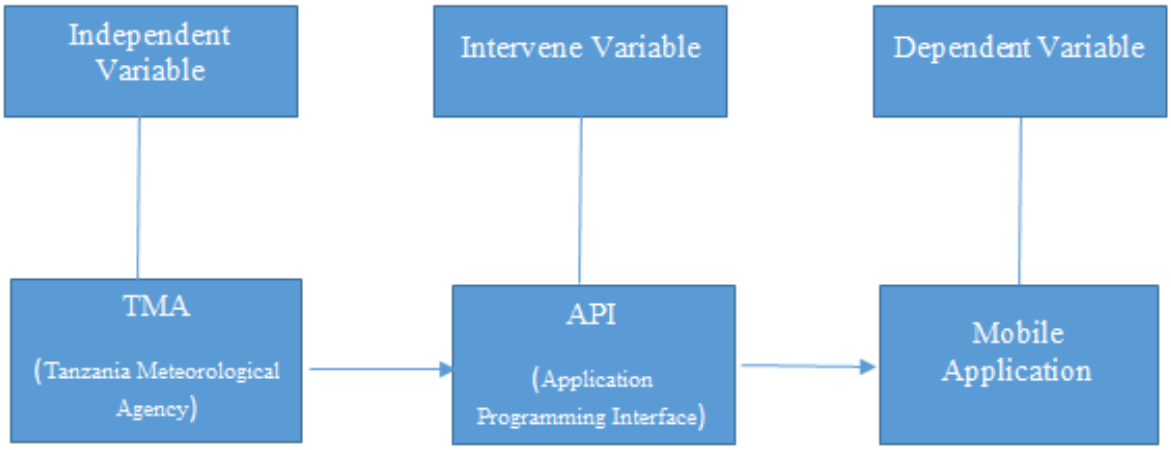


Fig.1: Conceptual frame work

2.3.1 Description of Conceptual frame work

In this conceptual framework, independent variable will be the TMA website which contain and provide all weather forecast information which is online.

The variable that intervenes in this framework will be the Application Programming Integration (API) which will act as a bridge between the two sub systems (the TMA website and the Mobile Application) to communicate to and fro. The API will help to create the relationship between the systems.

The overall dependent variables are security, trust, awareness and infrastructure. The mobile application will depend on the independent variable to feed its data via API and they both run under the same platform that is internet.

Dependent variable (Mobile Application) will help to solve barriers of weather forecast publication of information Tanzania, and will help to expand growth of weather publication of information.

2.4 Related Studies

Today's consumers are spending over 85 percent of their time on their smartphones using native applications (Perez, 2015). (Portal, 2016) Stated, this statistic shows a forecast for the number of mobile app downloads from 2009 to 2017. In 2009, worldwide mobile app downloads amounted to approximately 2.52 billion and are expected to reach 268.69 billion in 2017.

According to (Kristen Purcell, 2011) said, Local news is going mobile. Nearly half of all American adults (47%) report that they get at least some local news and information on their cellphone or tablet computer. What they seek out most on mobile platforms is information that is practical and in real time: 42% of mobile device owners report getting weather updates on their phones or tablets; 37% say they get material about restaurants or other local businesses. These consumers are less likely to use their mobile devices for news about local traffic, public transportation, general news alerts or to access retail coupons or discounts. One of the newest forms of on-the-go local news consumption, mobile applications, are just beginning to take hold among mobile device owners.

Also, the U.S. Department of Transportation's (USDOT) Federal Highway Administration (FHWA) and Research and Innovative Technology Administration (RITA) are jointly working to promote safety, mobility, and the environment on the nation's surface transportation system through a new connected vehicle initiative. This initiative is a multimodal effort to enable wireless communications among vehicles, the infrastructure, and passengers' personal communication devices. Which will enhance Americans' safety, mobility, and quality of life, while helping to reduce the environmental impact of surface transportation. (Transportation, 2013)

According to (Precision weather forecasting, 2016) asserts that, accurate forecast focused on your needs such as snowfall rates, how much and when snow/ice will accumulate on paved vs. non-paved surfaces, breaks or lulls, and times when icing is the greatest concern. This helps to decide whether to treat vs. plow from detailed information such as a specific start time and when the first inch of snow will accumulate on your roads. Receive certified past weather reports once the snow stops with town specific details of the event. Ability to call us 24/7 to discuss the weather and your actions with a local meteorologist. Receive alerts from us of upcoming weather so you can make the best of limited resources. Their findings revealed a practical and moderate way to help one to know when to schedule staff in a timely fashion conserving their budget.

Moreover, INRIX Road Weather is the first of its kind to give drivers advance warning of dangerous weather-related road conditions ahead, keeping them safer on their route. The solution aggregates big data from connected cars, as well as atmospheric weather conditions, then transmits that data to other cars and mobile applications, giving drivers

important information to either choose another route or change their speed well ahead of the problem. INRIX Road Weather will help reduce the number of traffic accidents related to weather, saving lives and reducing insurance costs for drivers (Inrix, 2016).

2.5 Research Gap

Many hazards happen and cause damages to society as an example (Mhagama, 2015) pointed out "The Director General of TMA, Dr. Agnes Kijazi, said this in Dar Es Salaam during a press conference to clarify over the heavy 30-minute storm which killed at least 42 people in Kahama District last week. Dr. Kijazi said that before the tornado ravaged the District, TMA issued a warning through weather forecast reports published and broadcast by various media organizations." Some people have grown not to use these reports and others have been seeking to verify if indeed something foretold will happen, instead of taking action to rescue their lives," she said. She noted that people should be alert whenever they hear that there will be dense towering vertical clouds which are professionally known as cumulonimbus associated with thunderstorms and atmospheric instability; measures should be taken as those signify a storm.

Furthermore, many studies do not focus suggesting technological solutions to improve weather forecast publication of data in Tanzania. In this world a single technology cannot solve all the problems. Technological integration approach can help to solve a number of problems in time.

The present study has focused on untouched aspects of mobile phone application due to the availability of brand technologies especially using mobile-internet. Such that with growth of internet which led to increase of smartphones usage and whereby most of people uses the smartphone to get various information, if used to send alerts and notifications to users would help people to get frequent alerts at a wide range and on time where everyone with the smartphone will get direct information from their trusted and recognized agency which would help to reduce hazards and risks in an environment. Users can also use the application to browse using their local mobile devices and be able to spread weather information all over the country sides meaning villages and town's service accessibilities and availabilities.

Research Methodology

3.0 Overview

This chapter describes different methods and techniques used in undertaking this study, it includes items like research design, research procedure, target population, sample population, data collection, limitation of the study and the research instruments used. The data collected in account was from Tanzania Meteorological Agency in Dar Es Salaam region.

3.1 Research design

This study employed case study and cross sectional research design approaches. Case study design is more flexible in the data collection. Cross sectional was helpful in collecting data in different respondents at a short period of time. In cross sectional research design, data collection was done once hence it was time efficient. Cross sectional was suitable for this study since it intended to analyze the diffusion of weather forecast information to the public by the time of this study.

Quantitative aspect aimed at measuring the number of individuals agreeing with some factors defined in the research tools, which implied the degree of acceptance.

Qualitative aspect was concerned with aspects that cannot be quantified such as the level of satisfaction.

3.2 Research population

The target population for this study included Key informants (Staffs) from Tanzania Meteorological Agency and the beneficiaries from Dar Es Salaam region. Dar Es Salaam region is growing fast in technological activities as witnessed recently there is high growth number of internet users led by use of smartphones which people use it frequently to access any information they want. This study was conducted in Kinondoni Municipal specifically at Wazo Ward which is located in Northern part of Dar Es Salaam city. Kinondoni Municipal Council has four divisions namely; Magomeni, Kinondoni, Kibamba and Kawe which constitute thirty-four Wards. Kawe division has ten Wards namely; Msasani, Kawe, Kunduchi, Mbweni, Bunju, Mikocheni, Mbezi juu, Makongo, Mabwepande and Wazo. Moreover, Wazo Ward is a highly populated Ward in Kawe division hence was convenient for this study to be undertaken in this area.

According to NBS population estimations of 2015, Wazo ward in Dar Es Salaam has a population of 59,651 people above 18 years old and the study covered the total of 100 beneficiaries from general public, and 30 staff members from the Tanzania Meteorological Agency.

3.2.2 Sample Size

The research study preferred to take the total sample of 30 respondents. The respondents included 7 Key Informants from TMA and 23 beneficiaries from Wazo ward. The researcher opted to choose such small sample size because large sample size would be time consuming and too expensive. The sample size for this study was obtained by using (Slovenes' formula) of:

$$n = \frac{N}{1+N\,(e)2}$$

Where n = Sample size, N = Sampled population and e= Level of significance at 0.05.

Table 1: Categories of Respondents Sampling

Categories	Sample size	Techniques	Data Tools
Beneficiaries Key Informants	23 7	Simple random sampling Purposive sampling	Questionnaire Interview and Questionnaire
Total	**30**		

Source: researcher (2016)

3.3 Sampling procedure

During this study, Cluster and Stratified sampling method were used to obtain sample from respondents. Both Stratified and Cluster sampling method were used to select

from a pool of staffs and users who made all the respondents of a sub-group to form a sample population. Stratified sampling was used because it grouped population into homogenous subsets that share the same characteristics and Clustered samplings were used because it selected groups rather than individual members because a sampling frame cannot be constructed.

3.4 Research Instrument

3.4.1 Survey

Surveys were conducted to beneficiaries and key informants by using a questionnaire (Appendix 1). This study used questionnaires due to its ability in collecting data from relatively large number of population within the short time with will less costs. The questionnaire comprised of both closed and opened ended questions.

Questionnaire was administered by researcher, assisted by research assistants. Before administering the questionnaire to the key informants and beneficiaries, questionnaire was pre-tested by administering to few respondents from Wazo Ward to check if it would collect the required information for achievement of the study objectives and also if there was same interpretation of the questions by all respondent hence making it easy for the researcher to detect a trend just by glancing at the responses.

3.4.2 Interview

In this study interviews were used to collect data from the key informants. The interviews gave a room for a more open conversation to get details regarding the subject of the study (Far, 2011). The study was using personal interviews for the key informants' respondents who have detail information about weather forecasting broadcasting. The interview comprised both structured and unstructured questions however, interview guide used to guide the interview (Appendix 2).

3.4 Validity and Reliability of the Instrument

3.4.1 Validity of the Study

The validity of the instrument was ensured by content and faces validity methods. The intention was to examine the correctness of the items in the instrument. Reliability of the instruments reflects its stability and consistency within the given context. The researcher did this repeatedly in the research fields.

3.4.4 Reliability of the Study

In order to ensure reliability of the study, pre-testing was done in order to check if the respondents faced problems in understanding questions in the questionnaire. Clarity of instructions were given to research assistants before administering questionnaire. All the research assistants that conducted this study during data collection, were trained on how to approach and ask participants.

3.5 Date Gathering Procedures

The researcher was issued a recommendation letter as identification from the faculty of applied science and Technology of Kampala International University Dar Es salaam Constituent College. This introduced the interviewer as a researcher trying to perform an academic and research study, thereafter the researcher went to the field to collect data by using the research instruments chosen for the study in data collection.

3.6 Data analysis

Data was coded in such way that it could be suitable to be analyzed by software package, Statistical Package for Social Scientists (SPSS). SPSS version 16 was employed as tool for data coding and analysis. The descriptive statistics that is frequency distribution and percentage was used to describe and summarize the data in demographic variables such as sex, age, marital status and educational level. Microsoft Excel 2013 was used to produce graphs and charts from the analyzed data in SPSS.

3.7 Ethical Considerations

In this research study, ethics is considered in the construction of interview questions and questionnaire whereby no names and sex were required. The data collected was made confidential and respondents were informed on the aim of the research prior to the collection of research information that was - the findings are used only for academic purpose whereby this helped to ensure respondents rights to anonymity that they felt free to express themselves without their health, value and dignity being destroyed and gave them a complete free choice to participate.

3.8 Limitations of the Study

Although the research was carefully prepared, there were some unavoidable limitations. First, because of the time limit, this research was conducted only on large size of population in Wazo ward at Kinondoni Municipal whom most of them were using smartphones to access different kind of information. Therefore, to generalize the results for larger groups, the study should have involved more research assistants and enough budgets to support them.

Second, the research depended on respondent knowledge and was limited on honesty of respondents, however, this was lessened by assuring respondents confidentiality and signing an agreement or an oath indicating that in case the researcher leaks the information on a respondent may use it to the court of laws for legal actions.

Third, difficulty in accessing the respondents due to their busy schedules however, the researcher used multiple skills like call backs, re-arranging appointments and extensive mapping.

Finally, some respondents failed to return the questionnaire which made the researcher to print out more questionnaires and ran out of budget.

System Analysis, Design, Testing and Implementation

4.0 Overview

This chapter presents the analysis of Weather Mobile Application, design and usage of the system. Data presentation and analysis was guided by the research objectives and questions and discussion of research findings relied on conceptual framework discussed in Chapter 2.

4.1 System Analysis

4.1.1 Feasibility study

In this chapter, the researcher started with feasibility study and focuses on current system of broadcasting weather forecast to the public. The researcher interviewed the ICT Manager, Environmental Manager and the Training Manager and found that there are three categories of notifications that are Information which is provided to tell

the beneficiaries the normal weather conditions, Advisory and Warnings if there is any endangerment seen from forecasts.

Moreover, every day from 01:00 pm to 3:00 pm weather forecast information is being prepared in a conference room for the next day and it is then sent to medias (television stations, radio stations) through internet, (emails, drop box application).

4.1.1.1 Technical feasibility

Furthermore, there is a studio where meteorologists are recorded in video where they present the weather forecast information in detail. This weather forecast information are also uploaded in their website (www.meteo.go.tz). And the following were found to be elements that are uploaded in excel format to the website that are: region number unique identifiers, region name, weather data, maximum temperature, minimum temperature, condition, sun set, sun rise and wind. This information can be accessed from the website in Swahili language and in English language.

4.1.1.2 Economic Feasibility

From the management, the researcher found that TMA has a system that is used to send weather forecast information to two groups, via mobile phones. The Starfish mobile through Vodacom-Tanzania and mFarmer through Tigo-Tanzania which they complained to be too very expensive since they pay for this service monthly to yearly.

Beneficiaries were likely to complain towards the system because information release happened to be delaying in case of giving warnings they could not be notified instantly. Therefore, using this implemented system will reduce hazards to the society by helping them get information warnings on time with no delays.

4.1.2 System requirements specification

In a bid to understand more about the Software requirements specification, services required from the system and their constraints on the system's operation were all considered. System requirements were collected in consultation with the users of the system; who were both general public users (the beneficiaries) and staffs of TMA Dar Es Salaam. By focusing on the current system the researcher came with solution of developing the weather mobile application system which would help TMA to publish weather forecast information to the public and reach more people instantly (with no delay) to cover the gap missed in current system.

Through use of questionnaire and Interviews helped a researcher for establishing software requirements specifications. These were grouped into two categories, functional requirements that tell what the system should do and non-functional requirements which are attributes that a system should possess in order perform its tasks.

4.1.2.1 Functional requirements

The following were identified from the themes created during analysis and were categorized as functional requirements of a mobile weather forecast system.

- The system should allow getting a daily forecast snapshot for your current and saved locations, providing at-a-glance view of the weather.
- The system should allow accessing a 48 hours and 15 days' weather forecast for Dar Es Salaam region.
- The system should stay up-to-date with hourly forecasts for the next two days and with three-hourly forecasts available for the next three to seven days.
- The system should allow beneficiaries to subscribe to push notifications and receive important alerts for the latest Dar Es Salaam severe weather warnings - including rain forecasts, strong winds etc.
- The system should allow beneficiaries to get probability of rain or drizzle.
- The system should allow beneficiaries to get actual temperature, including the high temperature for the day and the lowest temperature for the day as well as the 'feels like' temperature condition.
- The system should allow beneficiaries to get wind speed, direction and gusts.
- The system should allow beneficiaries to get the sunrise and sunset times.
- The system should allow beneficiaries to change their unit settings for temperature and wind speed that is from Fahrenheit to Celsius.
- The system should allow beneficiaries to get humidity of a place.
- The system should allow beneficiaries to refresh data.

From the system functions above, they define exactly what a system should possess. This was after data collections from both users and staffs of Tanzania Meteorological Agency. These requirements were looked at in relation to external contextual interaction (a user, or another system) with the system. The above requirements are in line with the functions performed by the Met Office Weather Application system for UK Meteorologist Agency which allows the users to access and view the latest daily weather forecasts and UK National Severe Weather Warnings (Office, 2016).

4.1.2.2 Non-functional requirement

In another theme that was created, another category of requirements was found to be non-functional requirements which are qualities, attributes or properties that the system must have to perform work appropriately. Interviewed respondents pointed out the following as properties that the system should have for it to perform its work as expected. They showed very well that the following should be considered important as attributes of the weather mobile application system: -

- The system should be simple and easy to use, get a snapshot of a week or quickly access extra detail when you need it.
- The system should help its users to personalize the forecasts and see how the weather could affect their day.
- Performance of a software has to be fast, including the response times (should not take long the app take to load and the screen refresh times), Processing times (should not take long to perform key functions) and Query and reporting times (accepting query times since API is provided should probably be considered.
- Availability of software should be available all the time and to everyone including hours of operation and location of operations.
- Recovery in case of a disaster system should not take long to get back up and running (restore time and backup time).

4.1.2.3 Hardware requirements

The following is a list of hardware requirements that are required for the mobile phone to support the system to function properly include: -

Table 2: Hardware Requirements

Hardware	Description
Memory (RAM)	Minimum 128MB, 512 MB recommended or higher.
Phone Storage	Minimum 2GB or higher
Screen Resolution	VGA 480 x 800 or higher resolution required
CPU	Dual Core 1.3 GHz and higher

Source: researcher (2016)

4.1.2.4 Software requirements

The following are the software requirements for the system:

Table 3: Software Requirements

Software	Description
Operating System	Version 4.0 Ice Cream Sandwich
Android Version	4.0 Ice Cream Sandwich or higher
Android Studio IDE	Version 2.1.2
Adobe Photoshop CC	Version 2015.1.2 Release
Adobe Illustrator CC	Version 2015.1.2 Release

Source: researcher (2016)

4.2 System Design

The design of this application is based on Android framework with the new design (Material Design) introduced in Android 5.0 - Lollipop. Material design is a design language developed by Google that is comprehensive guide for visual, motion and interaction design across platforms and devices. The application contains a number of activities. An activity in Android is said to be an application component that provides a screen with which users can interact in order to do something.

4.2.1 Logical Design

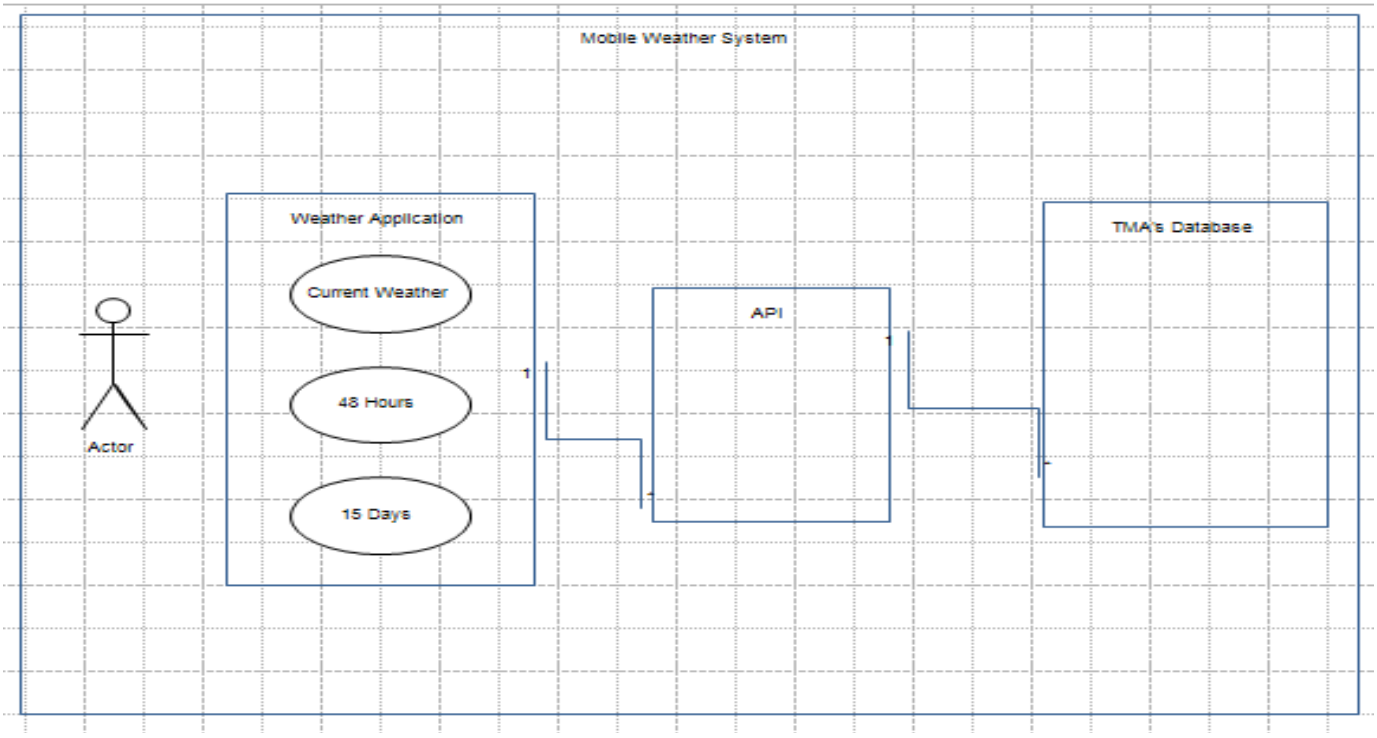


Fig.2: Shows use diagram for mobile weather system
Source: (Researcher, 2016)

Figure 4.2.1 shows an actor (beneficiary) of mobile weather application interact with the system by accessing the current weather, 48 hours' weather forecast and 15 days' weather forecast, which are represented by oval symbols that contain description of what the system users do with the system.

Application Programming Integration (API) which will act as a bridge between the two sub systems (the TMA website and the Mobile Application) to communicate to and fro. The API will help to create the relationship between the systems and passes data in JSON format.

TMA database contain all weather forecast information and this information is the one which will be presented on users(actor's) mobile phone weather application with the help of the API.

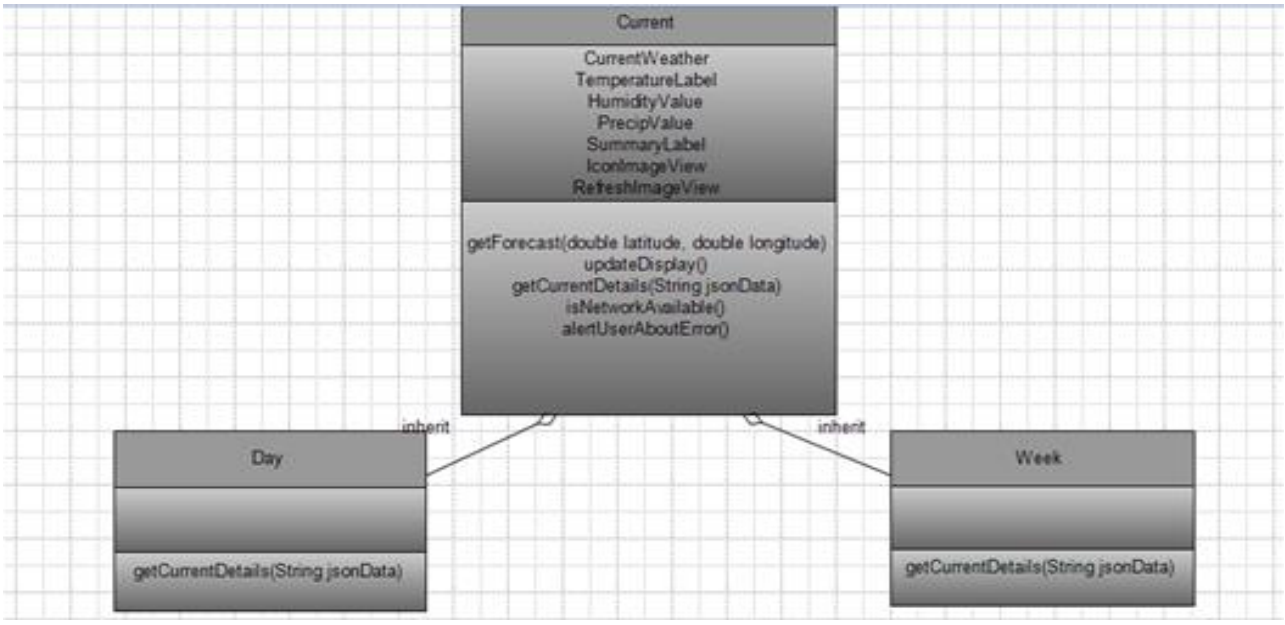


Fig 1: Shows class diagram for mobile weather system
Source: (Researcher, 2016)

Figure 4.2.2 shows the class diagram of how objects interact with one another on weather mobile application processes. The events that happen in the system as result of the interactions caused by objects in the system have been represented.

4.2.2 Main Activity

The main activity is an activity that is constantly updating the weather forecast from TMA's database. It tracks data from the database and uses the TMA's database to displays the data on the main activity (location, time, current temperature, hourly temperature, humidity, rain and temperature condition fields). In this activity users can share the forecasts with other users direct from application with just a single tap on share button.

Fig. 4: Main Activity

4.2.3 A 48 Hours Activity

The 48 hours' activity is an activity that is constantly updating the weather forecast from TMA's database. It tracks data from the database and uses the TMA's database to displays the data on the 48 hours' activity (location, temperature forecast for 48 hours' fields).

Fig. 5: 48 Hours Activity

4.2.4 Navigation Activity

User navigation (Figure 4.2.3) in the application is easily accessed from the menu icon from the main activity. The off canvas navigation is used, the activity slide to the right and push current activity to display the navigation activity. A number of activity links are accessed here namely; news for winter weather, significant weather, and support links.

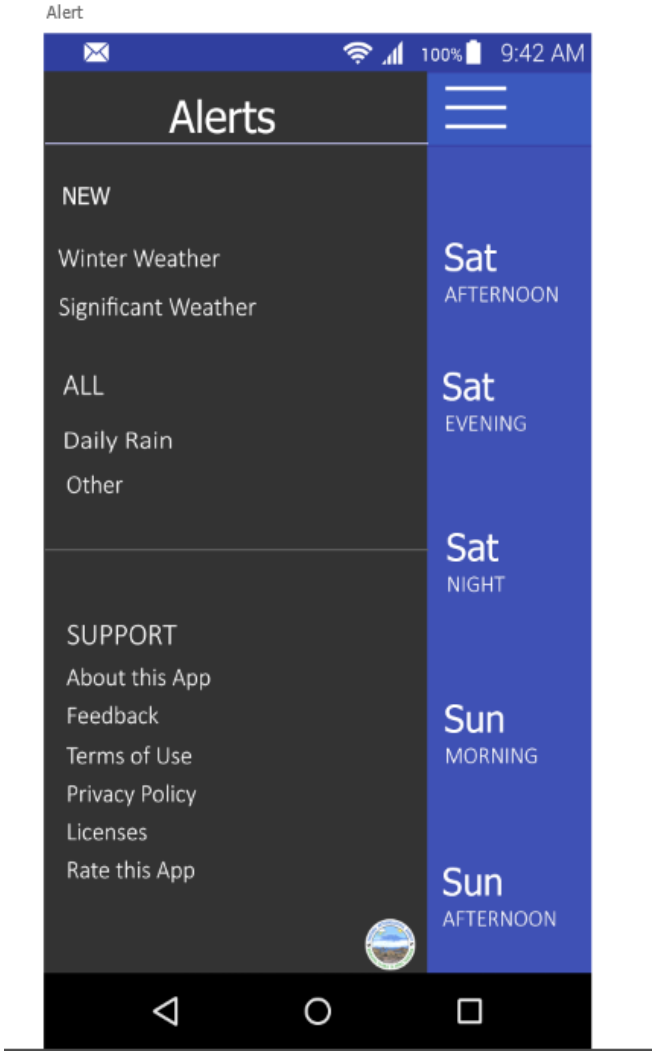


Fig. 6: Alerts Activity

4.3 System testing

System testing is the testing of the whole system based on its specification. It is a comprehensive testing and verification of the system against the requirement specification.

4.3.1 Unit Testing

Each unit or component of the system was independently tested to ascertain whether it worked properly. Defects were found, rectified and tested again. The class was the basic testing unit of software developed throughout the testing methodology. The following steps summarize the approach that was used during testing phase in this study.

The content model for the integrity to different system user's system was reviewed to uncover errors.

The system interface model was reviewed to ensure that all use-cases are accommodated.

The design model for weather application system and allocation system was reviewed to uncover errors in presentation and in navigation mechanics.

Selected functional components were unit tested one by one and met the user requirements.

Navigation throughout the entire system architecture was tested and it conformed to the requirements specified.

The system application was implemented on different virtual devices with the help of Genymotion which is a fast third-party emulator that was used instead of the default Android emulator to test the compatibility of different devices with different screen resolutions.

Security tests were also conducted in an attempt to exploit vulnerabilities in the system environment.

Performance tests were conducted, and controlled under the guidance of key informants; the results of interaction with the system were evaluated for the content and navigation errors, usability concerns, compatibility and performance.

Because many beneficiaries of the system evolve continuously, system testing is an ongoing activity conducted by system support staff that monitors system's performance basing on test results obtained by the designer.

4.3.2 Integration testing (Path testing)

The weather application system and TMA database were integrated together with Application Program Interface (API) which return data in *JavaScript Object Notation* (JSON) format and the developer chose few sample data in TMA database and the system worked as a whole and this was confirmed when the data was found to be accessed on the mobile phone. Sample of data retrieved can be seen under Main Activity in figure 4.2.1.1. At the end of this, a thorough testing of the entire system was considered a success and it qualified for the next level of testing (individual testing).

4.3.3 Individual Testing

Each part of the system was independently or individually tested to ascertain whether it worked properly logically and physical interfaces. Defects were found, rectified and tested again. The class was the basic testing unit of software developed throughout the testing methodology. The following steps summarize the approach that was used during testing phase in this study.

The content model for the integrity to different system user's system was reviewed to uncover errors

The system interface model was reviewed to ensure that each use-case is accommodated.

4.3.4 Validation testing

Under validation testing, the system was then tested on real physical devices in accessing the weather forecast information on multiple devices including the tablets and mobile phones by sample of users and it was showing the desired results hence makes the system being valid.

4.4 System implementation and Maintenance

The system was developed using Android Studio Integrated Development Environment (IDE). With Android studio, applications are usually developed in Java programming language using the Android software development kit (SDK). The application system is easy to install on all running android devices. The system must be maintained to ensure both the TMA database system containing weather forecast data is accessed only with authorized user so as to achieve the goals of Confidentiality, Integrity and Availability of the weather system to the user any time when needed and quick recovery of the system when faults

occur since it is integrated with the API which sends data to the Mobile phone.

Findings, Conclusions and Recommendations

5.1 Overview

This chapter presents the proposed prototype based on the findings and review of numerous weather forecasts mobile applications. The prototype aimed at expanding the publication of weather forecasts to the general public users. The expansion of weather forecasts broadcasting using mobile application will help information to be accessed anytime with no delay and reach many people on time and may help reduce impacts on daily social activities in Dar Es Salaam. In this chapter the findings as per research objective, conclusion to the research problem and recommendations and further work of the study.

5.2 Findings of the study

The study was set out to achieve three specific research objectives. The first was to identify how TMA, publish its weather forecast data. The second objective was to investigate factors that hinder publication of TMA weather forecast information and the third was to develop a Weather Mobile Application prototype that expands the publication of TMA weather forecast information.

To achieve the above research objectives, three questions were devised to guide data collection. The first question was; how does TMA publish weather forecast data? Secondly, what are the factors which hinder TMA in publishing weather forecast data? And finally, what at prototype (mobile application) can expand TMA's capabilities for publishing current weather forecast information?

The data for this study were collected through questionnaires for beneficiaries and Key Informants and in-depth interviews for key informants. Both data collection instruments had questions that were devised in way that enabled the researcher to collect data that could achieve the objective of the study. Data was also summarized in tables, pie charts and histograms for clear presentation and interpretation.

5.2.1 Demographic Information of Respondents

There were three categories of information which helped to describe demographic information of respondents involved in the study. The three categories included biographical information such as sex, age and education level distribution. The biographical data of respondents were very important for understanding the characteristics of respondents that is, beneficiaries and staffs in relation to this study. The demographic information of the respondent is summarized in the following table.

Table 4: Demographic Information of Respondents

Variables	Description	Frequency	Percent
Sex	Male	14	60.9
	Female	9	39.1
	Total	**23**	**100.0**
Age	18-27	16	69.6
	28-37	4	17.4
	38-47	1	4.3
	48-57	1	4.3
	58 >	1	4.3
	Total	**23**	**100.0**
Education	Primary Level	0	0.0
	Secondary Level	2	8.7
	College Level	5	21.7
	University Level	16	69.6
	Total	**23**	**100.0**

Source: Field data, 2016

Sex of respondents was considered in order to ensure that both men and women take part in the present study. Data as illustrated in Table 5.1 shows that 60.9% of respondents were male and 39.1% female. Majority of male in Wazo Ward are the ones engaging on technology activities.

On the relationship between age of respondents and the awareness on using smartphones technology applications, it was found that 69.6% of the respondents aged range from 18 – 27 years old and 17.4% of respondents aged from 28 - 37. Also there was lower percentage of respondents, 4.3% who were ranging from age 37 and above. This is because in 21st Century, many schools have introduced computer training as a compulsory subject; therefore, a big number of youth are computer literacy hence are aware of smartphones technology. Moreover, the people who are between 28 and 37 years old are in transition, experimenting and looking for new things, hence interested in using smartphone for communications and using it to access different information. According to Tanzania census of 2012, indicate that majority of population were youth between 15 – 35 years old that accounted 34.7% of total population (Tanzania Bureau of Statistics, 2012).

Table 5.1 also presents data on respondent's education level that are using smartphones in daily activities. Findings indicated that, 69.6% and 21.7% respondents have attained higher education levels from university and college education. None of respondents who with primary level education participated in the study. This is influenced by the fact that, respondents with higher education level can easily learn new technologies and own tools like computer and smart phones for accessing different information. This implies that education level has an influence the understanding and usage of smartphones application as it was also observed by Bird (2007).

5.2.2 How does TMA publish weather forecast information?

One of the focuses of this study was to investigate how TMA publish its weather forecast information, so as to find how information is reached to the beneficiaries. First of all, respondents were asked if they are aware of Tanzania Meteorological Agency, and the findings showed almost all respondents were aware of TMA as indicated on figure 5.2.2.

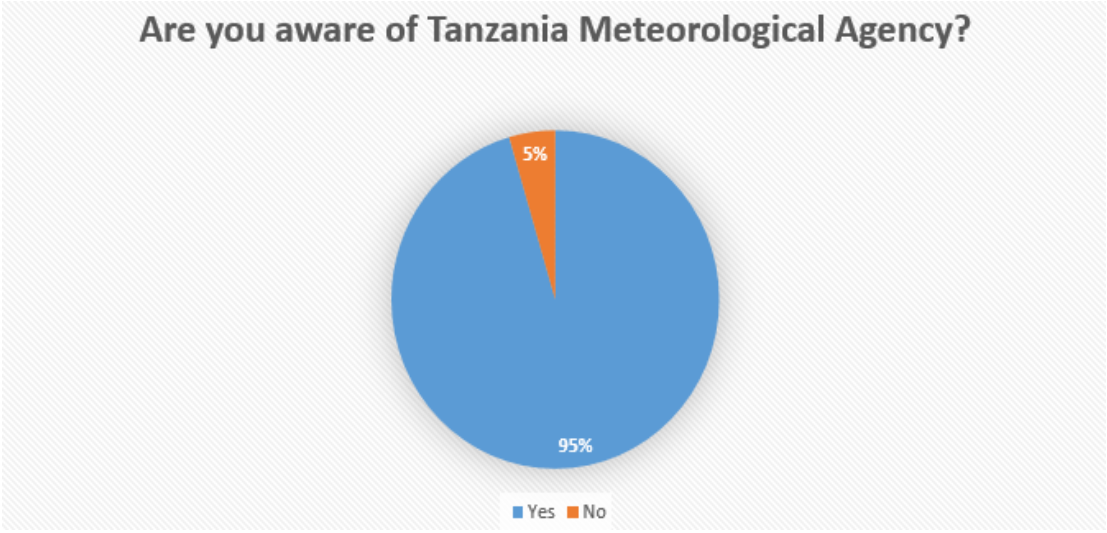
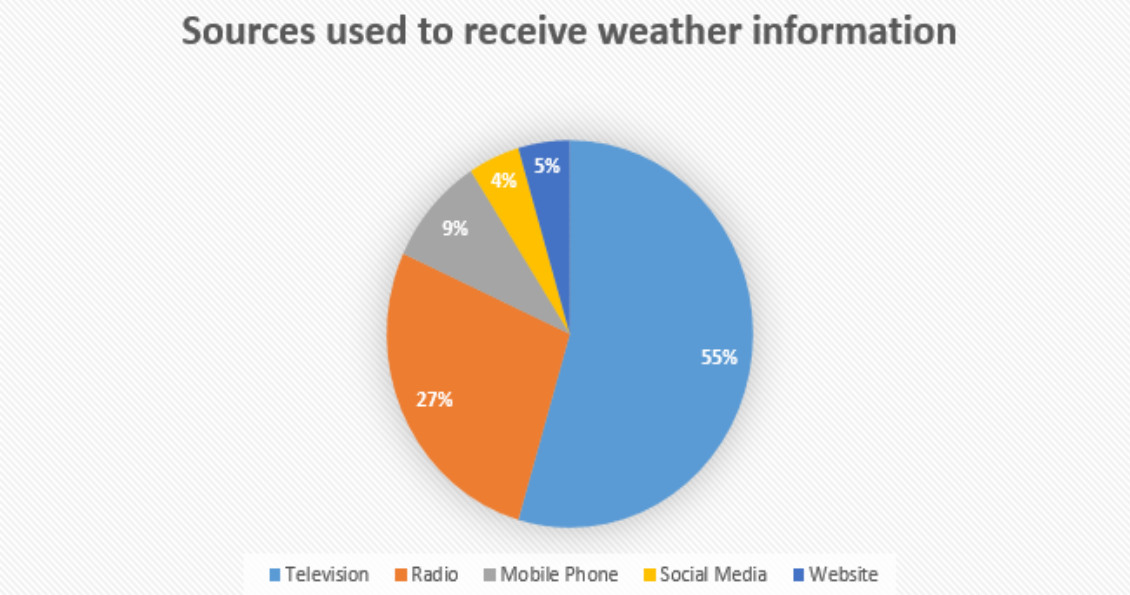


Fig. 7: Awareness of Tanzania Meteorological Agency
Source: Field data, 2016

TMA publish its weather forecast information using Television, Radio, Blogs, Newspapers, journals, mobile phones and social networks such as Facebook, Twitter and YouTube to reach the society, but findings shows that in Wazo ward, 55% of beneficiaries uses Television to get weather information from TMA as illustrated on the figure 5.2.3, 27% uses radio, 9% uses mobile phones, 4% uses social media and 5% of the beneficiaries uses website,



Figu.8: Sources used to receive weather information from TMA
Source: Field data, 2016

5.2.3 What are the factors which hinder TMA in publishing weather forecast data?

Another focus of this study was to investigate what factors hinder TMA in publishing its weather forecast information. TMA is the only Meteorological Agency in Tanzania that is responsible to broadcast weather information and have different functions such as to provide weather, climate services and warnings (e.g. floods or droughts) for the safety of life and property to the general public, to provide weather and climate services to various users including agriculture and food security, to provide weather and climate services to various users including surface transport.

According to other literature shows that, there is a growing interest in the use of mobile phones in communicating weather information (Caine ADorward, 2016). Yet, in this study, the findings were contrary to the (Precision weather forecasting, 2016) that 65% of beneficiaries as presented in the figure 5.2.3 preferred to receive weather information through their mobile phones, while the 22% of respondents preferred Television as well. This section shows factors that hinder publication of weather information from TMA to the public. TMA challenges include, information does not reach most of beneficiaries instantly because some of beneficiaries do not have television, expensive to send messages to all beneficiaries through mobile phones, and hence only few groups have been selected (Farmers and Lake Zone citizens) to receive weather information through their mobile phones.

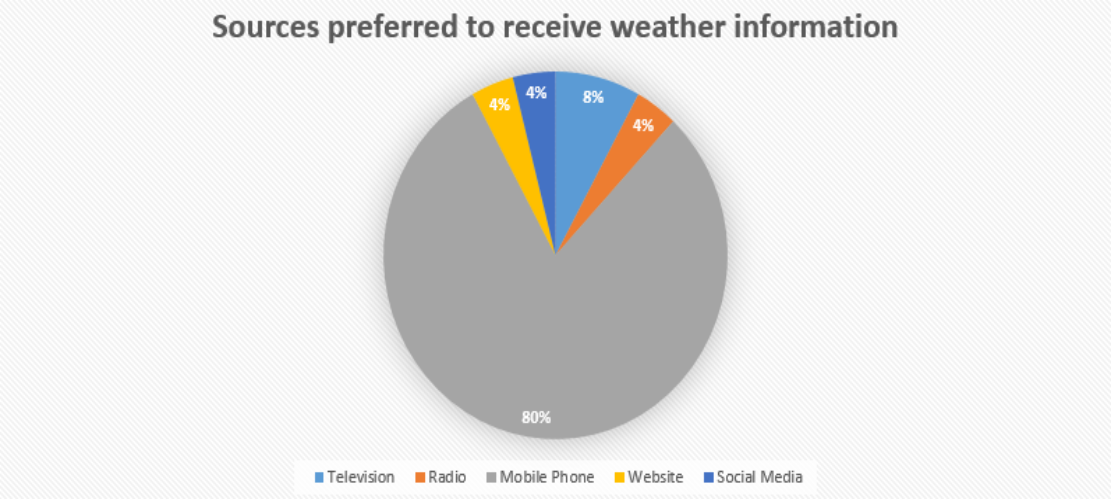


Fig. 9: Sources preferred to receive weather information from TMA
Source: Field data, 2016

These factors are main hindrances to the respondents on how they receive weather information. Where in the findings, some beneficiaries complained information broadcasted has been given short time such that if your late few minutes to watch the news you are being passed by that weather information or if it happens there is no electricity that day means you won't be able to get weather updates like wise to those who use radio to get weather updates, that if frequency is not stable they tend not to get any weather update. 52.2% of beneficiaries do not get instant weather updates on time.

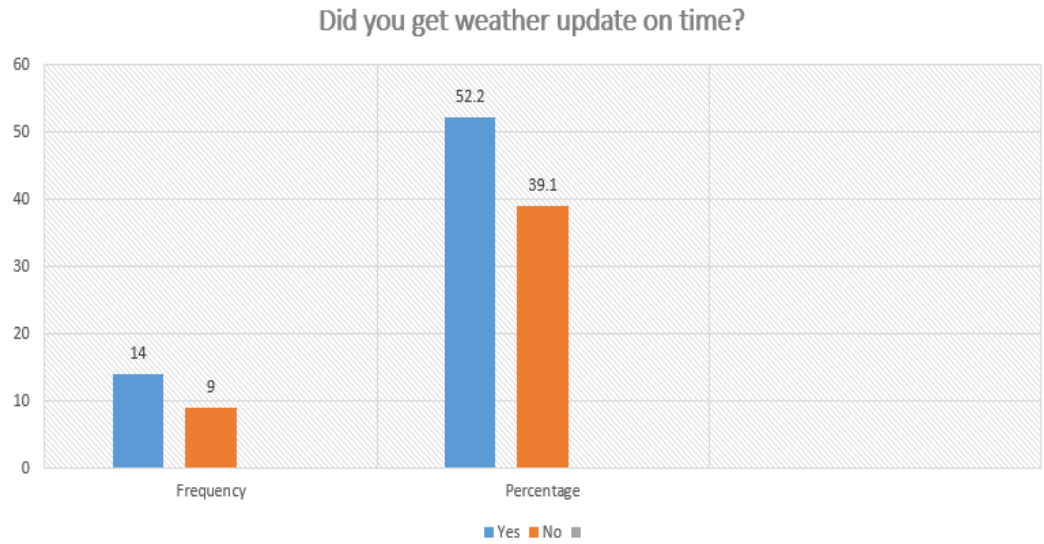


Fig.10: Did you get weather advisory, warning and information on Time
Source: Field data, 2016

5.2.4 What at prototype (mobile application) can expand TMA's capabilities for publishing current weather forecast information?

The last objective of this study depended on the respondents' feedback. According to these findings it is vivid that, there is a need to develop a system that will integrate with TMA system so as to expand the publication of weather information. Therefore, in this section the researcher designed weather application that was based on mobile application. This application was designed to be built targeting Android platform, however later on can be built for other device platforms. The designed application included features like sharing (posting) weather information. In addition to that, a 48 hours and 15 days' button will allow users to access weather forecast information respectively. Accessing the weather application was designed to be more users friendly. This application was designed in Adobe Photoshop CC 2015 and will be developed in an official Android Integrated Development Environment, the Android Studio.

5.3 Conclusion

This study found that, only 55% of beneficiaries use television to get weather information and complained this source has its challenges and therefore 80% of beneficiaries preferred to receive weather updates through their mobile phones which they can use it to access weather information through their mobile phones at any time. As a consequence, it was decided to design, implement and test a Weather Mobile Application to expand the publication of weather forecast information and reach most of the beneficiaries with no delay. The current major constraint of TMA is that, warnings and advisory information does not reach most of its beneficiaries on time. Though some weather information is sent via mobile phone to some specific groups which is

the fastest means to reach the beneficiaries, it is very expensive to use this method.

The designed prototype presents important functions to the beneficiaries, as they can access current weather information, a 48 hours' weather forecast and 15 days' weather forecast. Also, beneficiaries will receive any instant updates provided by TMA and can easily share this information with people they wish to share information with. This helps to reduce hazards to society for they will receive instant notification and help them make quick decisions that will keep them to safety with their properties, as well as wrong publication of weather information will be reduced in social media for beneficiaries will tend to check on their mobile phone weather application to see if that information published is true or false.

5.4 Recommendation and Further work

5.4.1 Recommendation

Tanzania Meteorological Agency and the Ministry of Science and Technology should work together to provide and improve the use of Information Technology. This will help improve better services to the beneficiaries.

The beneficiaries should be given the knowledge on the importance of weather forecasting and be encouraged to respect whatever notification and warnings given from TMA so as to save lives and properties.

Furthermore, beneficiaries should make sure that they bring trust and loyalty for their agency so as to help avoid avoidable endangerments on daily social economic activities.

5.4.2 Area for Further Research

Further studies should be conducted on weather mobile applications to improve on the efficiency in accessing and receiving of weather instant updates from the agency.

This study expands the capabilities of publication of weather forecast information in Wazo Ward. More comprehensive studies are still needed to gain more insight of challenges facing TMA and the beneficiaries from the agency in other Wards in Dar Es Salaam and Tanzania at large.

This study further suggests that more research should be done on the features the system should have to perform its intended tasks.

More research must be conducted by adding this system into other mobile operating systems that will make this system available to other user devices who are using other platforms other than Android operating system.

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