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Ecawsoft: A Web based Climate and Weather Data Visualization for Big Data Analysis Kadeghe G Fue¹ and Camilius A. Sanga²

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7 Abstract

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In Tanzania, data for climate and weather are normally analyzed by Meteorological Agency and then are published through TV, website and radio. Different stakeholders normally obtain the weather and climate data / information in a generalized way. This calls for a need of a system which allows data to be shared openly to different stakeholders so that they can analyze those data as per their specific needs.Design/methodology/approach: The paper presents the overview of the developed system, ECAWsoft. Also, it gives some few interfaces showing different outputs from the system.

16 Index terms— climate, weather, visualization, system, big data.

Abstract-Purpose: In Tanzania, data for climate and weather are normally analyzed by Meteorological Agency and then are published through TV, website and radio. Different stakeholders normally obtain the weather and climate data / information in a generalized way. This calls for a need of a system which allows data to be shared openly to different stakeholders so that they can analyze those data as per their specific needs.

The paper presents the overview of the developed system, ECAWsoft. Also, it gives some few interfaces showing different outputs from the system. Findings: The goal of this paper has been attained by developing a working data visualization tool for climate and weather called ECAWsoft. The system is current operational and is providing open data for different stakeholders. It is user friendly and interactive with capability of displaying visualization of data as per fine granularity required by user. Development of open data system for data visualization has lead to a transparency system which is helping farmers, researchers, policy makers (etc.) to make informed decision on weather and climate.

Practical implications: The system presented in this paper need to be scaled up so that more data from all weather stations in Tanzania can be populated in real time.

Originality/value: The development and adoption of open systems for visualizing weather and climate data remains seriously lacking in many countries including Tanzania. This paper provides an overview of some initiative to fill such a research gap.

³³ 1 I. Introduction

34 ever before in history has data been generated at such high volumes as it is today. Exploring and analyzing 35 the vast volumes of data (i.e. big data) is becoming increasingly difficult. Information visualization and visual 36 data mining can help to deal with the flood of information ??Keim, 2002). Visualizations of subspaces on the 37 World Wide Web can provide users the ability to identify relevant information from a set of Web pages, while gaining new insights or understanding of the space (Heo and Hirtle, 2001). Brodlie (1997) looked at the different 38 players involved in the creation of a Webbased visualization service, and hence, build a reference model for 39 Web-based visualization. Ondov et al. (2011) presented krona which is a powerful metagenomic visualization 40 tool and a demonstration of the potential of HTML5 for highly accessible bioinformatics visualizations. Its 41 interactive displays facilitate more infor med interpretations of metagenomic analyses, while its implementation 42 as a browser-based application makes it extremely portable and easily adopted into existing analysis packages. 43

Murray (2013) presented a 3D JavaScript-based tool for loading data into a web page and generating visuals from data. Murray's study provides a better understanding to novice programmers who have little programming experience or no at all. It is a tool for non programmers in many fields including those dealing with climate and weather.

We are in the era where the effect of climate change is very noticeable. This call for a tool to analyze 48 voluminous data generated from weather stations in real time in order to look for a pattern of effects of climate 49 change. Climate change extremes such as flooding and seasonal drought are already undermining the economies 50 of countries in the Horn of Africa 1 Buja et al. (1991) presented two principles used to design interactive system to 51 visualize different ecanerios. Two basic principles for interactive visualization of high-dimensional data-focusing 52 and linking were discussed. Focusing techniques may involve selecting subsets, dimension reduction, or some 53 more general manipulation of the layout information on the page or screen. A consequent of focusing is that each 54 view only conveys partial information about the data and needs to be linked so that the information contained 55 in individual views can be integrated into a coherent image of the data as a whole. Ladstadter et al. (2010) 56 reported that interactive system facilitates iterative and interactive browsing of the parameter space to quickly 57 understand the data characteristics, to identify deficiencies, to easily focus on interesting features, and to come 58 59 up with new, with agriculture and water resources being the most affected sectors (Rosenzweig et al., 2013).

60 hypotheses about the data. These properties extend the common statistical treatment of data, and provide a 61 fundamentally different approach. Tomiscki et al. (??011) reported on a survey that they conducted to evaluate 62 the application of interactive visualization methods and to identify the problems related to establishing such methods in scientific practice. The feedback from 76 participants showed clearly that state-of-the-art techniques 63 are rarely applied and that integrating existing solutions smoothly into the scientists' workflow is problematic. 64 They tried to illustrate how interactive visualization tools can be successfully applied to accomplish climate 65 research tasks. They showed some examples to support that interactive sys-tems were really required. Lu et al. 66 (??011) demonstrated the framework that has great flexibility and simplicity for end users intending to perform 67 data analysis by aiding the integration of data and tools and enabling interactive visualization on-the-fly. The 68 system was coupled with effective utilization of computational resources and data storage systems. 69

Therefore, this paper presents a technology developed to allow easy visualization and interaction with the 70 Agricultural Model Inter-comparison and Improvement Project (AgMIP) output data that contain climatic 71 information of several locations in Tanzania. AgMIP is a major international effort linking the climate, crop, 72 73 and economic modeling communities with cutting-edge information technology to produce improved crop and 74 economic models and the next generation of climate impact projections for the agricultural sector (Rosenzweig et al., 2013; Sanga et al., 2013). The technology that was developed for visualization of AgMIP output is known 75 as ECAWsoft. This is the short form of Enhancing Climate Change Adaptation in Agri-culture and Water 76 Resources in the Greater Horn of Africa (ECAW) Software. The data sets obtained from the ECAW project 77 that have been generated using models were used in the development of this system. The coding was done 78 mainly using PHP, HTML5 and JavaScript. The famous JavaScript libraries like jquery and bootstrap were 79 used to integrate interactive features of the visualization system. The system is web based and uses open source 80 tools that cost almost nothing because of the free license behind their innovations. The interaction system is 81 user friendly. The code integrated in this system might seem to be complex but it was made so to achieve the 82 best human to machine interaction and experiences. The system is designed for visual presentation of the data 83 based on the region-oriented metaphor that includes visualization levels and aggregation or fusion features of 84 the graphs. The system is able to present comparison of up to six locations of the information in the interactive 85 manner that allows the user to granulate or aggregate the data presented. 86

⁸⁷ 2 II. Materials and Methods

This system used the Unified Modeling Language (UML) for analysis and design of the system components. The system was designed to get text files from the folder and then process the data dynamically and draw the dynamic graphs (Figure 1). Figure 1 presents the logic flowchart of the ECAWsoft. The system reads input and creates a dynamic back end database then loads the information to the frontend which processes and present it output to the users. The information is presented as interactive information that allows front end database to be upda-ted with information from the database as requested by the user while navigating the system.

⁹³ with information from the database as requested by the user while navigating the system

⁹⁴ 3 b) Characteristics of the Input data

The data sets are provided in the form of text files with extensions "agMIP" (Mourice et al., 2017). The datasets were collected from the weather stations located in Tanzania and other missing data were generated automatically using weather modeling algorithms and software. The data sets include a form that text fields are separated by space. The algorithm goes through the data set to establish database that can be visualized using HTML5 capable browser. In Figure 2, the focus is on 7 types of data: Solar Radiation (SRAD), Maximum Temperature (TMAX), Minimum Temperature (TMIN), Rainfall (RAIN), Relative Humidity (RHUM), Wind (WIND) and Dew Point (DEWP) (Wambura et al., 2015). All the given data sets are presented using interactive line graphs

102 except rainfall datasets which are presented using bar charts. The data axis is presented against time -series.

103 Time series is the first column with @DATE as name. The file has important information such as LAT for 104 Latitude and LONG for Longitude of the weather station.

105 The user is given an opportunity to decide when to display the information and which data sets to include and

which places of that data set is desired for comparisons. In fact, the user can choose up to six places to display.

¹⁰⁷ The user may decide to add new dataset that can be displayed automatically by the system. These datasets ¹⁰⁸ are categorized in two parts; baseline simplescenario data and Coupled Model Inter-comparison Project phase 5

(CIMP5) generated data (Msongaleli et al., 2015).

¹¹⁰ 4 Implementation of the data sets and system

The visualization tool has integrated HTML5 features, PHP programming language version 5.6 and JavaScript scripting language to achieve a web-based visualization and interaction system. The system can easily be installed in Apache 2 web server. The system has been maximized to use google-chrome browser and in fact, it works very fine with other famous browsers like Firefox and Internet explorer. The on-line tool has been made easier for any user to install it even in a local machine with Apache 2 and PHP version 5 installed.

In a server-side application, a web browser is used to generate requests, send them to the application server, and display the results. The application server, connected with the web server via the Common Gateway Interface (CGI), processes the requests and delivers the result in a standard Web format (e.g. HTML) back to the client. In such an application, the client is usually an HTML page containing forms connected with the application server, while all the software as well as the databases resides on the server that is administrated by the deploying

121 organisation (Huang, 2003).

¹²² 5 a) Visualization and interaction system

123 In this section, the discussion is on the visual parts of the system used for visualization and interaction approaches 124 for visual analysis of the input datasets against time-series.

The main view of the visualization tool has two sidebars; left and right sidebars. The left sidebar show Home, Baseline data, Present Stations (These are Tanzania regions specific data) and help as presented in Figure 5 and

127 Figure 6. ()

128 **6** H

The right side shows all the climate baseline dataset stations that have been read from the climate database.
The user is able to choose the dates desired to be generated by this tool.

The user can then choose desired dates and places for comparison as in Figure 5, Figure 6 and For instance, if the user chooses four stations to visualize the information, then the system is going to show years only as shown in Figure 8 and Figure ??. Now, the user may decide to drag between the dates by holding left click and moving the cursor to visualize the information in detail as shown in Figure 10. Figure 11 visualize the chosen date from Figure 10. The rainfall data can be seen in each time, the rainfall was recorded. The detailed data

will separate the information so that the differences of rainfall data of the same day can easily be visualized by

the user as shown in Figure 14. This paper has presented a technique that can easily be loaded using a flash disc and manipulates data for easy visualization and interaction. The future
1 2 3 4 5 6

¹(retrieved from http://africanclimate.net/en/node/6080 on 2016/09/24)

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 $^{^5 \}odot$ 2017 Global Journ als Inc. (US) Figure 9: Weather data generator has generated the dataset between 2005-01-04 to 2009-01-23

 $^{^6 {\}rm Year}$ 2017 () © 2017 Global Journals Inc. (US) 1



Figure 1:

@ INSI	LAT	LONG	ELEV	TAV	AMP	REFHT	WNDHI				
USAM	42.017	-93.750	329	11.2	14.6	-99.0	-99.0				
@DATE	YYYY	MM	DD	SRAD	TMAX	TMIN	RAIN	WIND	DEWP	VPRS	RHUM
1980001	1980	1	1	1.2	1.3	-1.5	0.0	3.1	-0.3	6.0	89
1980002	1980	1	2	4.7	-0.3	-2.6	0.0	4.9	-7.6	3.5	58
1980003	1980	1	3	1.9	-0.3	-4.8	0.0	4.3	-9.0	3.1	52
1980004	1980	1	4	3.8	0.2	-2.6	0.0	4.1	-5.2	4.2	67
1980005	1980	1	5	1.0	0.2	-3.2	1.5	3.4	-2.5	5.1	82
1980006	1980	1	6	8.5	1.9	-7.0	2.1	9.1	-0.8	5.7	82
1980007	1980	1	7	6.7	-6.4	-15.9	0.0	8.2	-13.4	2.2	58
1980008	1980	1	8	6.7	-8.7	-16.5	0.0	2.9	-17.1	1.6	51
1980009	1980	1	9	2.2	-11.4	-20.4	1.5	3.7	-16.2	1.8	68
1980010	1980	1	10	8.0	6.3	-13.7	0.0	8.0	5.3	8.9	93
1980011	1980	1	11	4.0	11.3	-9.8	0.0	11.9	7.3	10.2	76
1980012	1980	1	12	8.6	0.8	-13.7	0.0	6.1	-10.4	2.8	43
1980013	1980	1	13	8.6	12.5	1.3	0.0	6.7	2.4	7.3	50
1980014	1980	1	14	2.1	6.9	-3.2	0.0	4.1	-1.0	5.7	57
1980015	1980	1	15	1.0	8.6	4.6	0.0	4.1	7.2	10.2	91
1980016	1980	1	16	1.9	7.5	2.4	24.4	5.6	7.4	10.3	99
1980017	1080	1	17	37	2.5	-2.6	1.2	5.6	-0.6	5.0	80

Figure 2: Figure 1 :



Figure 3: Figure 2 :



437

Figure 4: Figure 4 : Figure 3 : Figure 7 .

# Home	Please specify the parame	eters to generate gra	phs	
Baseline Data	Welcome, you can generate interactive graph	hs Sp	ecify upper Date	
Present Stations	specify lower Date		pecify upper Date	
	Choose datasets to compare			
BUKOBA	RUEMBE SUGAR ESTATE I [Baseline]	UYOLE AGROMET [Basel)	iii ARUSHA AIRPORT [[Baseline]
DAR IS SALAAM	B AMANI MALARIA UNIT (Baseline)	🗉 ARUSHA AGRIC. OFRICE [Baseline) 🛛 🔅 BAGAMOYO AGRIC	ULTURE [Baseline]
DAKES SALAAM	BINENGO TEA ESTATE (Baseline)	BUKOBA MET. STATION [Saseline) 🛛 🔅 BUSTANI YA WANA	NCHI (Baseline)
DODOMA	OHUNYA AGRICULTURE [Baseline]	DAR-ES-SALAAM AIRPORT	[Baseline] 📃 DODOMA AIRPORT	(Baseline)
	ENGARE RONGAI [Baseline]	GEITA AGRICULTURE [Bat	eline] [] KIGOMASHA [Base	ine]
KIGOMA	HANDENI AGRICULTURE (Baseline)	IGERI AGROMET [Baselin	E IRINGA EXPERIMEN	(TAL STN [Baseline]
MANYARA	E LONGA AOROMET [Baseline]	IRINGA MET (Baseline)	KARUME AIRPORT	(PEMISA) [Baseline]
	KIBAHA AGROMET [Baseline]	📋 KIGOMA AIRPORT (Basel	ne) 🗌 KAHAMA (Baseline	1
MBEYA	III KISARAWE AGRICULTURE [Baseline]	🗉 KILIMANJARO INT. AIRPO	RT (Baseline) 🛛 🔅 KILWA MASOKO (B	aseline]
	ISBONDO MAJI [Baseline]	E KONGWA ADMIN. OFFICE	(Baseline) KASULU (Baseline)	
MOROGORO	E LUSHOTO AGRIC. OFFICE [Baseline]	E LUPONDE FARM (Baselin	() 🔅 LUKUBA ISLAND (8	aseline]
ATTALLA	LAKE MANYARA MAJI [Baseline]	UNDI AGRICULTURE (Bas	eline] 🛛 LUSITU FARM [Bas	eline]

Figure 5: Figure 5:



Figure 6: Figure 6 :

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MBY	II KISARAWE AGRICULTURE	E KILIMANJARO INT. AIRPORT	KILWA MASOKO	III KIBONDO MAJI							
	KONGWA ADMIN. OFFICE	III KASULU	LUSHOTO AGRIC. OFFICE	UPONDE FARM							
MOROGORO	LUKUBA ISLAND	😢 LAKE MANYARA MAJI	LINDI AGRICULTURE	E LUSITU FARM							
	MAHENGE MET.	☑ MBEYA MET.	B MANYONI DISTRICT OFFICE	C MAFINGA BOMANI							
MTWARA	# MPANDA BOMA	MOROGORO MET. STATION	MPWAPWA RESEARCH	III MTERA							
MUSCOMA			STATION	E MUGUMU PRIMARY SCHOOL							
mojomn	E MTWARA AIRPORT	E MUSOMA MET.	MWANZA AIRFIELD	NAURURU							
SAME	III NEWALA AGRICULTURE	E NGUDU	III NYUMBA YA MUNGU	III NAMANYERE-NKANSI							
	INVANZA SALT MINES NO. 1	III NZEGA	B OLMOTONYI FOREST STATION	III RUBONDO ISLAND							
SONGEA	📋 RUBYA SEMINARY	SAME MET. STATION	SINGIDA DISTRICT OFFICE	III SHINYANGA MET							
TAROPA	SINGIDA DISTRICT OFFICE	E SONGEA AIRFIELD	E SUMBAWANGA AGRIC. STN.	TANGA AIRPORT							
Theorem .	II THEMI ESTATE	E TABORA MET. STATION	III TUKUYU AGRICULTURE	UKIRIGURU AGROMET							
TZWA	URAMBO FARM NO. 10	USA RIVER VETERNARY	E ZANZIBAR (KISAUNI) AIRPORT								
	Choose Weather data to display Solar Radiation Maximum Temperature Minimum Temperature Rainfall Relative Humidity Wind Dew Point										
								Generate Graph Reset			

Figure 7: Figure 7 :

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-	Specify lower Date		Specify upper Date				
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	Choose datafiles to display						
	E RUEMBE SUGAR ESTATE I	UVOLE AGROMET	ARUSHA AIRPORT	AMANI MALARIA UNIT			
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	BUSTANI YA WANANCHI	CHUNYA AGRICULTURE	DAR-ES-SALAAM AIRPORT	💷 DODOMA AIRPORT			
	ENGARE RONGAL	GEITA AGRICULTURE	E RIGOMASHA	HANDENI AGRICULTURE			
	IGERLAGROMET	RINGA EXPERIMENTAL STN	E LONGA AGROMET	IRINGA MET			
	KARUME AIRPORT (PEMBA)	E KIBAHA AGROMET	EI KIGOMA AIRPORT	🖾 KAHAMA			
	II KISARAWE AGRICULTURE	E KILIMANJARO INT. AIRPORT	E KILWA MASOKO	E KIBONDO MAJI			
	E KONGWA ADMIN, OFFICE	E KASULU	USHOTD AGRIC. OFFICE	E LUPONDE FARM			
	LUKUBA ISLAND	🗟 LAKE MANYARA MAJI	E UNDI AGRICULTURE	🗎 LUSITU FARM			
	MAHENGE MET.	RI MBEYA MET.	II MANYONI DISTRICT OFFICE	III MAFINGA BOMANI			
	MPANDA BOMA	III MOROGORO MET. STATION	III MPWAPWA RESEARCH	I MTERA			
			STATION	E MUGUMU PRIMARY SCHOOL			

Figure 8: Figure 8 :H



Figure 9: Figure 11



Figure 10: Figure 10 :



Figure 11: Figure 11 :



Figure 12: Figure 12 :



Figure 13: Figure 13 :



Figure 14: Figure 14 :H

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Present Stations	Specify lower Date		Specify upper Date	
	Choose datasets to compare			
BUKOBA	T2DAOQXX(Baseline)	TZDACAXA[Near-term RCP4.5]	TZDACBX4[Near-term RCP4.5]	TZDACCX4(Near-term RCP4.5)
D40 55 541 A444	E TZDACDXA[Near-term RCP4.5]	TZDACEXA[Near-term RCP4.5]	TZDACPXA[Near-term BCP4.5]	TZDACCIKA[Near-term RCP4.5]
DAR CO SALAAM	TZDACH04[Near-term RCP4.5]	TZDACIXA[Near-term RCP4.5]	II TZDACJXA[Near-term RCP4.5]	TZDACKX4[Near-term RCP4.5]
DODOMA	TZDACLXA(Near-term RCP4.5)	TZDACMXA[Near-term RCP4.5]	E TZDACNXA[Near-term RCP4.5]	TZDACOXA[Near-term RCP4.5]
KIGOMA	TZDACPIKA[Near-term RCP4.5]	TZDACQXA[Near-term	TZDACRX4[Near-term RCP4.5]	TZDACSKA[Near-term RCP4.5]
		RCP4.5]	TZDACTXA[Near-term RCP4.5]	E TZDAŁAXA[Near-term RCP8.5]
MANYARA	TZDAEBXA[Near-term RCP8.5]	TZDAECKA[Near-term RCP8.5]	II TZDAEDX4[Near-term RCP8.5]	TZDAEEXA(Near-term RCP8.5)
	TZDAEFXA[Near-term RCP8.5]	E TZDAEGXA[Near-term RCP8.5]	TZDAEHXA[Near-term RCP6.5]	TZDAEDA[Near-term RCP8.5]
MBETA	TZDACJKA[Near-term RCP8.5]	E TZDAEKKA[Near-term RCP8.5]	TZDAELXA[Near-term RCP8.5]	TZDAEMKA[Near-term RCP8.5]
MORDGORO	T7DAENXA/Near-term RCP8 5	III TZDAFOXA/Near-term BCPR 51	TZDAEPXAINear-berm BCPB.51	TZDAEOXAINear-berm RCP8 51

Figure 15:



Figure 16: Figure 15 :

- The results from this paper are better compared to that from Luhunga and Chang'a (2016) who presented a decision supports system for determining effects of climate change. Their system was not interactive and hence,
- 141 not adapted to rural farmers. On the other hand, ECAWSoft
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