



HAL
open science

Flood Disaster Management System for Situation Awareness and Response Using Twitter Data

Manzu Gerald, Kayoko Yamamoto

► **To cite this version:**

Manzu Gerald, Kayoko Yamamoto. Flood Disaster Management System for Situation Awareness and Response Using Twitter Data. 6th International Conference on Information Technology in Disaster Risk Reduction (ITDRR), Oct 2021, Morioka, Japan. pp.35-48, 10.1007/978-3-031-04170-9_3. hal-04082622

HAL Id: hal-04082622

<https://inria.hal.science/hal-04082622v1>

Submitted on 26 Apr 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



This document is the original author manuscript of a paper submitted to an IFIP conference proceedings or other IFIP publication by Springer Nature. As such, there may be some differences in the official published version of the paper. Such differences, if any, are usually due to reformatting during preparation for publication or minor corrections made by the author(s) during final proofreading of the publication manuscript.

Flood Disaster Management System for Situation Awareness and Response using Twitter Data

Manzu Gerald and Kayoko Yamamoto

The University of Electro-Communications, Chofugaoka, Chofu, Tokyo, Japan
k2030044@edu.cc.uec.ac.jp and kayoko.yamamoto@uec.ac.jp

Abstract. Social media has increasingly become a convenient tool for sharing and consuming information during emergencies and disasters such as floods. The annual floods of the River Nile in South Sudan devastates lives and property, leaving towns and villages submerged. The present study focuses on utilizing data from Twitter to develop a Flood Disaster Management System for Situation Awareness. Tweets about flooding are gathered and filtered from Twitter. Tweet location or mentions of locations or hashtags are important in getting the relevant content on flooding in South Sudan. Towns with reported flooding are represented on a web application with GIS functionalities. Information for Situation Awareness is generated and shared with flood victims, potential victims and humanitarian organizations, governmental and non-governmental organizations concerned with disaster response. The data collected during the half of the 2021 rainy season was experimentally used to evaluate this research and two of the areas reported to have had severe flooding in July and August 2021 based on Twitter data were also featured in an information report released by the United Nations Office for Coordination of Humanitarian Affairs (OCHA) in the first week of August 2021. The study aims to fully operationalize the Flood Disaster Management System for Situation Awareness and Response using Twitter in the next rainy season in 2022. This study shows that social media, particularly twitter is vital for gathering user generated flood related data and generating information for situation awareness which in turn can improve awareness and disaster response by partners concerned with disasters.

Keywords: Flooding, Twitter, Disaster Management, Disaster Response.

1 Introduction

Flooding is the worst natural disaster affecting parts of South Sudan almost each and every year. The country has two seasons: The wet or rainy season which runs from April to October and the dry season which runs from November to March. In recent years, the country has experienced devastating floods in towns situated along the White Nile and its tributaries, most especially in central and eastern South Sudan as reported by the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) [1], herein referred to as 'UNOCHA'. According to a November 23rd 2020 weekly re-

view by the Sudd Institute which is a South Sudanese Research Think-tank, heavy rainfall in 2019 and 2020 led to accumulation and an unprecedented rise of water levels in Lake Victoria, where the Nile starts its journey from [2]. A November 2020 report by UNOCHA termed flooding mainly in Central and Eastern parts of South Sudan as ‘abnormal’, following the overflow of the Nile, Sobat, Pibor, Lol and other rivers during the rainy season in 2020 [1].

This in turn led to flooding in eight (8) out of ten (10) states in South Sudan in 2019. In October 2020, preceded by a declaration of a state of emergency in the country, almost the whole town of Bor was submerged in what became as the worst floods in over a century [2]. Efforts from Humanitarian and Government agencies were overwhelmed by the magnitude of the floods.

UNOCHA reportedly estimated that in the 2020 floods in South Sudan, up to one million people (1,034,000) were directly affected, with flood response activities very much constrained by persistent heavy rains, infrastructure damage and physical accessibility, as well as insecurity and limited resources [1]. With this, it is imperative to consider other mechanisms of positively contributing towards disaster risk mitigation or reduction.

For that matter, Information Technology has since been used to support disaster risk reduction, with Palen et al. [3] suggesting the role of Information and Communication Technology in generating warnings and planning for response activities during the course of a natural disaster. In the past decade, coupled with citizen participation during disasters to publish, communicate, share and disseminate information, thereby helping in the response efforts of government authorities and partners [4, 5, 6]. To be particular, the role of social media networks in shaping disaster response and risk mitigation has grown ever since the devastating wild fires of San Diego in California, where Twitter was notably used to coordinate disaster response [7, 8].

The research questions (2) for this paper are: How can data on annual flooding in South Sudan, posted on Twitter be useful in Situation Awareness? How can the affected communities get information generated for Situation Awareness at times of flooding in South Sudan?

Affected populations, citizen journalists, humanitarian Organizations and others are increasingly utilizing social media during disasters by posting not only textual information, but also images and videos related to the incident. It is extremely useful for humanitarian organizations to gain situational awareness and plan relief operations supporting decision making and coordinating emergency response actions [6, 7, 8].

For the case of Flooding in South Sudan, utilizing data from twitter would aid in supplementing risk mitigation and response efforts of governmental and humanitarian organizations involved in the flood disaster cycle. In this case, it would act as an alternative source of information for Situation Awareness during floods.

2 Related Work

The present study develops a flood disaster management system for situation awareness and response using Twitter data, which aims at providing situation awareness to victims, potential victims and organizations involved in disaster management. The

field of Situation Awareness and the usage of social media particularly Twitter for situation awareness are both central to the current study. Therefore the current study explores both of these.

2.1 Situation Awareness

Situation awareness can be defined differently, in relation to the context and underlying paradigms. In the late 1980s, how pilots maintained awareness of the very many dynamic, yet complex events occurring simultaneously in a flight and how such information was used became such a growing interest. The term Situation Awareness (SA) was adopted to describe the process of attention, perception, and decision making that together form a pilot's mental model of the current situation [11, 12, 19].

One of the most common definitions of Situation Awareness (SA), is that agreed upon by The Enhanced Safety through Situation Awareness Integration in Training consortium as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future"[11]. This definition was further expanded into 3 phases of situation awareness namely [12]:

Level 1: Perception of the elements in the environment

The status, attributes and dynamics of the relevant elements in the environment have to be perceived in this level. In short, it is all about equipping oneself with the available information.

Level 2: Comprehension of the current situation. Based on the familiarity grasped in level one, level 2 situation awareness involves understanding the significance of the elements in level 1, leading to a holistic view of the environment.

Level 3: Projection of future status. The 3rd level makes it easier to project the future actions of the environments, given the knowledge of levels 1 and 2.

Hence Situation Awareness is not just limited to air traffic control but also used in many other fields like military operation systems and tactical areas such as firefighting and also spanning into fields like medicine.

Therefore, Situation Awareness in the context of Natural Disasters can be defined as "the ability to identify, process and comprehend the critical information about an incident", Federal Emergency Management Agency (FEMA) [10].

This research focuses on addressing Level 1 and Level 2 phases above.

2.2 Usage of Social Media for Situation Awareness during disasters.

Social Media Network sites such as Twitter are currently by no doubt active communication channels during disasters. Research has shown that usage of Social media dramatically increases when natural disasters occur, with communities affected by disasters, first responders, citizen journalists and news-seekers all trying to find useful information or to provide help and support where necessary. One of the biggest notable social media events followed the destructive Hurricane Sandy in 2012. Twitter reported

that the terms “sandy”, and “hurricane” were massively used and on the 3rd of November 2012, Twitter posted a tweet that said “People sent more than 20 million Tweets about the storm between October 27th and November 1st” (Twitter) [13].

2.3 Disaster Response and Relief

In the event of a disaster like a flood, potential victims need information as much as the first relief responders. In the event of a pre-disaster, during or after a disaster - potential victims, victims, Government agencies and humanitarian organizations are likely to become direct or indirect contributors of information via social media. The information from all actors posted on social media, if made into use for planning and or responding to a disaster, can provide alternative situation awareness information, secondary to that locally provided by the authorities.

Kumar et al. (2011) [14] worked on a tool that provided analytical and visualization functionalities that served as near real-time, data reduction and historical review.

Funayama et al., (2017) [15] extracted useful information from tweets by analyzing, and performing visualizations and developed a web application for extracting & searching effective information, which can be used in the time of disasters.

Ashktorab et al., (2014) [16] presented Tweedr as a Twitter-mining tool for extracting actionable information for disaster relief workers during natural disasters, - thereby enabling the extraction of relevant information for first responders from tweets generated during disasters in real time as well as enable analysis after the disaster has occurred. Tweedr consists of three main parts: classification, clustering and extraction [16]. The authors [16] extracted actionable information for disaster relief workers during natural disasters, validated with tweets collected from 12 different crises in the United States since 2006, demonstrating that “it is possible to extract nuggets of information from heterogeneous Twitter data using a relatively small set of labeled data”.

Using a number of classification methods such as sparse linear discriminant analysis (sLDA), support vector machines (SVM) and logistic regression, the authors classified whether a tweet reported a disaster damage or casualty information. Whereas during the clustering phase, filters were used to merge tweets that looked similar to one another. In the extraction phase, the authors used tokens and phrases that reported specific information about different classes of infrastructure damage, damage types and casualties [16].

Following the great East Japan Earthquake and Tsunami in 2011, Yuko Murayama et al., researched on the possibility of the usage of IT for disaster response and recovery in Japan [17]. One of the systems they implemented is the Recovery watcher, which is an information sharing system to keep people aware of the process of recovery in a disaster area by reporting images from the disaster area. According to the authors, the original idea of the Recovery watcher was to keep people aware of what was happening at the recovery stage after the disaster. They used cameras placed at multiple places in the disaster area with images uploaded to the server. After the images were processed, the people in need would then browse through the images for current situations. The information sharing space was also presented on an open street map (OSM) for lookups. To include emergency response for the actors on the scene of a disaster, they opened and implemented a functionality for people on the scene of a disaster to upload images

via social network sites (SNS) which would be managed by the information manager [17].

2.4 Originality of the present study

Flooding in South Sudan happens annually, making the areas in Central and Eastern South Sudan special in terms of socio-technical view.

The present study focuses on addressing level 1 and level 2 of Situation Awareness discussed earlier, by continuously streaming Twitter for data that can be used for Situation Awareness in areas that face severe flooding. So far, there are no studies that have utilized twitter for Flood Disaster Management and Response in South Sudan, hence the novelty of this research.

Technically, primary focus is almost always emphasized on sentiment analysis of tweets [15, 18]. In cases where the data posted on social media, Twitter in particular is too small, it presents a potential technical difficulty in sentiment analysis. South Sudan still has very low internet penetration [21] and limits the overall interactivity which is vital for sentiment analysis. This study therefore does not make use of sentiment analysis and only focuses on the main texts/messages being tweeted.

The study pursues collaboration with local sources of information, so as to share the messages generated for situation awareness with victims and potential victims as well as humanitarian organizations. Much of South Sudan is remote and exploiting other ways of sharing information other than using the internet alone is imperative in reaching the masses. This is necessary for communities that may rely much more on traditional sources of information sharing like community radio stations. Hence, the study's contribution to flood disaster management.

3 System Design

3.1 System Configuration

Individual tweets about flooding are gathered and filtered from Twitter. Tweet location or mentions of locations or hashtags are important in getting the relevant content on flooding in South Sudan. Towns with reported flooding are represented on a web application with functionalities of generating information on Situation Awareness which is relayed back to flood victims and potential victims, humanitarian organizations, governmental and non-governmental organizations concerned with disaster response.

3.2 Data Collection

Data about flooding is collected from Twitter with the help of the Twitter API (Tweepy). We created a Twitter bot account and developed a script that streams twitter for any content related to our hashtags or search terms. The script was coded to retweet any content that meets our criteria and the bot acted as an archive for flood related data.

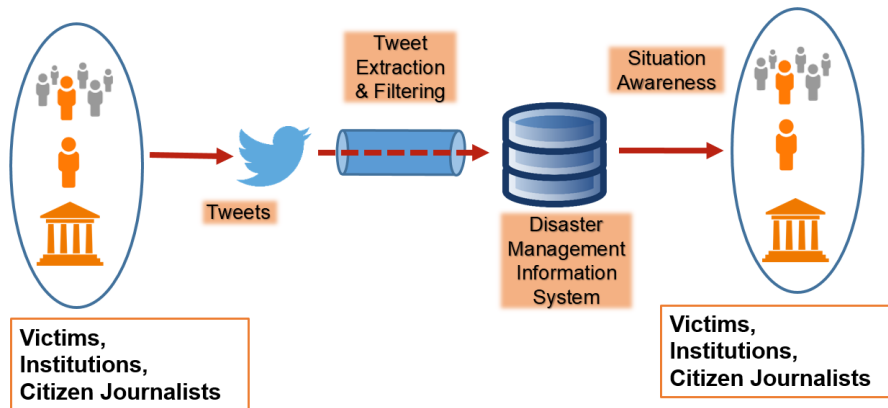


Fig. 1. System design

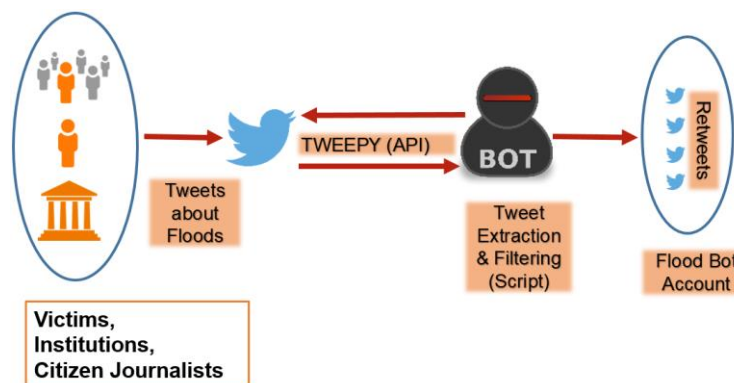


Fig. 2. Data Collection Overview

To capture random tweets might not include any of the hashtags, we also streamed tweets that mentioned any of the flood-prone counties (23) in Eastern and Central South Sudan, which contained the words flooding or floods. Otherwise a tweet is ignored.

Table 1. Streamed Hashtags, words and towns

Streaming Criteria [Hashtags, words, county-names]	
Hashtags	#floodsSouthSudan, #floodingSouthSudan, #SouthSudanFloods, #SSD-Floods, #FloodsSSD
Words	South Sudan Floods, South Sudan Flooding
Counties / Towns	Akobo, Ayod, Bor, Bor South, Pibor, Fangak, Duk, Nyirol, Pochalla, Twic East, Uror, Nasir, Maban, Maiwut, Malakal, Manyo, Melut, Ulang, Mangala, Bentiu, Rubkona, Aweil East, Aweil West

3.3 Extraction of Information Location

We filtered the data from the flood bot and looked for location matches, by comparing the location name(s) with flood prone locations in Northern, Eastern and Central South Sudan. The criteria of obtaining the name(s) of locations in the tweet data included:

1. Location mentions in the hashtags.
2. Location mentions in the tweet text if not included in the hashtag.
3. Tweet location, based on the location parameters of the original tweet author, if location settings were enabled by the tweet author.

3.4 Web Application

Flood locations plotted on a web map are based on the extracted location of the tweets from the flood bot data. A location has to be mentioned at least ten (10) times in different tweets by different tweet authors, in a period of at least fourteen (14) days. Every fourteen (14) days, the dataset is refreshed and only tweets that are within the period get plotted or refreshed. A list of affected locations is also generated and displayed.

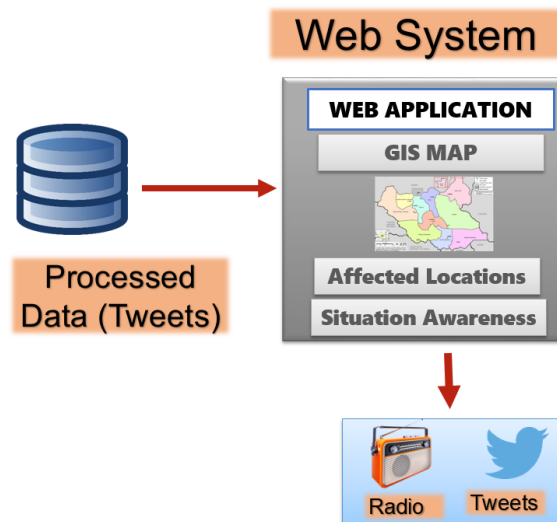


Fig. 3. Presentation on the web app

3.5 Situation Awareness

Information about flooded towns, current flooding, and Situation Awareness are displayed on the Web app. The same information is also tweeted by the Flood bot account (SSD Flood Bot). Population data of South Sudan's towns is separately stored in a database and linked to the data of the affected locations. Information for Situation Awareness includes the following: the name of the location, the population of the location and the number of tweets per the location.

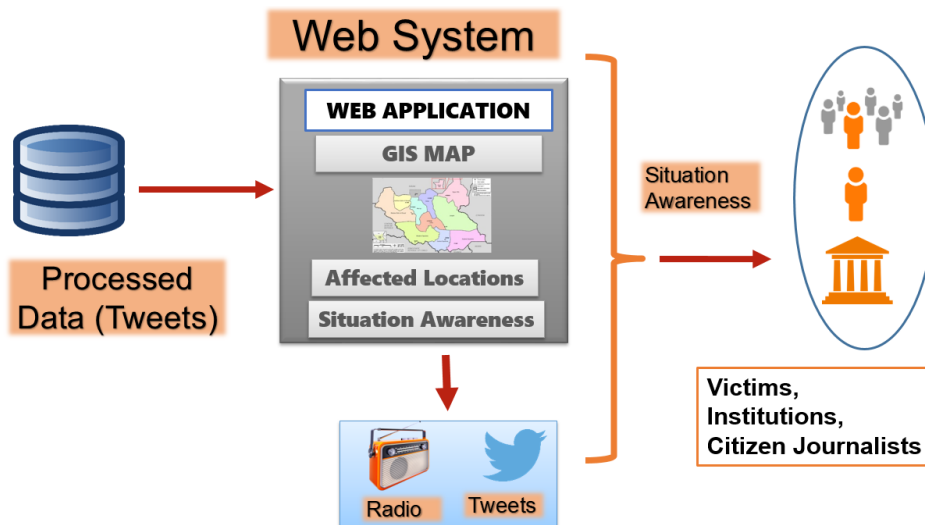


Fig. 4. Situation Awareness flow

4 System Development

4.1 System Frontend

4.1.1 Overview of System Frontend

Data obtained by the flood bot is accessed and automatic tweet locations are represented on the web map, so long as the criteria for consideration of representing the data on a map are met. For a random location to be plotted on the map, at least 10 tweets posted by different users mentioning referring to the said location are considered. This is important in reducing the possibilities of utilizing tweets that are possible sources of misinformation. The number of tweets mentioning the same location and the town population information are ingredients for generating information for Situation Awareness.

4.1.2 Flood Affected Towns

From the data extracted from the flood bot, a list of the affected areas is constructed and displayed on the web application.

4.1.2 Map Visualization of Flood Affected Towns

The web app utilizes Python's Folium library to automatically generate a map visualizing the areas/ towns that are experiencing flooding.

The web app also displays a flood heat map that visually shows the towns that are currently experiencing floods. The map and the heat map are essential visual components of the web application.



DASHBOARD

- Active Floods Map
- Current Situation
- Admin Tools
 - Affected Towns
 - Affected States
 - Map visualization

FLOOD AFFECTED TOWNS | TWITTER DATA

Show 10 entries
Search:

Town Name	Town Population	Town Description	State
Aweil East	440055.0	Major Town	JS
Ayod	192937.0	Major Town	JS
Fangak	151727.0	Major Town	JS
Rubkona	149679.0	Major Town	JS

FLOOD AFFECTED TOWNS | TWITTER DATA

Showing 1 to 4 of 4 entries
Previous 1 Next

Fig. 5. Page displaying towns affected by flooding



DASHBOARD

- Active Floods Map
- Current Situation
- Admin Tools
 - Affected Towns
 - Affected States
 - Map visualization

South Sudan Reported Floods - Areas

Map showing flood affected areas in South Sudan, including Aweil East, Rubkona, Fangak, and Ayod. The map includes an inset map of South Sudan and a scale bar.

Fig. 6. Page displaying a web map with flood affected towns

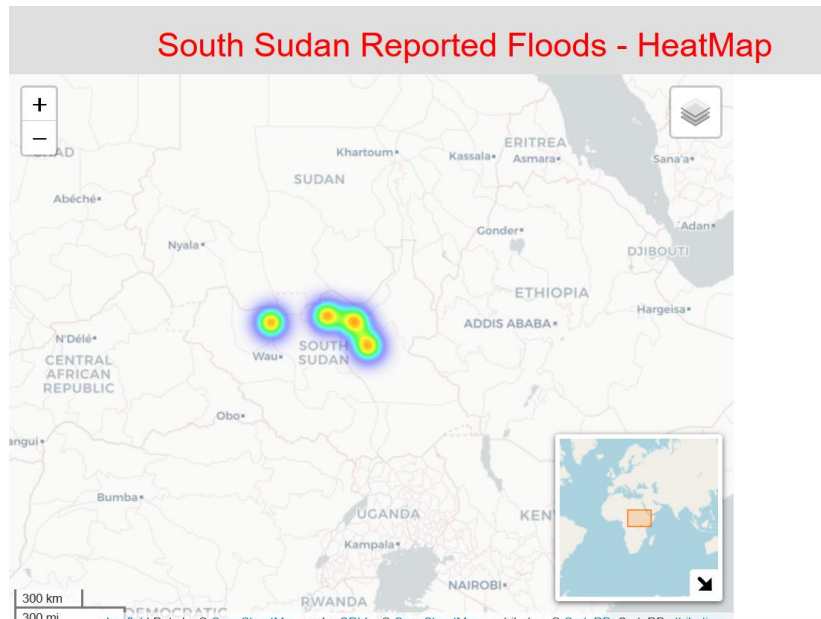


Fig. 7. Page displaying a heat map of the current towns experiencing floods

4.1.3 Situation Awareness

Information regarding a flooded town, including the population figures based on the 2008 Sudan Census and the 2017 Population estimate of South Sudan [20] are displayed on the web application and also shared on the Twitter account.

Logout

TWEET MONITOR FOR FLOODS

DASHBOARD

- Active Floods Map
- Current Situation**
- Admin Tools
 - Affected Towns
 - Affected States
 - Map visualization

Town Name: Fangak

As of August 25th 2021, Flooding has been reported in Fangak, Upper Nile. The town has a population of about 151, 727 inhabitants, according to South Sudan Population estimates of 2017.

The number of vulnerable people is unknown.

Fig. 8. Current information for Situation Awareness

4.2 System Backend

4.2.1 Process of getting and relaying data to Twitter.

The back end of the system has a connection to a Twitter account that runs on a script, called the “SSD Flood Bot”. The SSD Flood Bot Twitter account is the data source for the Flood Disaster Management System for Situation Awareness and Response.

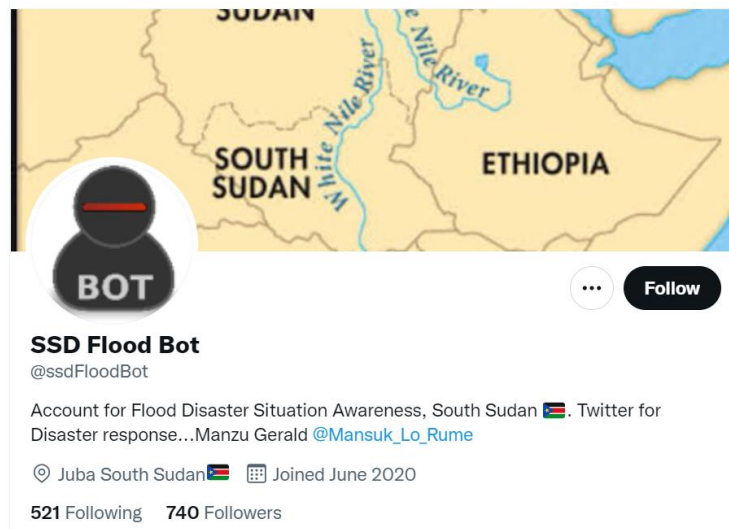


Fig. 9. Flood Bot account that streams for flood data

4.2.2 Process to Display Information on the Web Application with GIS functions

The web application makes use of the data obtained from the Twitter account by displaying a list of the affected towns in a table, and also acts as a Geographical Information System (GIS) portal in the form of displaying the flood affected towns using markers.

An extension of the GIS functionality includes a heat map, which can provide a generation view of areas or regions that are experiencing floods.

4.3 System Operation Environment

The web system can be accessed Google Chrome version 8.0.552 or higher, Internet Explorer 8 or higher and Firefox 5 or higher. The Flood Bot separately runs as a script of its own, hosted on Heroku. It interacts with Twitter using the Twitter API and Python Library called Tweepy. Python programming language was used to implement the scripts of the flood bot.

Implemented using Python and Django as the web framework for Python, the web portal as well as the flood bot scripts were both hosted on Heroku.

4.4 Operation Target Area

With severe flooding reported in Eastern, Northern and Central South Sudan in recent years [1, 2], the study target these areas in particular. The current system has been operating since June 2021 primarily focused on collecting preliminary data during the 2021 rainy season in South Sudan. In the next rainy season, the system is planned to fully be implemented in the target areas.

5 Conclusion

The system is primarily developed as a Situation Awareness and a response aid for flooding in selected major towns in Central and Eastern South Sudan. The data collected during the half of the 2021 rainy season was only used as experimental data. Complete evaluation of data awaits the completion of the rainy season. However, part of the results agreed with information released by UNOCHA in the first week of August 2021 [9]. Hence partial evaluation based on comparative reports was successful.

Within half-way the 2021 rainy season in South Sudan, UNOCHA released a Situation Report on August 6th 2021 [5] detailing about flooding and displacement of people. In the report, two (2) counties of Ayod and Fangak were both mentioned.

At the same time, based on the data that we collected from Twitter for the month of July and August, our data indicated that flooding was reported in at least four (4) towns of Aweil East, Ayod, Fangak and Rubkona. We can therefore use correlate the situation report by UNOCHA with our current findings.

This research shows that social media, particularly twitter is vital for gathering user generated flood related data and generating information on Situation Awareness which in turn can improve awareness and disaster response by partners concerned with disasters.

We have identified and sought coordination with local and national partners such as organizations and institutions that are primary sources of information to thousands of people who do not have access to the internet, for instance local radio stations. With a partnership as such, information can be broadcasted to thousands of people.

We intend to continue collecting more data and involve organizations, institutions and individuals in our research towards the end of the 2021 rainy season in South Sudan, so that the system can be fully operational in the next rainy season in 2022.

Acknowledgment: In order to interact with data on Twitter, a Twitter developer account is needed. And to make sure that the data is used in line with the Twitter API guidelines without misusing the data and without publicly sharing vital user information, the Twitter Developer Platform has been very helpful. We would like to register our gratitude to the Twitter Developer Team, of which without the resources, getting the needed information would have been a difficult task.

References

1. UNOCHA (2020, November). South Sudan Flooding Situation Report Inter-Cluster Coordination Group, as of 18 November 2020, <https://www.humanitarianresponse.info/en/document/south-sudan-flooding-situation-report>, last accessed 4 December 2020.
2. Nhial Tiimamer (2020, November). South Sudan's devastating floods: why there is a need for urgent resilience measures. The Sudd Institute, Juba South Sudan, https://suddinstitute.org/assets/Publications/5fbcef5b321bd_SouthSudansDevastatingFloodsWhyThereIs_Full.pdf, last accessed 3 January 2021.
3. Palen, L., & Liu, S. B. (2007, May). Citizen Communications in Crisis: Anticipating a Future of ICT-Supported Public Participation. Conference on human factors in computing systems, chi 2007 proceedings: Emergency action (pp. 727{736). San Jose, California, USA.
4. Truong, B., Caragea, C., Squicciarini, A., & Tapia, A. H. (2014). Identifying Valuable Information from Twitter during Natural Disasters. Proceedings of the American Society for Information Science and Technology, doi.wiley.com/10.1002/meet.2014.14505101162,
5. Sakaki, T., Okazaki, M., & Matsuo, Y. (2010, April). Earthquake Shakes Twitter Users: Real-time Event Detection by Social Sensors. Acm International World Wide Web Conference, www, 2010 (pp. 851,860). Raleigh, North Carolina, USA.
6. Imran, M., Elbassuoni, S., Castillo, C., & Diaz, F. (2013). Practical extraction of disaster-relevant information from social media. In Proceedings of the 22nd International Conference on World Wide Web - WWW '13 Companion (pp.1021 {1024). Rio de Janeiro, Brazil: ACM Press, <http://dl.acm.org/citation.cfm?doid=2487788.2488109>.
7. Imran, M., & Castillo, C. (2015). Towards a Data-driven Approach to Identify Crisis - Related Topics in Social Media Streams. In Proceedings of the 24th International Conference on World Wide Web - WWW '15 Companion (pp. 1205{1210). Florence, Italy: ACM Press, <http://dl.acm.org/citation.cfm?doid=2740908.2741729>, doi: 10.1145/2740908.2741729, last accessed 12 March 2020.
8. Imran, M., Castillo, C., Lucas, J., Meier, P., & Vieweg, S. (2014). AIDR: artificial intelligence for disaster response. In Proceedings of the 23rd International Conference on World Wide Web - WWW '14 Companion (pp. 159{162). Seoul, Korea: ACM Press. Retrieved 2020-08-19, from <http://dl.acm.org/citation.cfm?doid=2567948.2577034>, doi: 10.1145/2567948.2577034
9. UNOCHA (2020, August). South Sudan: Floods – Jul 2021, <https://reliefweb.int/disaster/fl-2021-000108-ssd>, last accessed 20 August 2021.
10. FEMA. Review: Situation Awareness, <https://emilms.fema.gov/IS2200/groups/106.html>, last accessed 22 May 2020.
11. Endsley, M.R. (1988). Design and evaluation for Situation Awareness enhancement. *Proceedings of the Human Factors Society 32nd Annual Meeting* (Volume 1, pp.97-101). Santa Monica, CA: Human Factors Society.
12. Endsley, M. R., Farley, T. C., Jones, W. M., Midkiff, A. H., & Hansman, R. J. Situation Awareness information requirements for commercial airline pilots (ICAT). Cambridge, MA: Massachusetts Institute of Technology International Center for Air Transportation (1998).
13. Techcrunch 2012, Twitter Releases Numbers Related to Hurricane Sandy: More than 20m Tweets sent during peak, techcrunch.com/2012/11/02/twitter-releases-numbers-related-to-hurricane-sandy-more-than-20m-tweets-sent-between-october-27th-and-november-1st/>
14. Kumar, S.; Barbier, G.; Abbasi, M.A.; Liu, H. TweetTracker: An analysis tool for humanitarian and disaster relief. In Proceedings of the Fifth International Conference on Weblogs and Social Media, ICWSM, Barcelona, Spain, 17–21 July 2011.

13. Funayama, T., Yamamoto, Y., and Uchida, O., "Development of visualization application of tweet data for extracting information in case of disaster," 2017, 15th International Conference on ICT and Knowledge Engineering (ICT&KE), Bangkok, 2017, pp. 1-5, doi: 10.1109/ICTKE.2017.8259620.
14. Ashktorab, Z., Brown, C., Nandi, M., & Culotta, A. (2014). Tweedr: Mining twitter to inform disaster response. ISCRAM.
15. Yuko, M., Kayoko, Y., & Jun, S. (2019). Recovery Watcher: A Disaster Communication System for Situation Awareness and its Use for Barrier-Free Information Provision, 2020, HAL-Inria Conference Papers, retrieved 26 May 2021, < <https://hal.inria.fr/hal-02799294/>> doi: 10.1007/978-3-030-32169-7_1.
16. Kaur, A. (2019). Analyzing Twitter Feeds to Facilitate Crises Informatics and Disaster Response during Mass Emergencies.
17. Adams, M. J., Tenney, Y. J., & Pew, R. W. (1995). Situation Awareness and the Cognitive Management of Complex Systems, *Human Factors*, 37(1), 85-104, <https://doi.org/10.1518/001872095779049462>.
The Republic of South Sudan – National Bureau of Statistics. Southern Sudan counts: Tables from the 5th Sudan Population and Housing Census, 2008, <https://www.ssnbss.org/home/documents/census-and-survey/south-sudan-counts-2008/>, last accessed 24 January 2021.
18. Individuals using the Internet (% of Population) – South Sudan, <https://data.worldbank.org/indicator/IT.NET.USER.ZS?locations=SS>