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THE DEVELOPMENT OF AN AGRO-METEOROLOGICAL MONITORING APPLICATION USING GEO-SPATIAL TECHNIQUES FOR PRECISION FARMING (CASE OF STUDY OF MAPS, TEMPERATURE AND HUMIDITY)

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ABSTRACT

This thesis is based on Android software development process using Android studio (the Android application developed during the project) and the case study were maps, temperature and humidity. It focuses on the use of geospatial technologies in precision farming. To achieve this, the thesis focus on how geospatial data is collected, analyzed and used in the decision making process to maximize crop yields by the android software developed. In other to fetch geospatial data, an agro-meteorological monitoring application using geo-spatial techniques for precision farming was developed. This application was developed to get current weather information basically (temperature and relative humidity) based on the user's current location and for optimization.The application was tested in Federal Polytechnic Ado-Ekiti, Ekiti State, thereby giving the average weather condition of the State. Statistical tools such as ANOVA and graphs were used to analyse the data and they shows that the results were at variance and this may be due to the location of the Automatic weather station because some were sited around river, hill, snow, farm land e.t.c. The application developed serves as a decision support tool to the farmer or the user of the application to have the knowledge and idea in order to make wise decision on which crop to plant on the farm from the data obtained from the app developed for temperature and humidity. The growing of plant in a good weather environment is very important to crop for good harvest, because some crops need to be protected against unfavorable weather condition from time of sowing to harvest time.

KEYWORDS: Agro-meteorological, Geo-spatial, Map, Temperature, Relative Humidity.

1. INTRODUCTION

1.1 Background of the Study

The advancement in technology has increased the capacity of mobile devices and has also increased drastically(Android Open Source Project 2015c; Sheusi 2013.). Smartphone's unlike classic mobile phones can now perform computer-like function; thus, they are computers with similar features. Mobile phone is now more powerful than it has ever been, a Smartphone is now been used for various purposes other than just making calls and sending SMS. These devices can now be utilized for various tasks that will normally require different gadgets like digital camera and music player. The Android Play Store is a large market for mobile software developers where developed mobile applications were deployed. Android devices accounting for more than 80% of activated mobile devices with this number of activated Android device users; the play store seems like a gold mine to software developers. The fast increasing number of Android mobile phone users has attracted many software developers(Android Open Source Project 2015c; Sheusi 2013.). The rate at which the number of mobile applications in Android play store grows is large; there is more than one application for the same purpose. This situation has challenged the developers to become more innovative in their development.

The development of sensor technologies has make it possible to implement precision agriculture combined with procedures to link mapped variables to appropriate farming management actions such as cultivation, seeding, fertilization, herbicide application, and harvesting. Another important element is the use of Variable Rate Technology (VRT) that allows precise seeding, optimization on planting density and improved application rate

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efficiency of herbicides, pesticides and nutrients, resulting in cost reduction and reducing environmental impact. Many sensors are currently available and used for data gathering or information provision as part of the precision agriculture calculated. These devices are designed for both and on-the-go recording. Devices exist to assess the status of soils, such as apparent electrical conductivity sensors, gamma-radiometric soil sensors, and soil moisture devices, among others. Others record weather information or micro-climate data (thermometer, hygrometer, etc.), particular importance is given to sensors developed to quantify the physiological status of crops (*e.g.* Nitrogen sensors). These sensors are based on remote sensing principles, gathering point- or spatial-based data where the spatial resolution, that is the size of the pixels digitally imaged, can vary from less than 2cm to over 10 metres. Sensing across various wavelengths (visible, near infrared, thermal) using multispectral and hyper spectral cameras on board airborne and satellite platforms, often has the goal to derive vegetation indices which explain the crop canopy condition (e.g. chlorophyll content, stress level) and its variability in space and time.

Special interest is devoted lately to the use of low-cost light-weight Unmanned Aerial Vehicles(UAV) often called drones, but now more correctly termed Remotely Piloted Aerial Systems (RPAS), initially developed for military purposes which are now being applied uncivil applications. RPAS are already available and operational, enabling the generation of very-high resolution (2 to 10 cm) farm-level imagery. Availability from satellite platforms is generally at lower resolution (0.5 to 10 m) and is generally more costly, whilst the new EUCOPERNICUS programme should provide easier and cost-free access to satellite data but only at 10m or lower resolution. There is a need of knowledge and skill on how to transform, through Geographic Information Systems (GIS), data collected by different sensors and geo-referenced into maps to provide information on crop physiological status and soil condition status. Additional skills and knowledge are required about how to use the large, assorted data sets and information gathered to assess the effects of weather, soil properties on production, and to develop administration plans to increase efficiency and adjust inputs in following years. In particular, models are needed in order to understand the causalities and interrelations between plant, soil and climate before inputs can be spatially adjusted. These Farm organization Systems are made accessible to farmers through consulting, advisory and training services and/or directly through dedicated software products. This journal report the phases of the development, requirement gathering and analysis, design, implementation or coding, testing, deployment and maintenance and also its usefulness to the farmers. Requirement gathering and analysis is the first stage in the development of an application. It involves collecting and analysing the functions and services a proposed system should perform. The design and implementation stage is the point where functional software was developed. The software developed is tested with respect to the requirements collected during requirement gathering and analysis. The verified software is published to users at the deployment phase. The last phase in the life cycle of software is the maintenance process. Software maintenance involves providing a cost effective support to an application and retiring the application if necessary. Application development is a never-ending story; the story ends when the application is retired.

The developed android application is a decision support tool (will give a solution to this problem), it will provide correct details for the temperature and relative humidity.The aim of this project is to collect geospatial data via reputable weather recourse api's (open weather maps) with the purpose of visualizing its real-time on android Smartphone using the device's inbuilt GPs to track current location.The objectives of this research are to: Develop an android application that will get current weather information basically (Maps, temperature and relative humidity) based on the user's current location; test the implemented package on available mobile devices; and analyze how mobile application can be used to enhance precision farming, assist farmers and subsequently increase crop yield.

2. RELEVANCE OF MOBILE APP TO AGRICULTURE

Among the technologies invented in the past few decades, Smartphone's have gained large market shares among various user sectors due to their usefulness, ease-of-use, and affordability. The number of new smart phone users continues to grow. It is estimated that, by 2016, the number of users will be more than 2 billion people worldwide (Wikipedia.org, 2018).Meanwhile, farmers in large-scale farms, who already adopt assistance from other information technologies, can now utilize smart phone-based sensors to increase productivity and facilitate various tasks throughout the farming cycle. Ensuring food security has been a global concern throughout human history, and the global food crisis of 2007-2008hasemphasizedtheimportanceofincreasingboth quantity and quality of food production. Agriculture, which is the upstream food producing sector, is, therefore, in need of new and modern methods to ensure the world's food security. Traditional agriculture was usually done within a family or a village and accumulative farming expertise and knowledge were passed down to their future generations.

2.1 Precision Agriculture

Precision agriculture relies upon specialized equipment, software and IT services. The approach includes accessing real-time data about the conditions of the crops, soil and ambient air, along with other relevant information such as hyper-local weather predictions, labour costs and equipment availability. Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from those images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions, such as precisely what fields to water and when or where to plant a particular crop. (www.futurefarming.com)

Precision agriculture, or precision farming, is therefore a farming concept that utilizes geographical information to determine field unpredictability to ensure optimal use of inputs and maximize the output from a farm (Esri, 2008). Precision agriculture gained reputation after the understanding that diverse fields of land hold different properties. Large tracts of land usually have spatial variations of soils types, moisture content, and nutrient accessibility and so on. Therefore, with the use of remote sensing, geographical information systems (GIS) and global positioning systems (GPS), farmers can more precisely determine what inputs to put exactly where and with what quantities? This information helps farmers to efficiently use expensive resources such as fertilizers, pesticides and herbicides, and more economically use water resources. In the end, farmers who use this technique not only take full advantage of their yields but also reduce their operating expenses, thus increasing their profits. (Esri, 2008).Today, however, mobile apps, smart sensors, drones and cloud computing makes precision agriculture possible for farming cooperatives and even small family farms.

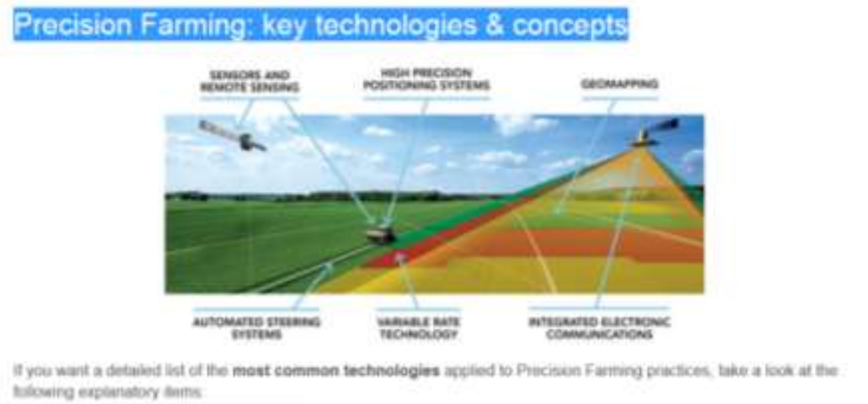

Figure 2.1: Precision Farming: key technologies and concepts
Source: (www.futurefarming.com)

Below are detailed list of the **most common technologies** applied to Precision Farming practices,

i. **High precision positioning systems (like GPS)** are the key technology to achieve accuracy when driving in the field, providing navigation and positioning capability anywhere on earth, anytime under any all conditions. The systems record the position of the field using geographic coordinates (latitude and longitude) and locate and navigate agricultural vehicles within a field with 2cm accuracy.

ii. **Automated steering systems:** enable to take over specific driving tasks like auto-steering, overhead turning, following field edges and overlapping of rows. These technologies reduce human error and are the key to effective site management:

   (a) Assisted steering systems: show drivers the way to follow in the field with the help of satellite navigation systems such as GPS. This allows more accurate driving but the farmer still needs to steer the wheel.

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- **(b)** Automated steering systems: take full control of the steering wheel allowing the driver to take the hands off the wheel during trips down the row and the ability to keep an eye on the planter, sprayer or other equipment.
- **(c)** Intelligent guidance systems: provide different steering patterns (guidance patterns) depending on the shape of the field and can be used in combination with above systems.

2.2 Weather Api's

Weather has become a pretty hot topic, especially in technology circles. Weather has not only become a standard app found on nearly every Smartphone and mobile device, but it's being used by many technology companies in new and innovative ways. One of the more recent and popular technological uses of weather is to create weather-information. Bloom Sky is a five-in-one weather station and HD camera that captures real-time weather data along with sky images at your location (www.programableweb.com, 2018). The goal of Bloom Sky is to build a crowd sourced meteorological network. Another recent and increasingly popular trend is the crowd sourcing of weather-related applications and devices. Examples include: Bloom Sky, Climate, Accu-weather, Open weather map, Weather bug, Yahoo Weather

2.3 Automatic Weather Station (AWS)

An automatic weather station (AWS) is an automated version of the traditional weather station, either to save human labour or to enable dimensions from remote areas. An AWS will typically consist of a weather-proof enclosure contain the data, rechargeable battery, telemetry and the meteorological sensors with an attached solar panel or wind turbine and mounted upon a mast.

The specific configuration may vary due to the purpose of the system. The system may report in near real time via the Argos System and the global telecommunications system, or save the data for later recovery. In the past, automatic weather stations were often placed where electricity and communication lines were available (www.Wikipedia.org, 2018). Nowadays, the solar panel, wind turbine and mobile phone technology have made it possible to have wireless stations that are not connected to the electrical grid or hard-line telecommunications network.

3. METHODOLOGY

This work started on the premise of the previous work done in 2016 by Akerele *et al.,* (2016). These authors have successfully developed Gumbel Mathematical model for predicting meteorological data in agriculture..

3.1 Material Selections For Development Of An Application

The material selections for the development of an android application and their functions are stated below as shown in Table 3.1.

Table 3.1: Material Selected For Android App Development

S/No.	Materials	Function
1	JDK(JAVA DEVELOPMENT KIT)	It contains JRE and tools such as compilers and debuggers for developing Java applications.
2	JRE(JAVA RUNTIME ENVIRONMENT)	JRE (Java Runtime Environment) contains JVM(java virtual machine), supporting libraries, and other components to run a Java program. However, it does not contain a compiler or a debugger.
3	ECLIPSE IDE	IDE stands for Integrated Development Environment.IDE is an example of a coding (programming) environment, one of its examples is eclipse.
4	SOFTWARE DEVELOPMENT KIT(SDK)	The Android software development kit (SDK) includes a comprehensive set of development tools.These include a debugger, libraries,documentation, sample code, and tutorials.
5	ANDROID STUDIO	Android Studio is Google's officially supported IDE for developing Android apps. It is support for building

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		Android TV apps and Android Wear apps.Android applications are packaged in apk format. Gradle-based build support C++ and NDK support.
6	COMPUTER SYSTEM (64bit)	This is where the android studio and other component are installed and the development of android application is carried out on the computer system.
7	ANDROID MOBILE PHONE	This is where the application is debug to when it has completed it development stage for testing.

3.2 Running Android Studio

Android Studio presents a splash screen when it starts running on the first run, it will be asked to respond to several configuration-oriented dialog boxes. The first dialog box focuses on importing settings from any previously installed version of Android Studio. The setup wizard invites to select an installation type for your SDK components. It is recommended keeping the default standard setting. The wizard will download and unzip various components. Click show details if you want to see more information about the archives being downloaded and their contents. Finally, you should see the welcome to Android Studio dialog box as shown below in Plate 3.1.

Plate 3.1: Android Studio

3.3 Application Development Procedure using android studio

In order to complete the development action for the app, the followings were considered:

i. API key was gotten from the open weather map which is an online service that provides weather data information, including current weather data. After this API key was gotten, it was parse into the java programming used.

ii. In order for the android device debugging, this was done; enabling USB debugging in the developer options was done by enabling the developer options. Where the settings app was opened (Only on Android 7.0 or higher), select system scroll to the bottom and select about phone scroll to the bottom. Open Developer options, and then scroll down to find and enable USB debugging. The flowchart of the program is in Appendix 1.

Note: A developer mode in Android phones that allows newly programmed apps to be copied via USB to the device for testing on a GPS enabled phone/with internet permission.

The following activities were developed in the android studio which each has enabling functions;

i **Get location:** this shows the latitude and longitude of exactly where the user is as shown in Appendix 2 and with the help of the enabled GPS on the device alongside with the java programming language.

ii **Weather information**: this also shows the weather information of the location of where the user is as shown in Appendix 3, which works together with latitude and longitude, and also with the help of the

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registered agriculture API gotten from the open weather map. The java language programmed weather information is (TEMPERATURE AND HUMIDITY).

iii **Map**: this shows the exact map of the location of the user as shown in Appendices 4 and 5. On android studio, the Google map activity was chosen, this activity enables to be able to view real time map on our device alongside the user location. The map activity code was written as well.

The above was done in the android studio in which each of the above button code was written and in java programming language. The button was created by Navigating to the Design tab, button was found (under the heading Widgets), and it was clicked and created.

NOTE: A button consists of text or an icon (or both text and an icon) that communicates what action occurs when the user touches it.

4 RESULTS AND DISCUSSIONS

4.1 Results

The results of the data obtained from app developed and other weather Apis (Accu weather, Yandex Weather, and Nimet) shows the data obtained from different automatic weather stations (AWS). The data obtained from the App developed was used to plot a graph in comparison with data from other automatic weather station like Accu weather, Yandex, and Nimet. The graphs of the temperatures are shown in Figure 4.1, 4.2 and 4.3 below.

4.1.1 Average weekly temperature of ado-ekiti for august, september, October

For the month of August, Figure 4.1 below shows that in week 1, Yandex recorded the highest temperature of 24.1 ^{0}C, while the App developed recorded a temperature of 24.1 ^{0}C and Accu weather recorded a temperature of 23.4 ^{0}C. In week 2, Accu weather temperature is 23.7 ^{0}C, Yandex 23 ^{0}C and app developed 22.9^{0}C. But in week 3 the following temperature were recorded; Accu weather 25.1 ^{0}C, Yandex 23.04^{0}C and app developed 22.6 ^{0}C. However in week 4, Accu weather recorded a temperature of 24.6 ^{0}C, app developed 23.8 ^{0}C and Yandex 23.1 ^{0}C.

For the month of September as shown in Figure 4.2, in week 1, Accu weather recorded a temperature of 24.2 ^{0}C, Yandex 23.1 ^{0}C and app developed 23.0 ^{0}C. In week 2, Accu weather recorded 23.2 ^{0}C, Yandex 23.1 ^{0}C and app developed 23.0 ^{0}C. However, in week 3, app developed recorded 24.0 ^{0}C, Accu weather 23.6 ^{0}C and Yandex 23.0 ^{0}C. But in week 4, Accu weather recorded23.8 ^{0}C, Yandex 23.0 ^{0}C and app developed 22.1 ^{0}C.
For the month of October as shown in Figure 4.3, the temperature recorded in week 1 by Nimet is 28.0 ^{0}C, Yandex 27.0 ^{0}C, app developed 24.0 ^{0}C and Accu weather 22.0 ^{0}C. In week 2 temperature from Nimet is 28.0 ^{0}C, Yandex 26.0 ^{0}C, Accu weather 24.0 ^{0}C and app developed 23.0 ^{0}C. In week 3 Nimet recorded 24.0^{0}C, Yandex 23.0 ^{0}C, Accu weather 23.0 ^{0}C and app developed is 23.0 ^{0}C. However in week 4,Nimet recorded 34.0 ^{0}C, Yandex 33.0 ^{0}C, Accu weather 32.0 ^{0}C and app developed 31.0 ^{0}C.

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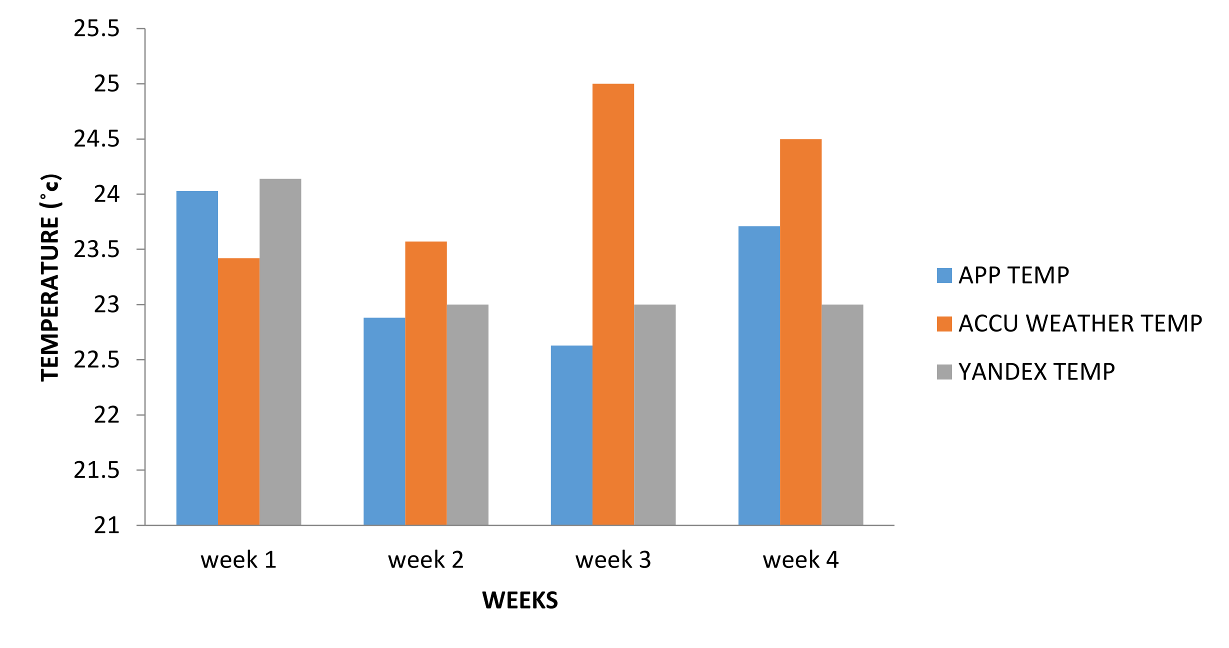

Figure 4.1: Average Temperature (˚c)of Ado-Ekiti for the Month of August

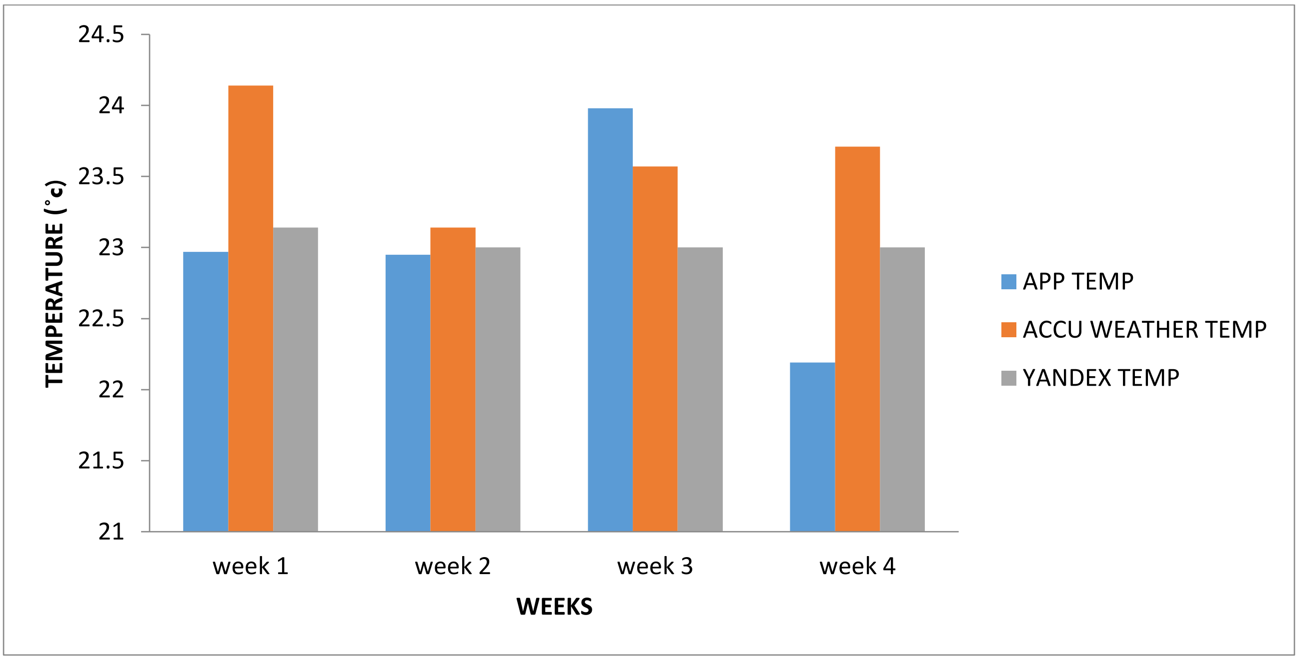

Figure 4.2: Average Temperature (˚c)of Ado-Ekiti for the Month of September

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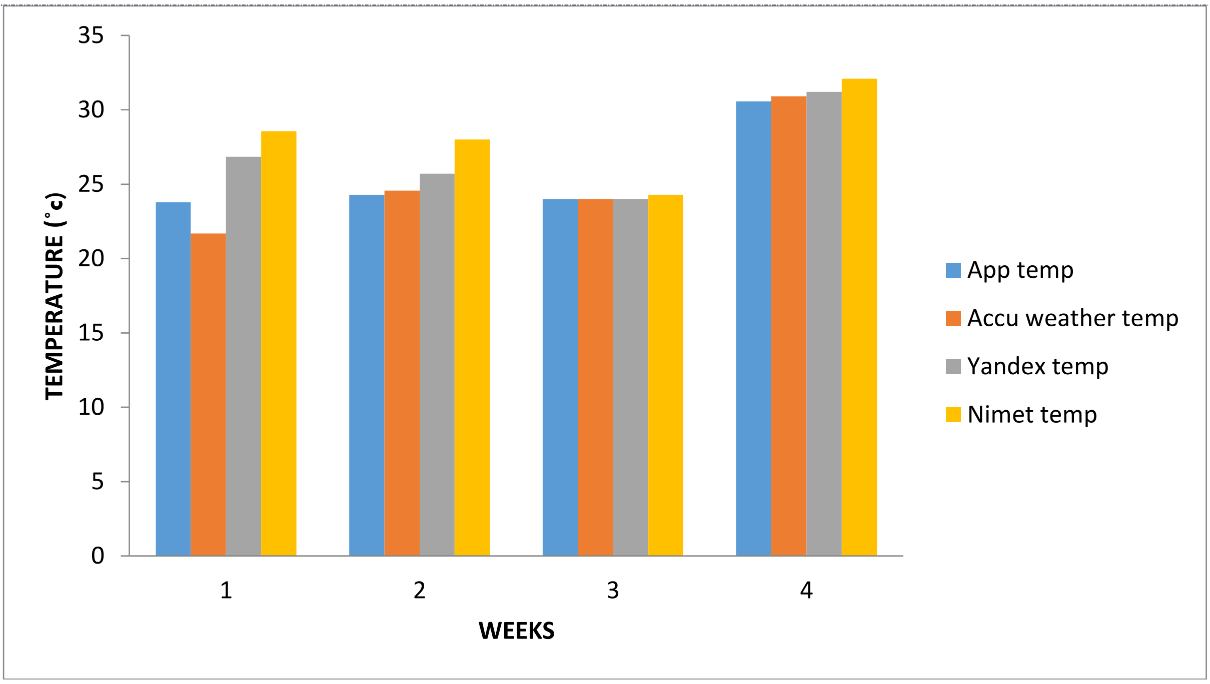

Figure 4.3: Average Temperature (˚c)of Ado-Ekiti for the Month of October

4.1.2 Average weekly humidity of ado-ekiti for august, september, October

The graphs of the humidity are shown in Figure 4.4, 4.5 and 4.6 below. For the month of August, Figure 4.4 below shows that in week 1, My weather recorded higher humidity than the App. In week 2, 3 and 4, App recorded higher humidity than in My weather.

For the month of September, Figure 4.5 below shows that in week 1, 2, 3 and 4, App humidity is higher in all the four weeks.

For the month of October, Figure 4.6 below shows that in week 1 and 2, App recorded highest humidity, followed by My weather and lastly Nimet. In week 3, Nimet has the highest humidity, followed by my weather and lastly Nimet. But in week 4, the humidity recorded by the App is the highest, followed by My weather and lastly Nimet.

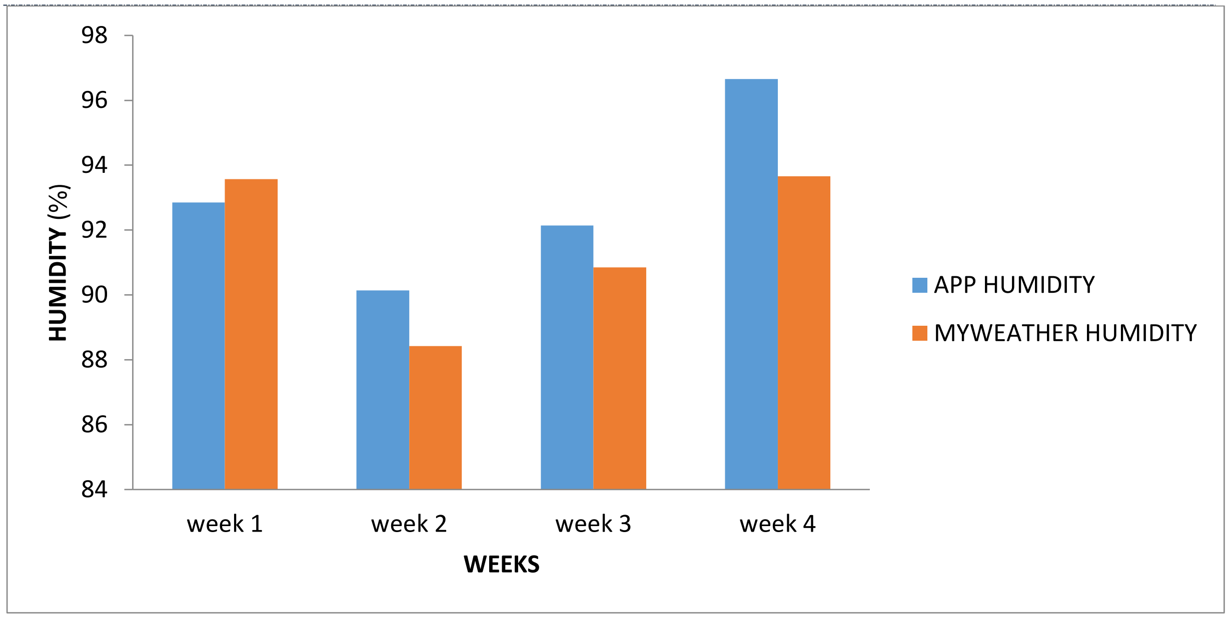

Figure 4.4: Average Humidity (%)of Ado-Ekiti for the Month of August

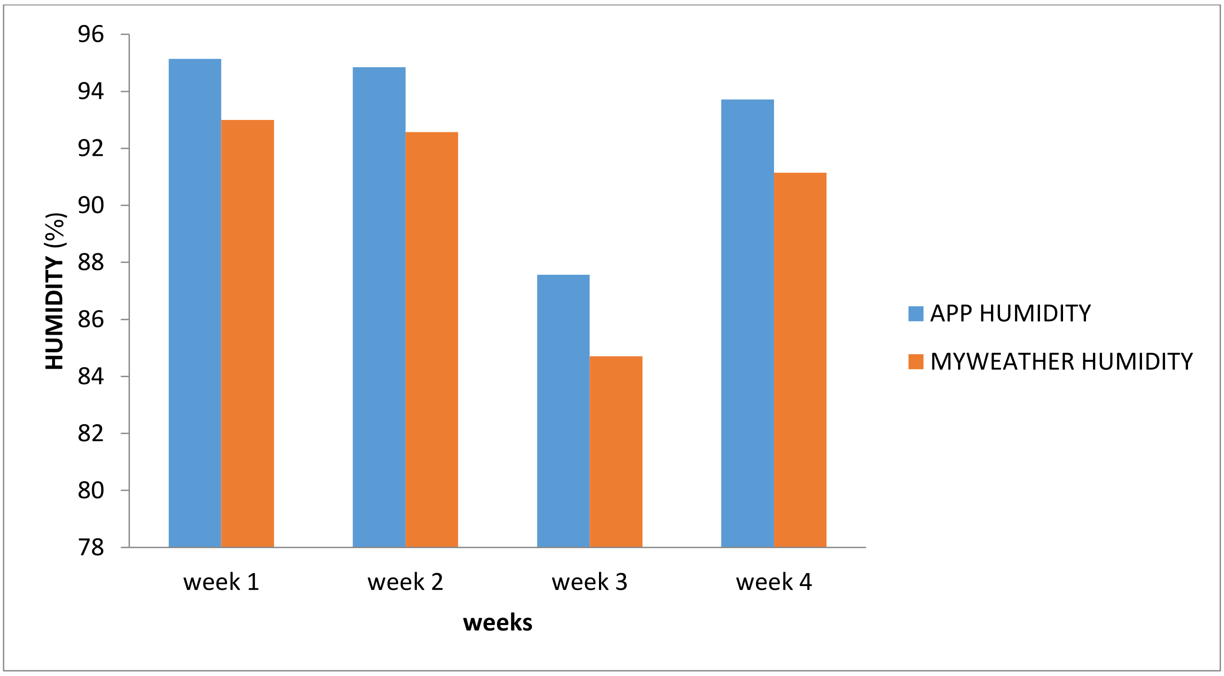

Figure 4.5: Average Humidity (%)of Ado-Ekiti for the Month of September

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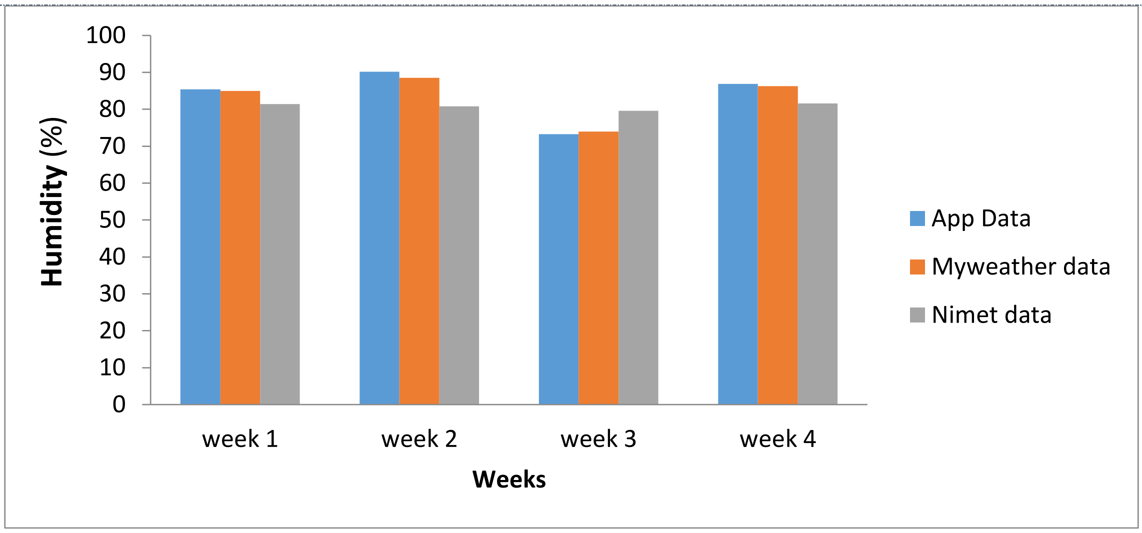

Figure 4.6: Average Humidity (%)of Ado-Ekiti for the Month of October

4.1.3 Anova for temperature

Table 4.1 and 4.2 is the ANOVA single factor for the temperature value which shows there is no much significant difference in all the values obtained, while Table4.3 and 4.4 is the ANOVA single factor for humidity which show no much significance difference.

Note: if F value is smaller than the F critical, we accept the hypothesis. This is the case; F(2.350435) is smaller than F critical (4.006873). Therefore the two data's are close to each other.

Table 4.1: ANOVA: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
APP	31	791.15	25.52097	12.66094
NIMET	31	966.4	31.17419	2.195312

Table 4.2: ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	495.3639	1	495.3639	66.68762	2.55E-11	4.001191
Within Groups	445.6874	60	7.428124			
Total	941.0513	61				

Anova for Humidity

Table 4.3: ANOVA Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
APP	30	2541	84.7	195.8724
NIMET	30	2419	80.63333	14.92989

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Table 4.4: ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	248.0667	1	248.0667	2.353548	0.130435	4.006873
Within Groups	6113.267	58	105.4011			
Total	6361.333	59				

4.2 Discussions

This is comparison of data obtained (temperature and humidity), Figure 4.1 shows the August average weekly temperature of Ado Ekiti, comparing data obtained from app developed with accu weather and yandex data for the month of august, as it is shown on the graph, the value of temperature against weeks. At week 3 there is a bit significant difference in the temperature data of app (22.6 ^{0}C) compare to accu weather (25.0 ^{0}C). Though the value of the app developed is still within the range to plant any crops, but the cause of these differences is due to the fact that the location of each automatic weather station is different from each other. Some automatic weather stations were located at the river bank, some on the mountain while some may be on the dry land.

Another cause of these differences can also be from the sensors, that is the sensors may have been faulty and it kept on repeating data, and this may also cause data variation when comparing with other data from another automatic weather station.

Figure 4.2 shows September average week temperature of Ado -Ekiti, in week 1 and 2 there is also a bit significant difference between the data's on the graph. Figure 4.3 shows the October average weekly temperature of Ado- Ekiti, from the graph there is no difference in the data when compared except for week 1. Though the app developed temperature value in week 1 for the month of October is still within the range of planting of crops and rearing of animals. The app developed temperature value compare to Nimet value which is the standard are very close.

Figure 4.3 shows the comparison between app data and other data obtained, also when compare with other three weather data (accu weather, Yandex and Nimet) having indicated that the temperature value were very close.
For humidity, when compare the value of app humidity with others (myweather data and Nimet data) from Figure 4.4, Figure 4.5, and Figure 4.6, it shows that the values are relatively close. From all the data obtained the app developed is suitable to be used by farmers as a decision support tool by knowing the proper farming conditions/parameters. Farmers' being aware of real-time weather conditions like humidity and temperature is the best way to protect farms to produce a high and healthy yield. Extreme weather such as hot temperature and low humidity or low temperature and high humidity can cause instant plant stress, thus causing production failure and increased cost.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The development of an agro-meteorological monitoring application using geo-spatial techniques for precision farming was carried out with the use of android studio, computer system and android mobile phone. The testing of the application was also carried out by debugging the app into the mobile phone and click on the application on the screen of the mobile phone and the app was tested well.This reveal the significant effect of mobile application in farming system and the study also show the possible ways of using mobile phone application to get weather data.

The developed Android application is to enhance precision farming by knowing the accurate information regarding the weather (temperature and humidity) so that farm activities can be planned in order to prevent unpleasant events. Being aware of real-time weather conditions like humidity and temperature is the best way to protect crops and safe a high and healthy yield. The application can be afforded by small scale, medium and

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large scale farm enterprise. This is a predictive analytics software that uses the data to provide farmers with guidance about crop rotation, optimal planting times, harvesting times and soil management.

5.2 Recommendations

i. This project work is basically crooned to strengthen the relationship between computerization and agro-meteorology in order to enhance technological growth in the agricultural sector by giving farmers and meteorologists a boundless access to data and meteorological parameters.

ii. This project serves as a basis for which agricultural methods and practices can be enhanced using computer which is a common, efficient and flexible machine relatively useful in agriculture and other meteorological related fields, as well as geo-spatial techniques which is widely becoming a very useful tool in every developing sector.

iii. This application is recommended to every farmer both young and old to help because is cloud computing which serves as a decision support system.

iii This application Integrate sensor data and imaging input with other data, providing farmers with the ability to identify fields that require treatment and determine the optimum amount of water, fertilizers and pesticides to apply.

iv. This helps the farmer avoid wasting resources and prevent run-off, ensuring that the soil has just the right amount of additives for optimum health, while also reducing costs and controlling the farm's environmental impact.

v. The application will make youth find agriculture interesting because on their mobile phone, they can control and carry out some activities on the farm.

vi. Through the agricultural extension agent, the illiterate farmers can also be helped to benefit from this new innovation.

vii This research will serve as a basis for which agricultural methods and practices can be enhanced using mobile devices which is a common, efficient and flexible machine relatively useful in agriculture and other meteorological related fields as well as geo-spatial techniques which is widely becoming a very useful tool in every developing sector.

6 NOTE

Software maintenance is defined as the aggregate of all activity (either compulsory or obligatory) required providing a cost effective support to a software or software system.

The recommendations are that the following maintenance listed below should be given to the application to ensure proper functionality.

Corrective Maintenance: is performed in reaction to malfunctions, faults and defects discovered in software or system after delivery. This fault might be as a result of designing error or logical or coding error. Design errors occur when changes made to the software are flawed, deficient, wrongly transmitted, or the change request is misunderstood.

Perfective Maintenance: involves updating software to improve functionality by implanting new services and correcting latent defects before they escalate to a major malfunction. Perfective maintenance might include improvement of graphical user interface, improving code to raise efficiency and reduce responds time.

Preventive Maintenance: encompasses the act of anticipating tackling imminent error and the modification of a software product to correct these errors before they occur. Preventive maintenance might include updating documentation, code restructuring and code optimization. Preventive maintenance also includes updating the software document so that it reflects the current state of the software.

Adaptive Maintenance: is provided to adjust the software so that it is able to adapt to change in its operating environment. The phrase operational environment in this context denotes external conditions and the influences that act on the system. For example, accommodation changes in the hardware of an operating system.

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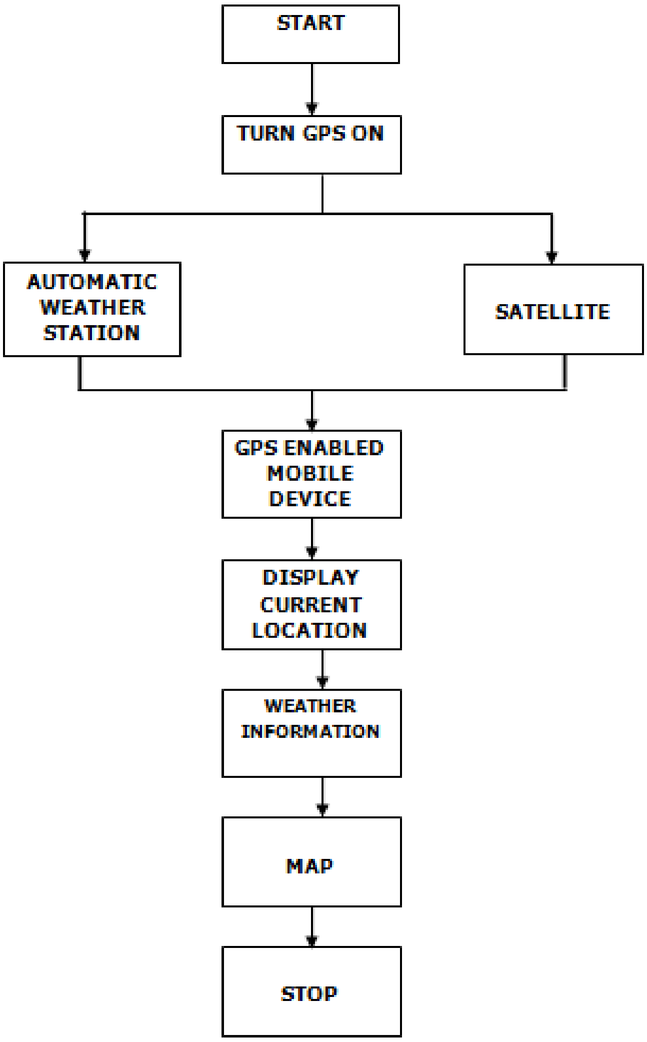
APPENDICES



APPENDIX 1: Flowchart

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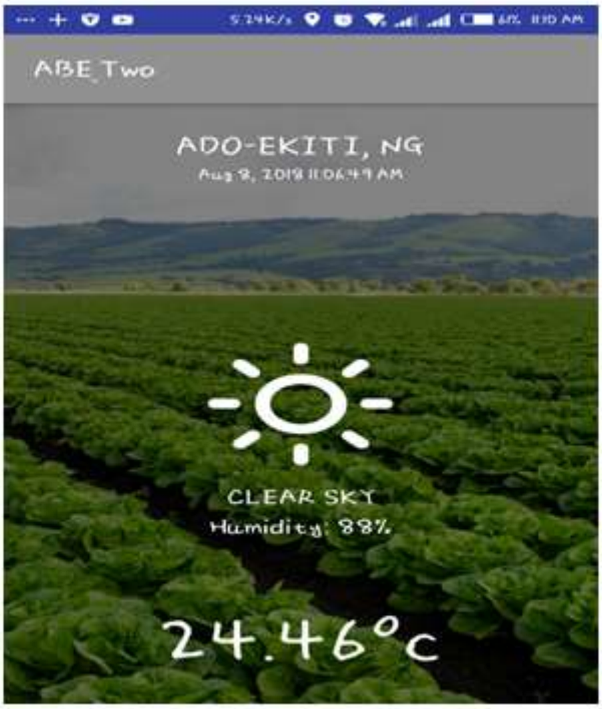
APPENDIX 2: GPS Coordinates



APPENDIX 3: Weather Information

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APPENDIX 4: Map 1

APPENDIX 5: Map 2