

NORHED Project on: Improving Weather Information Management in East Africa for Effective Service Provision through the Application of Suitable ICTs (WIMEA-ICT)

Report on National Survey Assessing the Status of Weather Records' Storage and Access in selected weather stations in Uganda

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1. Introduction

Makerere University is implementing a five-year project supported by NORAD under the NORHED programme. This project is titled “Improving Weather Information Management in East Africa for effective service provision through the application of suitable Information & Communication Technologies (WIMEA-ICT)”. The other partners in this project are University of Bergen (UiB), University of Juba (UoJ) and Dar es salaam Institute of Technology (DIT). Within Makerere University, the project is being implemented by a multidisciplinary team comprising of the University Library (Maklib), the Meteorology Unit under the College of Agricultural and Environmental Sciences (CAES), College of Engineering Design Art & Technology (CEDAT) and is coordinated by the College of Computing & Information Sciences (COCIS).

Makerere University invited the Uganda National Meteorological Authority (UNMA), formerly the Uganda Department of Meteorology (DOM) as a key stakeholder of the research project.

One of the project activities was to conduct a nation-wide survey on the status and availability of weather records with the goal of promoting awareness of the weather data available to a wide-range of stakeholders. Prior to the survey, the WIMEA-ICT project team had, through a NORAD seed grant, partnered with DOM to conduct a preliminary survey, which informed the project of the need to conduct a comprehensive survey. It was envisaged that the increased awareness will result in increased access/use, thereby complementing the efforts of the UNMA and related institutions towards meteorological data collection, management and dissemination.

Additionally, the results of the survey will inform the implementation of digitization of weather records, which is also one of the project activities. The selected weather records that will be digitized will be a sample that will inform the comprehensive efforts of UNMA, National Agricultural Research Organisation (NARO) and other organisations towards digitization of the weather data collection and management processes.

A team of 10 researchers [included as Appendix A] participated in the survey to assess the status of weather records’ storage and access in selected weather stations in Uganda. Data from the interviews was entered in an online google form and analysed using the google spreadsheet. Below are the results of the survey. 16 interviewees participated in the survey. These include 4 Meteorologists, 1 Meteorological Superintendent, 1 Meteorology Senior Supervisor, 3 Meteorology Assistants, 2 Weather Observer, 2 Officers in Charge, 1 Data Scientist, 2 Research Officers, 1 Research Assistant, 1 Senior Meteorological Assistant and 1 Technician. The data collection instrument (attached as appendix B) was developed and pretested at two stations prior to the main data collection exercise. The survey instrument was then refined based on the pre-test data collection experience.

2. Results and Discussion

In this section, we present and discuss the survey results. The results are discussed in 6 subsections namely i) the general information about the weather stations; ii) the type of weather data collected; iii) the document types used to record weather data; iv) the data management and

retrieval efforts; v) the strategies for long term preservation of weather records; and vi) any other comments.

2.1 General information about the weather stations

2.1.1 List of weather stations

The research team collected data on available weather records from the following 26 weather stations: Lira (UNMA), Kitgum (UNMA), Masindi (UNMA), Kyembogo (Kabarole district), Agromet Station Namulonge (Wakiso district), Buginyanya coffee research station (Budairi district), Serere Agromet, Soroti weather station (UNMA), Mbarara Zonal Agricultural Research Station & Development Institute (Mbarara-ZARDI), Kachekano NARO station (Kabale district), Kampala (UNMA), Kasese (UNMA), Kotido (UNMA), Entebbe (UNMA), Tororo (UNMA), Kibanda (Rakai district), Aduku VTC, Mbale (UNMA), Mukono Zonal Agricultural Research Station & Development Institute (MuZARDI), National Livestock Resources and Research Institute (NaLIRRI), Jinja Meteorology Station, National Fisheries Resources and Research Institute (NaFIRRI), Moroto (UNMA), Gulu (UNMA), Arua (UNMA) and National Forestry Resources and Research Institute (NaFORRI, Mukono). Owing to the fact that the research team was only able to make firm contacts/appointments with relevant personnel at just a few weather stations at the time of data collection, the list of the weather stations mentioned represents a sample that was purposively selected.

2.1.2 Ownership of the weather stations

Owned by UNMA	17 65%
Owned by other organization but part of UNMA network	9 35%

Most (65%) of the stations are owned by UNMA and 35% are owned by organisations other than UNMA but the data can be accessed by UNMA. The existing synergies between the operations of UNMA and other organisations involved with weather data collection and management are greatly applauded.

2.1.3 Type of weather station

Of the 25 weather stations from which data was collected, 41% were synoptic, 21% agrometeorological, hydrometeorological (3%), AWS (24%) and rainfall (10%). It was noted that some stations had more than one type of weather stations.

2.2 Type of Weather Data

2.2.1 Meteorological Parameters

The data that was collected reflected the following meteorological parameters. All stations recorded precipitation data, which naturally typifies tropical climate in Uganda.

Table 1: Meteorological Parameters

Parameter	Number of Stations
Precipitation	26
Temp. Max	16
Temp. Min	18
Temp Dry Bulb	11
Temp Wet Bulb	12
Temp Grass min	0
Number of sunlight hours	8
Cloud cover	1
Soil temperature	1
Air pressure	2
Humidity (Dry/Wet)	13
Wind speed	18
Wind direction	15
Evaporation	2
Solar radiation	1
River gauge data	0

From table 1, inconsistencies in weather data recording was evident and some parameters not being collected. Some of these were attributed to broken or vandalised equipment, stock-out and inadequate maintenance.

Kyembogo (Kabarole district) weather station has not been included in table 2 because there were no records kept on station as the data was transmitted directly by phone message service. Data on cloud cover, air pressure, evaporation and solar radiation has also been captured in the table because of its scanty nature as seen below:

Data on the following parameters was in just a few stations so it has not been included in the table:

- 1 Cloud cover: registered at only the Masindi station in 1986-2014,
- 2 Soil temperature: recorded only at Buginyanya in 1950-1980)
- 3 Air pressure: recorded at Masindi station in 1986-2014 and Mbarara station in 1971-2014
- 4 Evaporation: recorded only at Buginyanya station in 1950-180 and 2004-2014
- 5 Solar radiation: recorded only at Moroto station in 2013-2014.

2.2.2 Weather records available by meteorological parameter and period

The tabular presentation below shows the meteorological parameters and corresponding data collected at the different stations. The following data was based on the interviewees' knowledge of the weather station's history. Data from 10 of the UNMA stations was collected directly at the UNMA records archive (UNMA headquarters).

Station	District	Precipitation	Temp max	Temp min	Temp dry bulb	Temp wet bulb Start date	Sunlight hours	Humidity (dry/wet)	Wind speed	Wind direction
Aduku VTC	Apac	1947-2004								
Arua	Arua	1922-2014	1992-2014	1992-2014	1992-2014	1992-2014	1974-2000	1960-2014	1980-2014	1980-2014
Buginyanya	Budadiri	2004-2014	2004-2013	2004-2014	2004-2014	2004-2014		2004-2014	2004-2014	2004-2014
Entebbe	Wakiso	1951-2014	1962-2014	1962-2014	1987-2000	1987-2000	1977-1999	1960-2014	1976-2014	1976-2014
Gulu	Gulu	1937-2014		1960-2014	1960-2014	1960-2014		1991-2014	1980-2014	1980-2014
Jinja	Jinja	1903-2014	1960-2014	1960-2014	1995-2000	1995-2000	1976-2004	1964-2014	1980-2014	1980-2014
Kachekano	Kabale		2010-2014						2010-2014	
Kampala	Kampala	1943-2014	1993-2014	1993-2014	1993-2003	1993-2003	1993-2006	1993-2014	1995-2014	1995-2014
Kasese	kaseses	1963-2014	1964-2014	1964-2014	1964-2010	1964-2010	1974-2006	1964-2014	1973-2014	1973-2014
Kibanda	Rakai	1965-2014	1999-2014	1999-2014						
Kitgum	Kitgum	1992-2014		1992-2014	1992-2013	1992-2014			1992-2014	1992-2014
Kotido	Kotido	1947-2012	2000-2010	2000-2010						
Lira	Lira	1988-2014		1992-2014	1992-2014				1992-2014	1992-2014
Masindi	Masindi			1986-2014	1986-2014	1986-2014		1986-2014	1986-2014	1986-2014
Mbale	Mbale	1963-2014								
Mbarara ZARDI	Mabrara	2010-2014	2010-2014	2010-2014				2010-2014	2010-2014	
Moroto	Moroto	1948-1999								
Mukono ZARDI	Mukono	2012-2014								
NaFIRRI	Jinja	2012-2014						2013-2014	2013-2014	

NAFORRI	Mukono	2012-2014								
NaLIRRI	Tororo	2012-2014	1977-2007						2007	2007
Namulonge	Wakiso	1950-2014	1950-2012	1950-2012	1950-2010	1950-2010	1950-1990		1950-1990	1980-2014
Serere	Serere	1923-2014	2004-2014	2004-2014				1923-2014	1923-2014	1923-2014
Soroti	Soroti	1971-2014	1971-2014	1971-2014			1971-2009	1971-2014	1971-2014	1971-2014
Tororo	Tororo	1923-2014	1961-2014	1961-2014	1995-2000	1995-2000		1980-2014	1990-2014	1990-2014

Table 2: Weather records available by meteorological parameter and period

From table 2, the earliest precipitation data was recorded in 1903 by the Jinja weather station. In 1950 Agromet Station Namulonge recorded the earliest temperature data. The latest weather records were registered in 2014 by most of the stations. This trend indicates that presently more current data is recorded than in the past. Weather stations were not functional during the years of civil unrest, which explains the inconsistencies. The researchers were also informed that the National Agricultural Research Organisation's (NARO) weather stations, which were visited, were automatic weather stations (AWS) hence the data was collected centrally and regularly dispatched to the NARO climatic focal persons. However, it should be noted that the NARO AWS were only installed in 2012 so the available data was for the period since 2012.

2.2.3 Document types used to record weather data

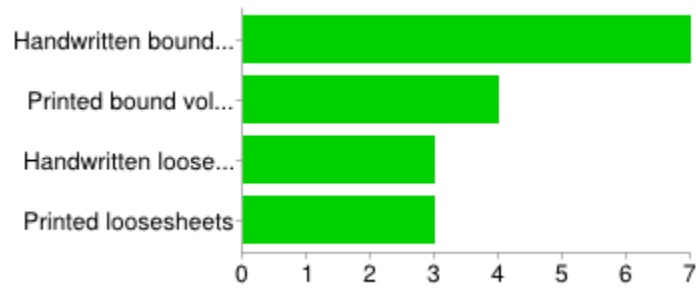


Figure 1: Document Types used to record weather data

- (i) 41% of the stations reported that weather records were kept in handwritten bound volumes
- (ii) 23% of the stations reported that weather records were kept in printed bound volumes
- (iii) 18% of the stations reported that weather records were kept in handwritten loose sheets
- (iv) 18% of the stations reported that weather records were kept in printed loose sheets

The implication of this distribution is that there is a great need for digitization of the paper-based records which have not been digitized by various methods including scanning them for preservation. Increased physical contact with the old paper-based records, increases the deterioration rates. A repository of the scanned (digitised) records will provide quick and easy access for the scanned records so that physical access to the paper-based record shall be limited to only when it must be done. Operationally, a digital repository may be more advantageous in comparison to the current postal/courier system that weather stations currently use to transfer monthly returns of paper records to the UNMA central registry. Secondly a digital repository will reduce on required shelving space since the registry will need less space for filing paper records.

2.3 Data Management and Retrieval

The sub-section provides an analysis of how weather data is managed and retrieved

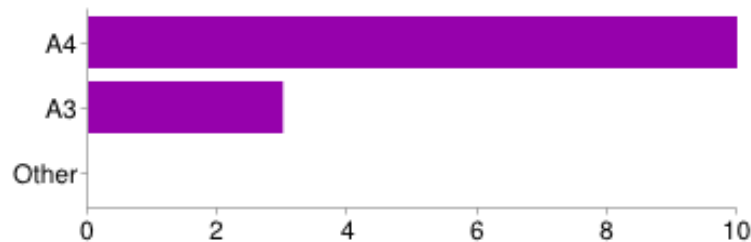


Figure 2: Paper size of documents with weather records

(i) 77% of the records are provided in A4 paper size.

(ii) 23% of the records are provided in A3 paper size

The implication is that the purchase of digitization equipment should cater for mostly A4 and A3 bound volumes as well as loose-sheets.

2.3.1 Digitisation Efforts So Far

There were 62.5% of stations that maintained some paper-based records, while 37.5% of the records were reported to be entered in MS Excel database in addition to being processed at the UNMA headquarters using Clicom and Climsoft software packages. This implies that most of the weather data predominantly has remained in paper form.

2.3.2 How weather records/data are retrieved at weather stations/UNMA weather records archive

a. A weather records list (catalogue) of the holdings of the weather archive	0%
b. Manual naming of files and no use of a records list (catalogue)	0%
c. Performing a search in the MS Excel database	31%
d. Availing access through Google drive/drop box	0%
e. Manual searching of physical paper-based records by meteorological staff	69%

The highest (69%) weather records retrieval is through manual (physical) access/checking of paper-based records by Meteorological/authorized staff. This is followed by MS Excel Database at 31%. This explains why retrieval of specific weather records was not possible at some of the stations.

2.3.3 Challenges faced in the management of manual/paper-based weather records according to the interviewees

The following were listed as the challenges in managing manual weather records:

(i) Deterioration of paper-based weather records due to environmental factors	21%
(ii) Poor storage equipment such as poor shelving	18%
(iii) Destruction of paper records by humans, rodents & insects	15%
(iv) Delays/failure to retrieve certain records	13%
(v) Limited shelving space	12%
(vi) Understaffing	21%

The most challenging issues as seen above were deterioration of paper-based weather records due to environmental factors and understaffing. Some interventions therefore need to be initiated in order to address the challenges.

2.3.4 Suggested solutions by interviewees towards the challenges of managing manual records

(i) Purchase storage equipment and stationery

- (ii) Avail funds for fumigation
- (iii) Allocate space for shelving
- (iv) Digitizations of paper-based records
- (v) Make back-up copies of the original data
- (vi) Purchase of appropriate software and computers

The suggested solutions imply that UNMA may need to invest in a well equipped ICT unit. In addition, it may be necessary to upgrade the records management infrastructure.

2.3.5 Challenges faced in the management of electronic weather records

- | | |
|--|-----|
| (i) Absence of necessary software/available software is not user-friendly | 24% |
| (ii) Limited electronic storage capacity | 19% |
| (iii) Absence of necessary equipment such as computers | 14% |
| (iv) Limited bandwidth | 10% |
| (v) Slow/old computers | 19% |
| (vi) Preference of users for ready processed weather datasets | 4% |
| (vii) Potential users complain that access is too restrictive hence it discourages utilization of much needed weather records/datasets for research or other use (payment for cost recovery) | 10% |

2.3.6 Suggested solutions for challenges of managing electronic records

- (i) Refresher courses e.g. software training
- (ii) Equip the stations and UNMA head-quarters with computers
- (iii) Provide internet connectivity with good speed
- (iv) Develop back-up systems e.g. servers
- (v) Improve security of the weather station

The suggested solutions imply that UNMA may need to invest in a well-equipped ICT unit. Specifically, UNMA may consider the following back-up strategies: use of in-house and off-site backup server for electronic records.

2.4 Areas where meteorological staff require ICT related training in view of the challenges encountered in management of weather records/data

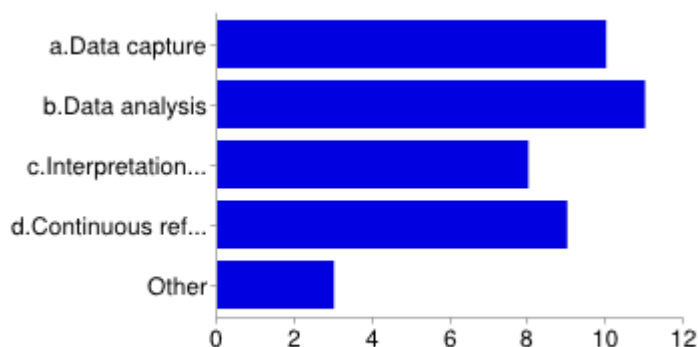


Figure 3: Training needs of Meteorological Staff who were interviewed

a. Data capture	24%
b. Data analysis	27%
c. Interpretation of weather data	20%
d. Continuous refresher courses	22%

2.5 Other Comments from the respondents

In addition to the above, UNMA may consider the following issues raised by interviewees that indirectly affect weather records management:

- (i) Increase staffing levels
- (ii) Improve communication between the head-quarters and weather stations
- (iii) Continuously motivate staff
- (iv) Encourage data sharing with relevant research and local communities

3. Implications and Recommendations

1. Given the poor storage of paper-based weather records demonstrates a great need for investment in better weather records management infrastructure country-wide.
2. the current centralized system, which enables control & security of the weather data, necessitates appraisal and improvement/strengthening of the existing data acquisition and distribution systems.
3. UNMA should increase the annual budget allocation for weather records management-R
4. UNMA should streamline data acquisition and distribution systems.- an automated weather
5. The synergies built by UNMA and NARO are applauded and should be consolidated to produce a national weather data system. Given the fact that research findings in weather, climatic change, meteorology and related disciplines informs policy and practice, which is a contribution towards better meteorological practice, it is recommended that the existing mutual relationship between the UNMA and research institutions should be strengthened further. Therefore UNMA should with immediate effect take a more proactive approach in liaising with relevant research institutions.

6. It is also recommended that given its legal mandate and responsibility for the coordination of meteorological data efforts country-wide, UNMA should perform a comprehensive needs assessment of the required weather data management infrastructure country-wide by December 2015 so that it plans to include these in its annual budgets on a gradually incremental but sustainable basis with effect from financial year 2016/2017 budget.
7. Subsequently, with the input of competent research institutions (whereby Makerere University – WIMEA-ICT project in particular is interested in contributing), UNMA should conduct a study of the return on investment in weather data management infrastructure and how to communicate the results to central government and key stakeholders in order to ascertain appreciation and budgetary support for meteorological services.
8. Over 60% of weather data retrieval is by manual search of paper records, which constrains resources such as time, money, efforts, etc
9. UNMA should adopt a user-friendly electronic weather data repository by December 2016, which would also archive and integrate both manually observed data and the data from automatic weather stations in formats required for various purposes.
10. In order to adopt an organized weather data management practice and meteorological research centre, UNMA needs to build a competent meteorological research data centre, which is adequately furnished with pre-requisite high computing facilities and competent meteorological researchers.

In respect to the existing memorandum of understanding and mutual partnership with UNMA, Makerere University under the WIMEA-ICT project intends to make the following contributions / recommendations in response to some of the ICT-related challenges revealed by the survey:

- a. Facilitate and supervise the digitisation of un-digitised precipitation records, if any, for a selected number of stations with representation from each climatological zone of Uganda. The selection will be made by UNMA. The Makerere University digitization experts will supervise the digitization of the records, which will take place at UNMA headquarters. Precipitation is critical data to Uganda’s meteorological modeling and the survey revealed that all the stations had precipitation data.
- b. Facilitate and supervise the scanning of paper-based weather record, which are critical for preservation. UNMA will select the records to be scanned for preservation and the scanning will take place at UNMA headquarters. The Makerere University digitization experts will provide expertise to supervise/guide the scanning exercise. The survey revealed that there were several paper records in bound volumes.
- c. Develop a weather data repository (WDR)
The design will be carried out in consultation about system requirements with UNMA and other stakeholders. The proposed WDR will solve the challenges that have been faced with the existing software packages. The project team should consider benchmarking with University of Nairobi and the Kenya Meteorological Department, which developed a robust WDR.

- d. Makerere University digitization experts will provide related training and advise for the implementation of the digitisation process. Makerere University should recommend / provide to UNMA the experts needed for digitization / records management as far as this component is concerned since UNMA has Meteorology experts but lack records experts.
- e. Prior to digitization, there are crucial activities needed such as proper record keeping and arrangement, proper data entry, data rescue (scanned data & recorded data) and data screening. The project should have this in place in preparation for digitization. In summary, UNMA contributions should be synergized with records management.
- f. UNMA needs to equip the ICT Department to fuel forecasting, transmission and ease of weather data access for proper sustainability of the project results.
- g. The quality of data should be thoroughly checked during the process of digitization.
- h. Sustainability of the digitization equipment should be considered.
- i. The existing ties between UNMA and NARO need to be strengthened further in order to streamline access to weather data from NARO by UNMA. This should also apply to all other stakeholders, who are involved with collection of weather data in order to strengthen the weather database of UNMA,
- j. UNMA needs to invest in infrastructure that will strengthen its ability to restrict access to weather data only to authorized parties in order to enforce the principles of weather data integrity.
- k.

It is hoped that with the proof of concept developed between Makerere University and UNMA, the government will invest in the sustainability of ICT-based solutions for appropriate weather records management.

~ END ~

Appendix A:

The Research Team (Name and Department)

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