International Journal of Intelligent Information Systems
2022; 11(6): 78-90
http://www.sciencepublishinggroup.com/j/ijiis
doi: 10.11648/j.ijiis.20221106.11
ISSN: 2328-7675 (Print); ISSN: 2328-7683 (Online)

Development of a Cloud-Based Meteorological Historical Data System

Gilbert Imuetinyan Osaze Aimufua[1], Sulaiman Ammar Gummi[1], Muhammad Umar Abdullahi[2]

[1]Department of Computer Science, Nasarawa State University, Keffi, Nigeria

[2]Department of Computer Science, Federal University of Technology, Owerri, Nigeria

Email address:

aimufuagio@Gmail.com (Gilbert Imuetinyan Osaze Aimufua), asgibngummi@gmail.com (Sulaiman Ammar Gummi), umarfaruq54@gmail.com (Muhammad Umar Abdullahi)

To cite this article:

Gilbert Imuetinyan Osaze Aimufua, Sulaiman Ammar Gummi, Muhammad Umar Abdullahi. Development of a Cloud-Based Meteorological Historical Data System. *International Journal of Intelligent Information Systems*. Vol. 11, No. 6, 2022, pp. 78-90. doi: 10.11648/j.ijiis.20221106.11

Received: August 19, 2022; **Accepted**: September 21, 2022; **Published**: December 15, 2022

Abstract: Meteorological data has played a significant role in most developed and developing nations. However, in Nigeria, the storage of meteorological data has been so limited, scattered and without defined structure. The purpose of this paper is to develop a cloud-based meteorological data management system as well as a sales portal to improve the management of meteorological data and associated climate services at the Nigerian Meteorological Agency (NiMet). This agency has indisputable importance in the nation's economy, but poor management leads to either loss or damage of the data. Additionally, the process of accessing NiMet data and products for research is often long and stressful. To address these problems, this paper adopts the waterfall and descriptive models to develop a new system. This approach divides the project activities into sequential phases, where each phase depends on the deliverables of the previous one and corresponds to a specialization of tasks. The developed system will be the central hub for numerous meteorological services, including statistical reports, graphical analyses, data extractions, climate summaries, and health sectors, which will dramatically improve work flow, data consistency, and integrity beyond previous practices in Nigeria.

Keywords: (ABS) Cloud Computing, Meteorological Management System, Historical Data System, Waterfall Model, Descriptive Model, Database Management System, Sale Portal

1. Introduction

Many human activities, such as agriculture, transport, power, engineering, insurance, industrial and marketing planning, tourism, sport, mass events, national security, and many more, are heavily influenced by atmospheric conditions [1, 2]. In addition to influencing the value and safety of meteorological and hydrological data sets, this type of data is often necessary to accurately answer scientific questions about the quality of meteorological data sets used in these types of studies [3, 4].

National meteorological organizations gather high-quality in-situ information in accordance with World Meteorological Organization criteria (WMO). At the same time, they are responsible for maintaining and distributing their archived databases. Globally, surface synoptic observations (SYNOP), Meteorological Terminal Air Report (METAR), and TEMP (meteorological code for upper air soundings) provide a substantial amount of weather data for free [5].

Although most of this information is confined to basic meteorological parameters and only applies to the main synoptic stations, it is still considered more accurate than coarse-gridded reanalysis that is commonly used.

Meteorological archives are available in varying degrees in different nations. Usually, there is no free access to such databases. However, near-surface meteorological data are freely accessible to the general public thanks to the interchange of meteorological reports (e.g., FM-12 code established by the WMO) is stored online. In addition to being one of the most popular web services for meteorological data, OGIMET.com relies heavily on freely accessible data from the National Oceanic and Atmospheric Administration (NOAA, United States 2019). These archives are processed in raw, human-readable format. The archival dataset begins in the second half of 1999 and will be updated as new reports are released [6, 7].

The meteorological data are compiled over time (past and present) of weather conditions in a particular area. They include information regarding atmospheric characteristics at a particular time period [1].

These data play an important role in many aspects of our daily lives; students may need meteorological data to know whether to carry an umbrella or jacket when going to school, a businessman selling clothes may want to know the weather conditions beforehand. In a hypothetical situation, sportsmen may possibly wish to know whether weather conditions are appropriate for sporting events, farmers may want to know when rainfall begins and ends, and emergency management authorities may possibly wish to know when extreme weather conditions will occur.

The environmental parameters commonly measured include solar radiation, sunshine hours and temperature, precipitation (primarily rainfall), humidity, vapor pressure, evaporation, and wind speed direction. However, in Nigeria and other parts of the world, temperature and rainfall seem to be the most common weather phenomena reported. These factors have a well-established influence on a wide range of other measurements.

Meteorological data are also very essential for decision-making in the agricultural, aeronautical and marine sectors of the economy. In agriculture, they provide the basis for decisions regarding what kind of crops grow or need to be planted and at what time; in aeronautics, the availability of timely, accurate, and relevant aeronautical and meteorological information in the cockpit is important to the safe operation of aircraft and forms the basis for Air Traffic Management (ATM) decision making [8-10].

The development of climate and meteorological services in developed countries is rapidly progressing, and these services are being implemented for public and private sector users. However, developing countries neglect to make use of these services, due to a variety of reasons, including climate and meteorological services are not well known for their efficiencies and benefits; local weather and climate data are not reliable; and there are limited resources to build and sustain the capacity to provide these services [11]. From the foregoing, this paper aims to develop a cloud-based meteorological database that can be accessed by climate science end-users and other stakeholders/users of meteorological data.

2. Literature Review

To predict different forms of atmospheric change, Ali. et al. [12] used data mining algorithms including decision trees, Naive Bayes, and KNN. Data were acquired from Cairo Airport reports, and the variables studied in the data were pressure, temperature, humidity, dew point, and wind speed and direction. The data was analyzed using an open data science software platform that provides data preparation, machine learning, deep learning, text mining, and predictive analysis. The confusion matrix, correlation, and root mean square error was calculated to evaluate various models. Based on the results, the Bayes theorem was the most efficient at categorizing and modeling data, followed by the decision tree. However, this research does not have a centralized database to store and manage all the prediction results for future reference.

In the work of Mahmood et al. [13], the main goal is to predict precipitation using approximate meteorological factors to train machine learning algorithms. Study factors such as minimum and maximum temperatures, relative humidity, and wind speed were considered when predicting rainfall. To reduce the chances of overfitting, the data was separated into two parts: 70% for training and 30% for testing. Several different machine learning algorithms were used to analyze the dataset, including decision trees, random forests, K-nearest neighbor, neural networks, and support vector regression. The Root Mean Square Error (RMSE) was utilized to analyze and select the prediction strategies, whereas the machine learning methodology was considered based on its accuracy. Nonetheless, there is no central server in this work to preserve and manage all forecast findings for ease of reference; A sales portal to improve the management of Meteorological data and associated climate services is not also implemented in this research.

The works of Chakraborty, Nagwani & Dey [14] proposed a generalized incremental K-mean clustering algorithm for weather forecasting. The authors illustrated how tool clustering may be utilized to create various forecasting tools. K-means is used to divide the data into clusters based on a previously established weather category. The prediction examines West Bengal's air pollution. The goal of this study is to provide a weather forecast technique to limit the effects of air pollution and to launch targeted modeling calculations for weather event prediction and forecasting. The authors conducted many tests to assess the suggested technique. This work, however, does not contain a sales gateway to improve the management of meteorological data and related climatic services.

Kalyankar & Alaspurkar [15] utilized data mining techniques to obtain weather data and uncover hidden patterns within a huge dataset. Time series, K-mean clustering, and Nave Forecast were used to categorize and predict a meteorological situation. This data mining method is used to extract information from the Gaza city weather dataset. This knowledge may very well be utilized to provide important predictions for decision making, however, dynamic data mining algorithms must be developed in order to learn dynamically. Rapid changes in weather and unexpected occurrences can be predicted using a dynamic model. This study collects and forecasts meteorological data in the same way. There is no pattern or observation. As a result, the forecast is prone to error. This strategy is only appropriate in areas with little weather swings, i.e. when the weather stays steady all year. Because regular prediction would fail when the number of outliers increased.

The research of Hemalatha [16] used data mining methods in combination with a Global Positioning System (GPS) to guide the route of ships while sailing. The dataset is evaluated using the ID3 and C4.5 classification methods to create the Decision Tree prediction model. Climate, temperature, humidity, and stormy were the factors evaluated in the dataset. Continuous features must be updated because they do not suit the ID3 technique directly. The weather report for the tracked region is compared to the existing database, and a decision is made to alert the ship of the safest course given the current weather conditions. However, the deployment of this system is prohibitively expensive due to the high cost of such devices and their uncertain accuracy.

In their research, Sawale & Gupta [17] introduced a neural network-based system for predicting atmospheric conditions at a given location. The information was obtained over the preceding three years and included around 15000 cases. The model includes humidity, wind-speed and temperature, as weather characteristics. For initial modeling, a Back Propagation Neural Network (BPN) is utilized. Both models were properly merged, the prediction error is extremely tiny, and the learning process is short. This study was able to detect the non-linear relationship between weather variables and anticipate what the weather will be like in the future. This strategy is only appropriate in areas where there are little weather swings, i.e. it is steady throughout. Because normal prediction would fail if there were more outliers.

Saxena, Verma & Tripathi [18] provided a review of weather forecast methodologies employed by different researchers using Artificial Neural Networks (ANN). Artificial neural network is a computer-based technique inspired in how human brains learn. This technique changes its structure based on the data that flows in the network. The research determined that an ANN is capable of predicting weather conditions like temperature, thunderstorms, rainfall, and wind speed. The authors concluded that Back Propagation (BP) and Multiple Linear Regression (MLR) models are suitable to forecast weather. However, this methodology lacks a sales portal to enhance the administration of meteorological data and related climatic services. Nonetheless, no central server is used in this effort to save and organize all predicted findings for future reference.

3. Methods and Material

This paper adopts the waterfall and descriptive models, which divide the project activities into sequential phases, where each phase depends on the deliverables of the previous one and corresponds to a specialization of tasks. The approach is typical for certain areas of engineering design which proposes to implement a system that could ensure all data generated across offices and stations of the Nigerian Meteorological Agency get transmitted to a central database at the Headquarters for archiving and proper management.

3.1. System Requirement Analysis

The case study for this work is the Nigerian Meteorological Agency; the processes involved in its data archival, retrieval and processing are described in Figure 1.

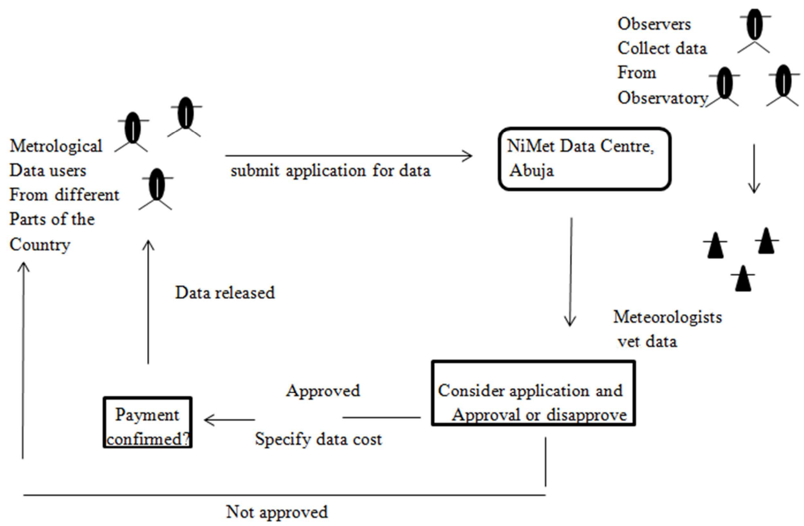

Figure 1. *System Analysis Chart.*

Figure 1 shows the stages involved in obtaining meteorological data from NiMet. The data recorded by observers are collated from the different stations via email or phone calls to update the database. Meteorologists usually vet the data before the database is updated. At the top left-hand corner of the chart, meteorological data users from different parts of the country go to the Nigeria Meteorological Agency's Data Centre to lodge their requests for data via hand-written applications. These applications contain the type of data required (that is daily, monthly, etc.), the period for which the data are required (for example 2001 - 2019) and the parameters for which these data are required (rainfall, temperature, wind speed, etc.). After the requests are reviewed by the officer in charge, they may be approved or not, based on the availability or volume of data requested. If approved, the data user will be billed for data (Nl00 per parameter, per station, per month), once payment is confirmed, the data is released in excel format either via email or by copying into a flash drive.

In order to complete these processes, it may take several days or even run into weeks depending on the availability of the data and the staff in charge. After data is received, the user goes ahead to process them before use, as data are usually released in raw form. As can be clearly seen, the processes involved are tedious and time-consuming.

3.2. Proposed System Design

This study proposes to implement an improved version of the system described earlier for data acquisition. The processes involved in the improved version are described in Figure 2.

In Figure 2, a centralized database is built which can be accessed online from any part of the world, data administrators from all meteorological stations nationwide upload data directly and concurrently into the database at an appointed time. Data users no longer have to travel to the Data Centre at the Headquarters in order to have access to raw data and products. Customers can use their (Debit/Credit card) to pay for the products and services. Once payment is confirmed, data is released in the specified format to the user. This way data access is made a lot easier and faster.

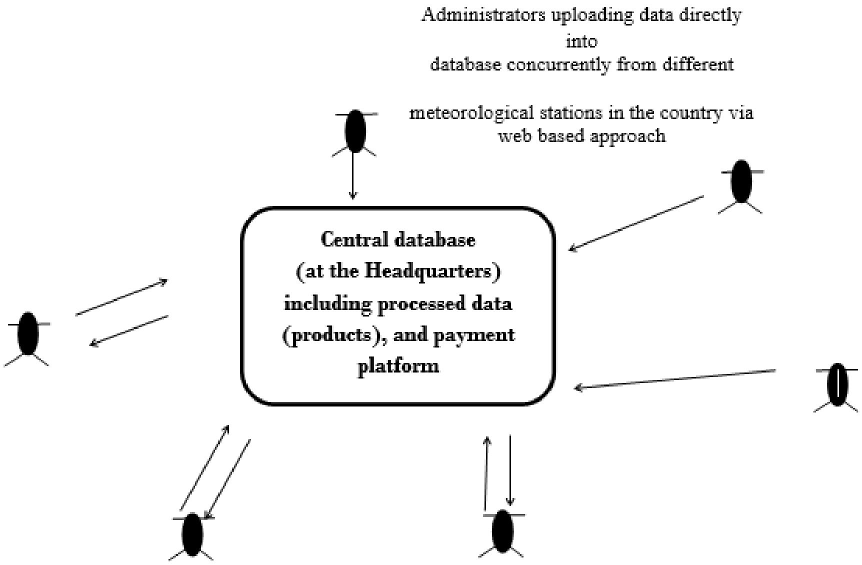

Figure 2. *Web-based Meteorological Data Architecture.*

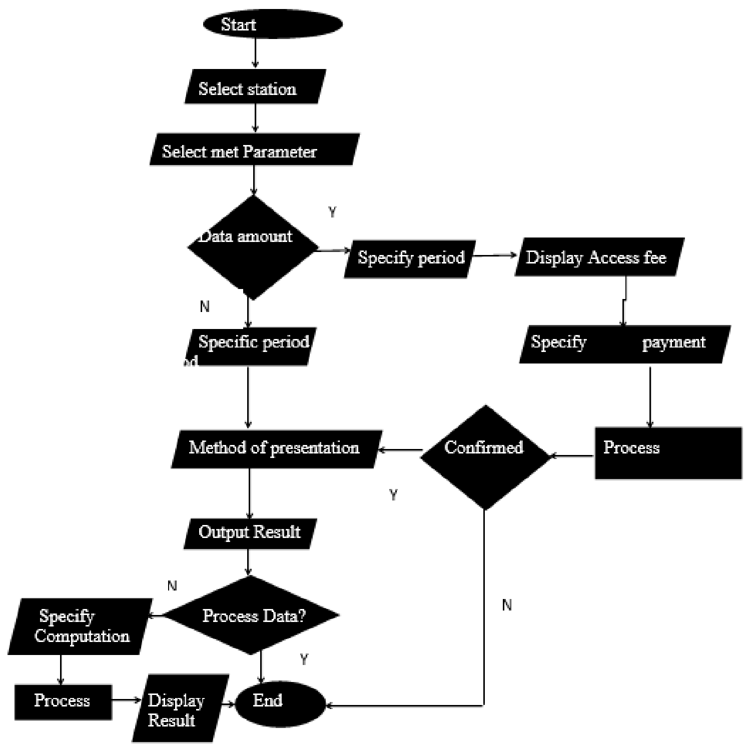

Figure 3. *Program Flow Chart.*

3.3. Program Flow Chart

Flowcharts are a graphical illustration of how data flow in a program or algorithm as it is being coded. It is used to quickly explain concepts of the system under development. Figure 3 depicts the program flow of the proposed system.

The Interpretation of Figure 3 is as follows;

1) Start: Entry point on the interface;
2) Select Station: A list of all the stations for which data are collated by the institution or company will be displayed from which the user can select the required station;
3) Select Meteorological Parameter: Select the parameter(s) required from the station specified;
4) Data Amount: Specify the amount of data required by selecting the period.
5) Process Payment: After paying for data by using any of the following methods: MasterCard, Verve or Visa cards.
6) Confirm Payment: When payment is confirmed, proceed to display data, if not exit the page;
7) Display Result: Display data in the form specified and downloadable.
8) End: Exit the interface.

4. Result and Discussion

The system interface was created using PHP programming language, HTML, JavaScript, and Cascading Style Sheets (CSS). As a web-based program, it can be accessed using a web browser on a variety of computing devices including mobile phones, tablets, and phablets. Additionally, the system was initially developed on a Windows machine before being tested on Mac and Linux. It was evaluated to work accurately and performs the required functions as expected without any case of compatibility issues. Structured Query Language (SQL) was also used to develop a database purposely to store NiMet's data and also to ensure easy retrieval from the interface. The storage facility is of great significance as records to preserve and manage all forecast findings are kept in a secured database. Whereas in the work of Mahmood et al. (2019), the focused is centered of predicting precipitation using approximate meteorological factors to train machine learning algorithms. As this neglect the importance of storage and future usage. Similarly, in the work of Ali et al. (2019), the Bayes theorem was evaluated to be the most efficient at categorizing and modeling data, followed by the decision tree. However, a centralized database for storing prediction findings is also not provided. Furthermore, this work also implements a secure payment platform for all meteorological data products and services of Nigerian Meteorological Agency. Whereas the works of Ali et al. (2019), Mahmood et al. (2019), Alaspurkar (2013), and Hemalata (2013) neglects this feature. Finally, the proposed new system was tested to determine that it performs the intended functions without posing any compatibility issues.

4.1. Dataset

This paper considers monthly data for climatic factors such as rainfall, sunshine hours, radiation, relative humidity, and temperature from 1980 to 2018. Data were obtained for the following stations: Sokoto, Kano, Zaria, Bauchi, Nguru, Maiduguri, Ilorin, Minna, Abuja, Ibi, Yola, Lagos, Ibadan, Abeokuta, Benin, Akure, Warri, Onitsha, Port Harcourt, Owerri, Enugu, and Calabar. These were gathered from NIMET's existing data bank as a case study for this research. As a result of this investigation, it was discovered that all of NiMet's data (except the most current ones) were available in soft copies, whereas the old data sets were in hard copies. It was also revealed that certain data were missing.

Some NiMet stations were used for testing the application, the selection was done in such a way that the scope of the work will be reduced and also maintain an even amount of data for each parameter. These data were therefore preserved in a reliable database system (SQL Server) to allow seamless retrieval via the interface. As shown in Figure 4, the structure of the SQL Server database includes some of the parameters and stations. Thus, it is essential and imperative to know that this is not the only data that has been uploaded into the tables.

id	station_id	user_id	datetimeCollected	heightOfLowestCloud	visibility	AmtOfCloudCovSky	windDirection	windSpeed	tempDryBulb	tempWetBulb	tem
1	10	63	2016-10-31 02:00:00	360	15000	2	150	5	32.8	24.8	
2	0	68	2016-10-31 02:00:00	4	12	7	280	6	32.5	25.9	
3	12	47	2016-10-31 14:00:00	360	10000	7	60	4	35	22.6	
4	28	69	2016-10-31 14:00:00	9000	10000	7	30	8	36	21	
5	56	74	2016-10-31 13:00:00	390	1000	4	210	2	30.5	25.7	
6	41	61	2016-10-31 14:00:00	4	10000	7	240	7	31.3	26.5	
7	0	68	2016-10-31 03:00:00	4	12	7	260	4	32.7	25.9	
8	47	18	2016-10-31 02:00:00	270	10	6	180	10	30.2	26.6	
9	32	71	2016-10-31 14:00:00	360	10	7	220	4	32.3	25.7	
10	28	69	2016-10-31 15:00:00	9000	10000	7	90	5	36	21	
	12	47	2016-10-31 15:00:00	360	10000	7	0	0	35	22.5	

Figure 4. *Screen shot of SQL Server database with Hourly Records data for different.*

Tables were created for parameters, irrespective of the station. The initial archival was done directly to SQL Server in bulk, due to the cumbersome nature of entering them individually. However, for continuous update of the data, real-time, online archival interface has been provided, such that administrators from different stations in the country can update the same database directly, concurrently and at the right time without necessarily seeing the main database demonstrated in Figure 4.

id	station_id	user_id	datetimeCollected	hour	rainfallAmount	created
19	10	63	2016-10-31 06:00:00	03:15:23	999	2016-10-31 06:07:00
20	28	69	2016-10-31 18:00:00	00:00:00	0	2016-10-31 18:07:18
21	12	47	2016-10-31 18:00:00	00:00:00	0	2016-10-31 18:09:34
24	41	72	2016-10-31 20:00:00	00:00:00	0	2016-10-31 19:12:14
25	41	72	0000-00-00 00:00:00	00:00:00	0	2016-10-31 19:12:14
26	47	78	2016-10-31 18:00:00	00:00:00	2.8	2016-10-31 18:17:43
31	56	73	0000-00-00 00:00:00	00:00:00	0.3	0000-00-00 00:00:00
32	47	78	0000-00-00 00:00:00	00:00:00	11	0000-00-00 00:00:00
42	17	51	2016-11-01 06:00:00	00:00:00	0	2016-11-01 05:52:00
43	32	79	2016-11-01 06:00:00	00:00:00	3.7	2016-11-01 06:05:32
44	56	73	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:06:09
45	40	49	2016-11-01 06:00:00	00:00:00	0	2016-11-01 05:16:02
46	12	54	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:17:31
53	17	55	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:58:00
54	47	78	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:18:35
61	29	57	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:36:54
62	29	64	2016-11-01 06:00:00	00:00:00	0	2016-11-01 06:47:33

Figure 5. *Screen shot of SQL Server database with Rainfall Records data for different stations.*

Data quality checks were implemented to prevent erroneous data entry by registered administrators, as people are prone to making mistakes. This paper only made use of sample monthly data from NiMet, therefore, for advanced work, a more comprehensive archival process can be adopted to accommodate all the different products available from meteorological archiving organizations.

4.2. Web Interfaces of the New System

The first page when the URL (Uniform Resource Locator) of this system is visited is a login page shown in Figure 4. The users will be required to log in, as this will enable the system to determine which of the defined interfaces are shown to the user for further interaction and usage within the system.

Figure 6 shows the login page where all meteorological activities are carried out. Meteorological data (Real-time and Historical data) are entered and stored online to the central database from all meteorological stations across the country. The login page only allows authorized personnel to have access to the system.

Figure 6. *Login and Home Page.*

Figure 7 shows the dashboard or control unit, where all the activities happen. The dashboard has, the account settings, hourly synoptic data, rainfall data, upper air data, agrometeorological data, marine meteorological data. Each user has separate dashboard.

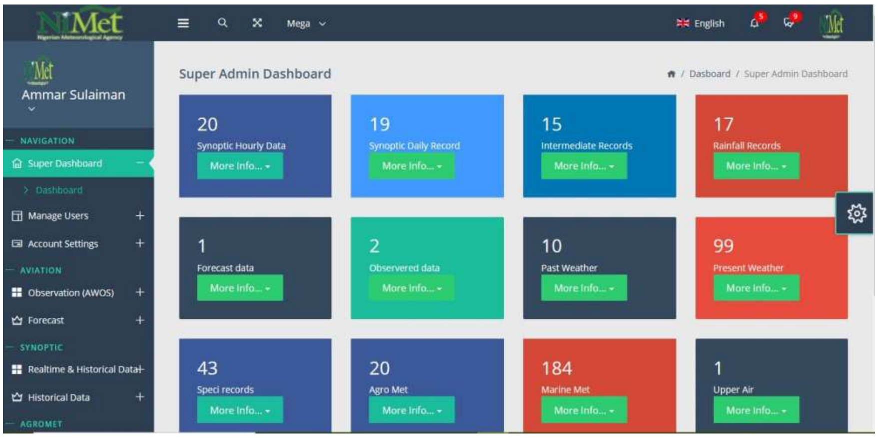

Figure 7. *The Dashboard.*

In Figure 8 it shows the dashboard for the pilot. It has always been the practice that the pilots have to come down from the control tower to the briefing room to have access to their flight folders TLF (Trend Landing Forecast). It was made a lot easier by the system for the pilots from their comfort zone; they could login to the system and have access to their flight folders TLF (Trend Landing Forecast).

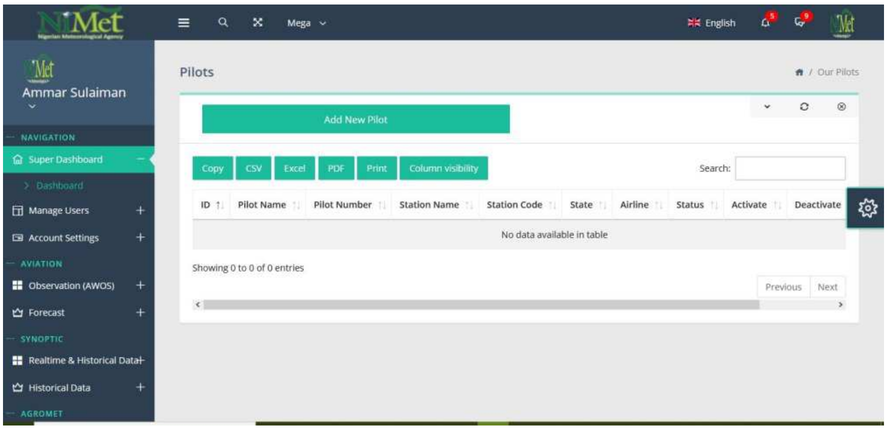

Figure 8. *Shows the Pilot Data.*

Figure 9 shows the synoptic hourly records which refer to the data collected hourly starting from our hour 00. At each hour observers input the observed data from the observatory to the database.

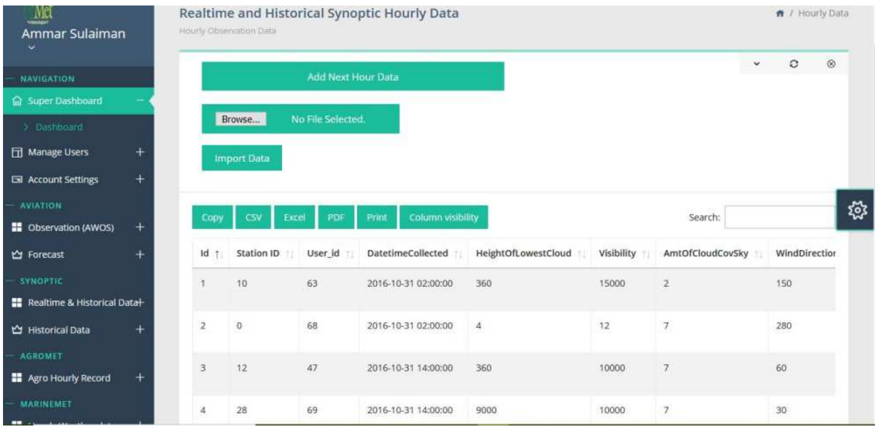

Figure 9. *Synoptic Hourly Data.*

Figure 10 shows the upper air data which is invaluable to forecasters. The figure illustrates the current meteorological conditions. On the 300 and 200 MB analyses, the jet stream, for example, can be observed, MB refers to millibars. A millibar is a measurement of height based on pressure.

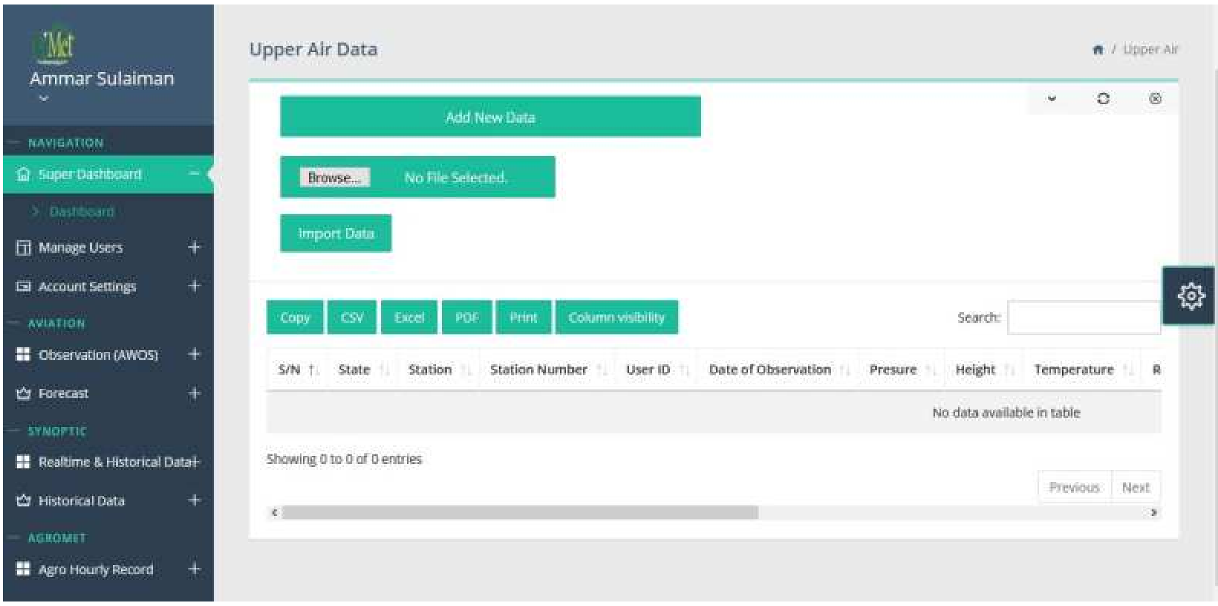

Figure 10. *Shows the Upper Air Data.*

Figure 11 shows the user record and profiles, each registered user to the system can upload or change profile pictures, and change password. It also shows the user log, this is the audit trail where user logs and activity logs record are captured and stored for security purposes.

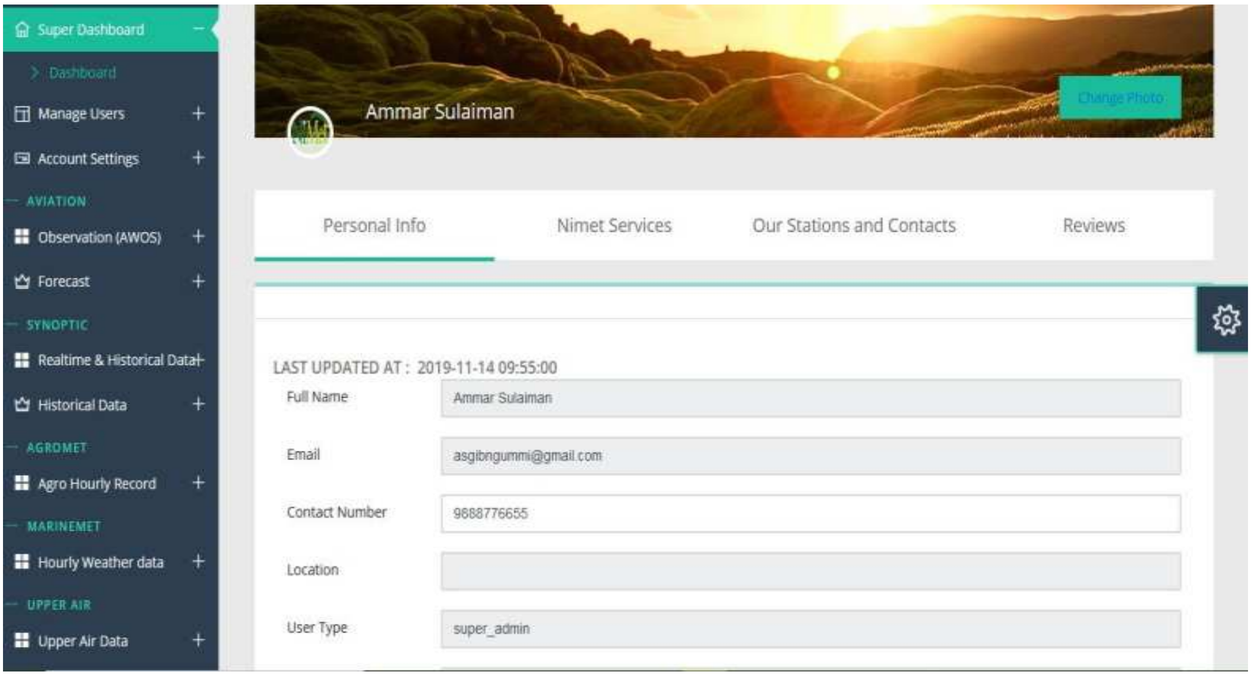

Figure 11. *Shows the User Profile Data.*

4.3. Data Request Procedure

For data request by clients as shown and demonstrated in Figure 12, the entry point of the interface; a user loads the start page on a web browser by typing the web URL (Uniform Resource Locator) in the address bar or by clicking on the link from the source website. The user then logs in a data request as shown in Figure 12 and submit. The request is then received by the data officer for processing. The user/client then receives response to his/her request within two (2) working business days.

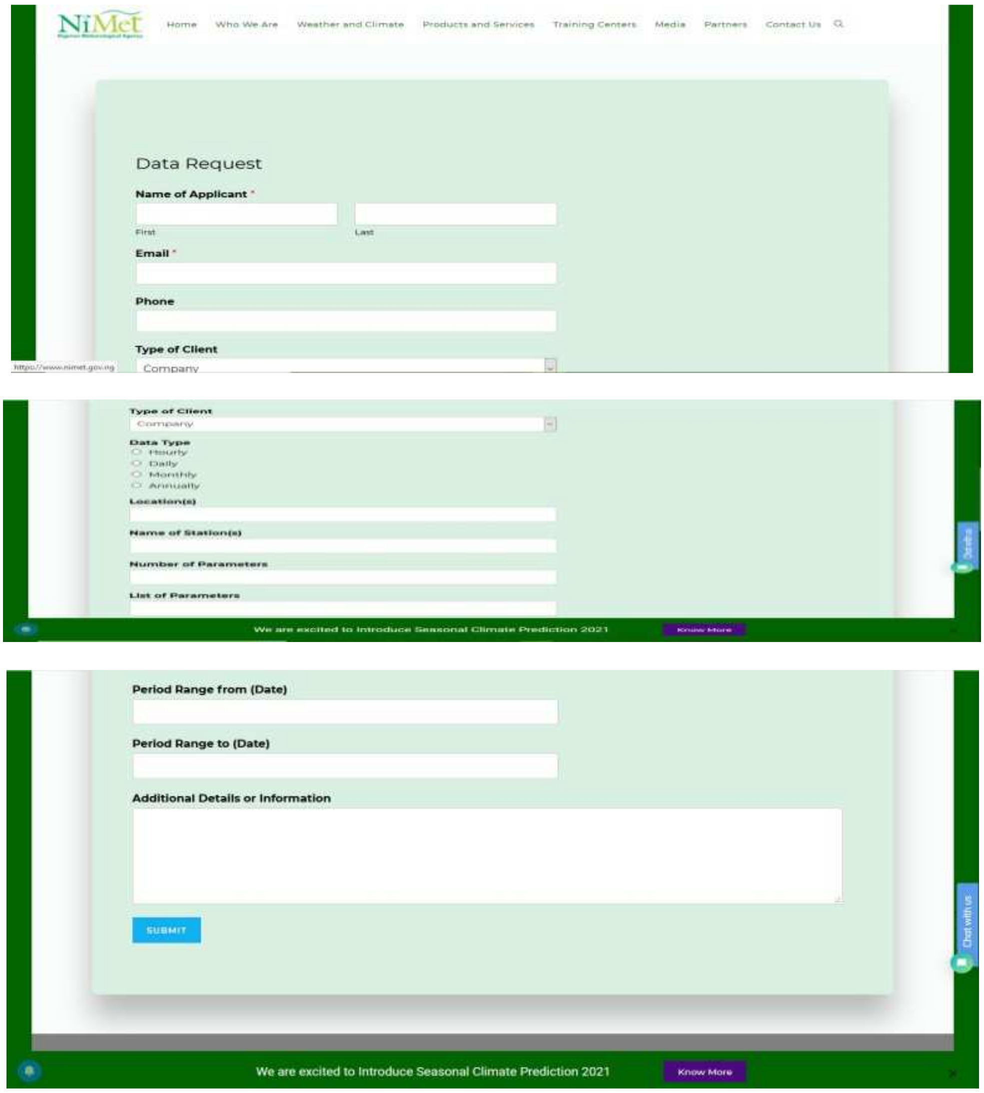

Figure 12. *Data Request Form.*

4.4. Products and Payment Portal

This paper also aims to explore and provide a secure and dependable platform for the sales of digital data services from the Nigerian Meteorological Agency. The payment platform was developed employing leading-edge digital sales and service technologies. Nigerian meteorological data created and preserved in a central database might be sold directly through the platform or turned into products and services before being uploaded to the site for sale. Third-party online services such as PayPal, Stripe, Paystack, Remita, and others were used to provide payment platforms. To purchase, a customer or client might go to the site and find the product(s) and service(s) of interest, then enter the "Master Card," "Verve," or "Visa" Card data. The data, goods, and services are made available to the client as a downloaded file as soon as payment is verified. Figure 13 show the Home page of data, products and services sales portal. The transaction procedure begins on this page. The VIEW ALL PRODUCTS button allows users to access and view all of Nimet's offered services. The user may also desire to utilize the GET THE LATEST INFORMATION option to check for updates on new services launched or soon to be introduced by Nimet.

Figure 13. *Home page for Data, Products and Services Sales Portal.*

Figure 14 shows Products Sale Customer Information. On this page, the categories of product, tags and the cost delivering the selected services are shown. Once the user is done, the CHECKOUT button is used to proceed to the next step.

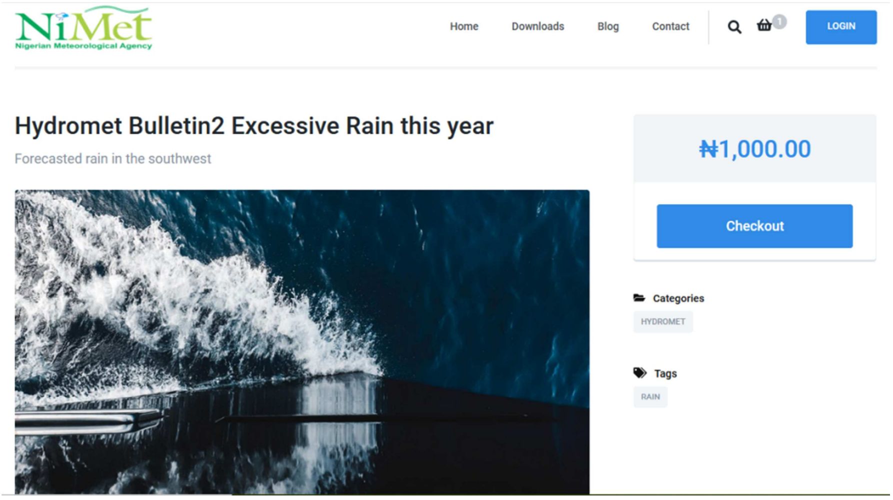

Figure 14. *Product and price display.*

Figure 15 shows the Products Sales Customer Information with the purchase option. The information of customers is collected on this page. Details such as email address, First Name, Last Name, comments, and check box for the purpose of accepting the terms and conditions of Nimet before proceeding to the next step.

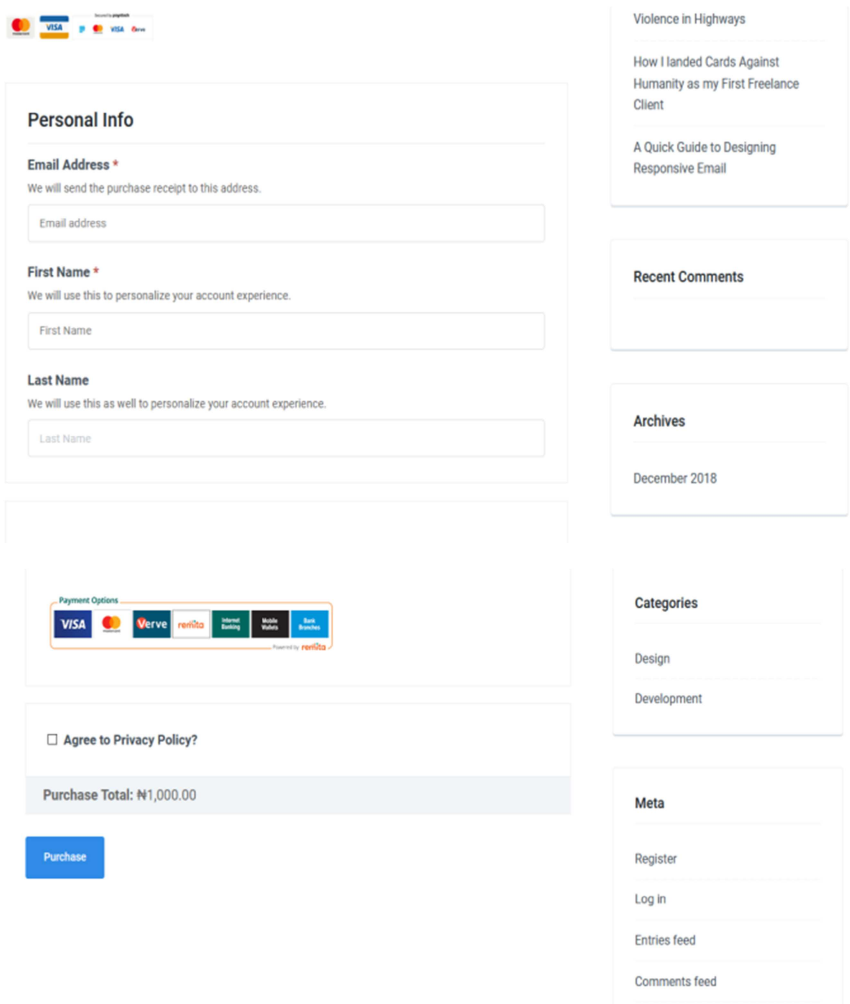

Figure 15. *Products Sales Customer Information.*

Figure 16 shows the Products Checkout page. This page is related to payment and billing details. The checkout page gives customers the opportunity to enter payment details and complete their order.

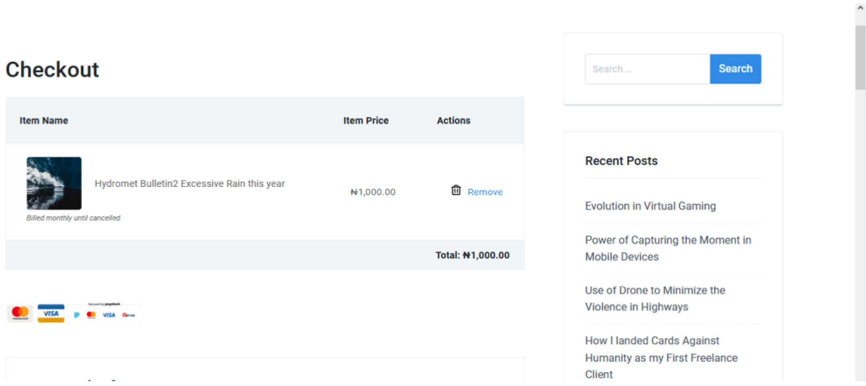

Figure 16. *Products Checkout page.*

Figure 17 depicts a product purchase using a card and Remita. This page enables the user to make purchases and payments using an ATM (Automated Teller Machine) card. To proceed with the payment, the user must input the card number, expiration date, and CVV (Card Verification Value) on the page. When the payment is validated, the user receives a receipt and the page returns them to the customer dashboard.

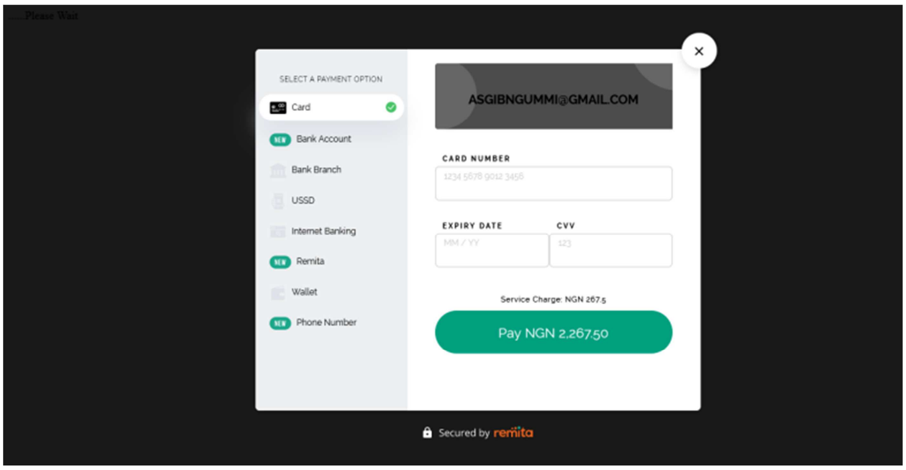

Figure 17. *Products Purchase using Card with Remita.*

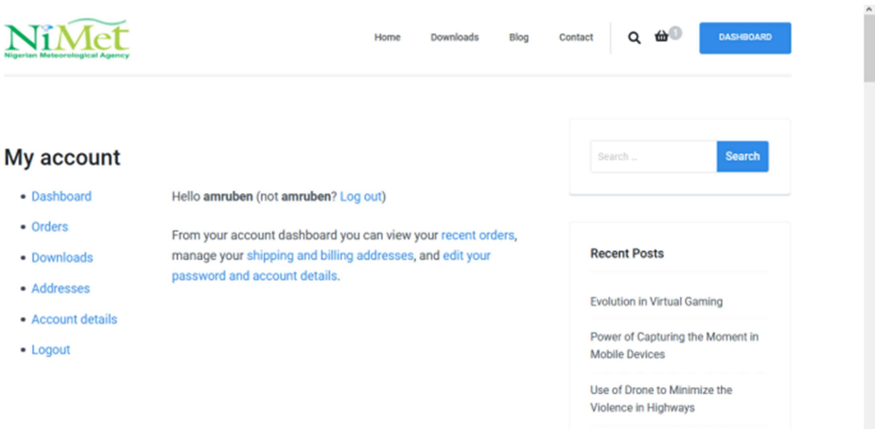

Figure 18. *Customer Dashboard.*

4.5. Discussion of Findings

The results and discussion in this paper focused on the three main objectives of the study. The first focus involves transforming NiMet's past meteorological data archive from hard copies into soft form and uploading same into a reliable database management system in order to make it more durable, portable and secure. The second focus will be on providing access to both real-time and historical processed meteorological data for various end-users. The third and final focus will be on creating a more reliable and secure payment platform for all meteorological data products and services of Nigerian Meteorological Agency.

5. Conclusion

The automation of a large meteorological database has simplified the archival, retrieval and processing of meteorological data more than the manual method which were adopted in the past and in the present. It has made it possible for a much wider access, as end users are no longer constrained by time and space (as it was in the time past and present) since the internet is global and can be accessed from anywhere and at any time. The importance of meteorological data preservation and usage control was studied; hence the need for automation of these processes was established.

The archival process necessitated the use of a database management system (DBMS) for data storage and SQL Server sufficed for accomplishing that phase of the work; also a web retrieval/processing platforms were needed for online access to users and all meteorological stakeholders, which was accomplished by the use of PHP Programming Language, HTML, JavaScript, Cascading Style Sheet (CSS), WordPress, easy digital downloads. The final phase of the work involved providing a reliable and secure online payment platform for sales of Nigerian Meteorological Agency's digital data, products and services.

6. Recommendation

In order for this work to be fully implemented and optimally utilized in a large meteorological archiving institution in a robust form, the following are recommended:

1) The organization must have a central server that can house/store the database which can grant data access from any part of the world via internet connection. The database should also accommodate all the different types of data available in that institution (daily, hourly, synoptic, etc.). This should be installed at the head office or regional offices depending on the structure of the organization.
2) There must be technical staff who will manage the server and also a resident administrator for each meteorological station who will be responsible for uploading data directly to the server on daily basis.
3) Products and Services Payment portal to be used should be contracted from a third party web service provider such as Remita, Stripe, interswitch or PayPal for proper service delivery and accounting.

7. Future Work

1) Hosting the application on a physical server will require a lot of money which could not be afforded during this research work.
2) Contracting third party web service provider for the payment platform will also attract a rental fee which also could not be afforded for this work; this lead to the building of a dummy payment portal.
3) Some data were missing from the Agency's (NiMet) database, this reduced the amount of data that were used to test the application.

References

[1] Martin, D. J., Howard, A., Hutchinson, R., McGree, S., & Jones, D. A. (2015). Development and implementation of a climate data management system for western Pacific small island developing states. Meteorological Applications, 22 (2), 273-287.

[2] Czernecki, B., Głogowski, A., & Nowosad, J. (2020). Climate: An R package to access free in-situ meteorological and hydrological datasets for environmental assessment. Sustainability, 12 (1), 394.

[3] Frei, T. (2010). Economic and social benefits of meteorology and climatology in Switzerland. Meteorological Applications: A journal of forecasting, practical applications, training techniques and modelling, 17 (1), 39-44.

[4] Palmer, T. N. (2002). The economic value of ensemble forecasts as a tool for risk assessment: From days to decades. Quarterly Journal of the Royal Meteorological Society: A journal of the atmospheric sciences, applied meteorology and physical oceanography, 128 (581), 747-774.

[5] Balogh, W., & Kurino, T. (2020). The World Meteorological Organization and Space-Based Observations for Weather, Climate, Water and Related Environmental Services. In Space Capacity Building in the XXI Century (pp. 223-232). Springer, Cham.

[6] Rudenko, R., Pires, I. M., Liberato, M., Barroso, J., & Reis, A. (2022). A Brief Review on 4D Weather Visualization. Sustainability, 14 (9), 5248.

[7] WMO (2020). State of the Climate in Africa 2019. WMO-No. 1253. Geneva: World Meteorological Organization. Available online at: https://library.wmo.int/doc_num.php?explnum_id=10421 (accessed January 09, 2022).

[8] Susmitha, P., & Bala, G. S. (2014). Design and implementation of weather monitoring and controlling system. International journal of Computer applications, 97 (3).

[9] Aguirre-Munizaga, M., Gomez, R., Aviles, M., Vasquez, M., & Recalde-Coronel, G. C. (2016, November). A cloud computing based framework for storage and processing of meteorological data. In *International Conference on Technologies and Innovation* (pp. 90-101). Springer, Cham.

[10] Chauhan, S. S., Pilli, E. S., Joshi, R. C., Singh, G., & Govil, M. C. (2019). Brokering in interconnected cloud computing environments: A survey. Journal of Parallel and Distributed Computing, 133, 193-209.

[11] Szewrański, S., Chruściński, J., Kazak, J., Świąder, M., Tokarczyk-Dorociak, K., & Żmuda, R. (2018). Pluvial Flood Risk Assessment Tool (PFRA) for rainwater management and adaptation to climate change in newly urbanised areas. Water, 10 (4), 386.

[12] Ali, M. F. M., Asklany, S. A., El-wahab, M. A., & Hassan, M. A. (2019). Data mining algorithms for weather forecast phenomena: comparative study. *International journal of computer science and network security*, *19* (9), 76-81.

[13] Mahmood, M. R., Patra, R. K., Raja, R., & Sinha, G. R. (2019). A novel approach for weather prediction using forecasting analysis and data mining techniques. In Innovations in Electronics and Communication Engineering (pp. 479-489). Springer, Singapore.

[14] Chakraborty, S., Nagwani, N. K., & Dey, L. (2014). Weather forecasting using incremental K-means clustering. arXiv preprint arXiv: 1406.4756.

[15] Kalyankar, M. A., & Alaspurkar, S. J. (2013). Data mining technique to analyse the metrological data. International Journal of Advanced Research in Computer Science and Software Engineering, 3 (2).

[16] Hemalatha, P. (2013). Implementation of data mining techniques for weather report guidance for ships using global positioning system. *International Journal of Computational Engineering Research*, *3* (3), 2.

[17] Sawale G. J. & Gupta S. R. (2013). Use of Artificial Neural Network in Data Mining for Weather Forecasting. *International Journal of Computer Science and Applications, 6 (2)*.

[18] Saxena, A., Verma, N. & Tripathi K. C. (2013). A Review Study of Weather Forecasting Using Artificial Neural Network Approach. *International Journal of Engineering Research & Technology* (IJERT), 2 (11).