2020 International Conference on Computational Science and Computational Intelligence (CSCI) | 978-1-7281-7624-6/20/$31.00 ©2020 IEEE | DOI: 10.1109/CSCI51800.2020.00219

An Interactive Dashboard to Study the Impact of Hurricane Florence on Food Bank Operations

Bantwale Enyew
Applied Science & Technology Phd Program
North Carolina A&T State University
Greensboro, USA
bdenyew@aggies.ncat.edu

Kehinde Odubela
Department of Industrial and Systems Engineering
North Carolina A&T State University
Greensboro, USA
kaodubela@aggies.ncat.edu

Steven Jiang
Department of Industrial and Systems Engineering
North Carolina A&T State University
Greensboro, USA
xjiang@ncat.edu

Lauren Davis
Department of Industrial and Systems Engineering
North Carolina A&T State University
Greensboro, USA
lddavis@ncat.edu

***Abstract*—North Carolina is the third most hurricane-prone states in the US. In 2018, Hurricane Florence caused a lot of damages to households in North Carolina. The Food Bank of Central and Eastern North Carolina (FBCENC) serves 34 counties in North Carolina, and 22 of them were affected by Hurricane Florence. This research aims to investigate the impact of Hurricane Florence on the operations of FBCENC. We developed interactive dashboards to visualize food bank operational data and other relevant data and studied the trends and patterns of food distribution in three key stages: preparedness, response, and recovery. These dashboards enable food bank operations managers to explore and interact with the data with ease to explore the operational data at different stages, at different branch level, and on a different time scale (monthly, weekly, or daily). The impact on the operations of affected service areas vs. not affected areas could be investigated as well. The findings of this research will provide insight into how humanitarian relief agencies can better prepare for, respond to, and recover from the disruptions caused by hurricanes.**

Keywords—Interactive Dashboard, Hurricane, Food Bank

I. INTRODUCTION

Food insecurity is one of the serious problems facing America. In 2018, about 1 in 9 Americans experienced food insecurity equivalent to over 37 million Americans, including more than 11 million children [1]. The United States Department of Agriculture (USDA) has defined low food security as "reduced quality, variety, or desirability of diet" with "little or no indication of reduced food intake" and very low food security as "multiple indications of disrupted eating patterns and reduced food intake [1]. Natural disasters such as floods and hurricanes caused by extreme weather and climate events, interacting with exposed and vulnerable human and natural systems, can lead to disaster [2], causing pervasive disruption across all socio-ecological models. These disasters can impact market access, trade, food supply, reduced income, and increase in food prices, increasing the prevalence of food insecurity and malnutrition [3].

Tropical cyclones, which include hurricanes (in the North Atlantic and East Pacific) and typhoons (in the west Pacific), are among the most severe natural disasters that cause tremendous loss of life and property that causes suffering among societies and post-disaster food insecurity [4]. When a natural disaster such as a hurricane happens, food banks play an essential role in alleviating food insecurity and other problems associated with it. Food banks are non-profit hunger relief organizations that strive to counteract the adverse effects of food insecurity; they mainly rely on donors' goodwill that provides cash or in-kind food donations [5, 6].

The Food Bank of Central and Eastern North Carolina is a non-profit organization that provides food for the people facing hunger in 34 counties in central and eastern North Carolina for the past 40 years [7]. It is affiliated with Feeding America, the nation's largest food relief organization.

Hurricane Florence was a powerful and long-lived Cape Verde hurricane that caused catastrophic damage in the Carolinas in September 2018, primarily due to freshwater flooding due to torrential rain [8]. Florence made landfall in the United States just south of Wrightsville Beach, North Carolina, as a Category 1 hurricane, it caused storm surge. It flooded due to the record-breaking rainfall with a maximum total of 35.93 inches in some areas in North Carolina.

Florence affected 22 counties related to 2 branch locations of Foodbank of central and eastern North Carolina (FBCENC)-Wilmington and New Bern, caused 15 direct fatalities, nearly 140, 000 residents registered for disaster assistance, and damage loss of about $22 billion in North Carolina alone [8]. The fatalities and social and economic impacts of hurricane Florence are documents in detail by a brief communication paper [9]. The food bank typically responds to hunger need in the counties under its service area; however, the destruction caused by Hurricane Florence further increased that need as the affected people were mostly without food, water, and power. In preparation for the hurricane, the food bank opened 43 shelters in the potential area of impact to support people in need of accommodation and food. Even as the food bank continued distributing relief items it received from donors to those affected, many of its partner agencies were out of operation. This disruption to its network impaired the foodbank's visibility to demand and its supply of food was limited by restricted access to people in need. These challenges are the motivation

978-1-7281-7624-6/20/$31.00 ©2020 IEEE
DOI 10.1109/CSCI51800.2020.00219

for this project. Employing an interactive data visualization and analysis techniques, this documents the challenges encountered by FBCENC after Hurricane Florence by exploring and analyzing its operational data before, during, and after the disaster to quantify the extent of the disruption it caused. This study aims to explore and analyze the operational data of FBCENC to quantify the impact of Hurricane Florence on its operations. The research questions are:

1. What was the amount of food distributed during the preparation, response, and recovery periods of Hurricane Florence at the food bank level as well as at branch levels?
2. How much food is distributed by each county in central and North Carolina?
3. What was the disaster's effect on donations, and how did the donation evolve over time?

II. METHOD

A. Data Collection and Preprocessing

We collected food bank operations data from FBCENC that covers the period from May 2018 to May 2020. The data contains about 800,000 records and 93 variables. Some of the variables include information regarding the agencies, branches, counties served, the type and amount of food given to each agency at any time of visit, the reason for that donation and many others. Figure 1 displays a screenshot of the variables.

Fig. 1. Snapshot of the operations data from FBCENC

For this research, we focused on a few selected variables as show in Table 1. Posting Date provides the date the data was posted. Entry type indicates the record is related to distribution, transfer or purchase. Description describes the type of food (i.e., dry food). Ext_Gross_Net Weight provides the weight of the items received and NC Branch Code indicate the specific branch this operational data belongs to.

Before operations data can be analyzed, preprocessing including checking for erroneous data, missing data, outliers, interpreting data, and filtering data were conducted. The operations data were entered by more than one person at the food bank, so there are tendencies to have some incomplete data, inconsistencies, and mismatches, and other errors. Erroneous data were corrected, and missing data were removed before analysis. For this data set, the outliers in the field relating to the amount of food distributed were included in the analysis since they reflected the actual data obtained for the food bank operations.

TABLE I. DATABASE FIELDS AND DESCRIPTION INCLUDED IN THIS RESEARCH

Variable Name	Description
Posting Date	Date item was entered
Entry type	Classifies entry as distribution, negative adj, positive adj, purchase or transfer
Description	Food type
Ext_Gross_Net Weight	Weight of item received
NC_Branch Code	Letter assigned to define each branch
FBC_County_Code	Name of counties in North Carolina

Using the timeline of Hurricane Florence, we divided the data into three sets corresponding to the three time periods: the preparedness period (May 30, 2018 – September 07), response period (September 08 – September 29, 2018) and recovery period (September 30 – December 31, 2018). The decision to choose these time periods is based on the time of FEMA emergency declaration and emergency of state declaration by state governor, which is between September 08 and September 29, 2018 [8,10]. The affected and unaffected counties are also identified based on the FEMA designated areas that qualify for receiving some kind of assistance.

B. Development of Interactive Dashboards

We interviewed FBCENC operations managers and affiliated agency representatives to determine their needs of the interactive dashboards. It was determined that such dashboards need to allow them to explore their food distribution at the food bank level as well as the branch level. They would like to see monthly, weekly, as well as daily data and the dashboard should provide an easy way for them to change the visualizations. They would also like to be able to compare the operations data between affected and non-affected counties in their service area.

Python was used to import the data and develop the interactive dashboards.

III. Results and Discussion

Based on the food bank managers' input, we have developed various interactive dashboards to assist them to assess the impact of Hurricane Florence on their operations.

A. Food Distribution Dashboard

FBCENC has six branches: Raleigh, Durham, New Bern, Hanover, Greenville, and Wilmington. This interactive dashboard allows the user to explore their distribution data by choosing from the entire food bank or selecting a few branches. The user can also use the slider bar to choose the range of time for exploration.

Figures 2 depicts the interactive dashboards for the amount of monthly food distributed by each branch for the period from August 2018 - May 2020. The figure shows that the monthly food distribution generally trends upward (an increasing trend in food distribution) for all counties. The highest food distribution was made by the Raleigh branch and the lowest amount made by Sandhill branch. The operations managers could be interactive with the visualization for different combinations of periods and branches.

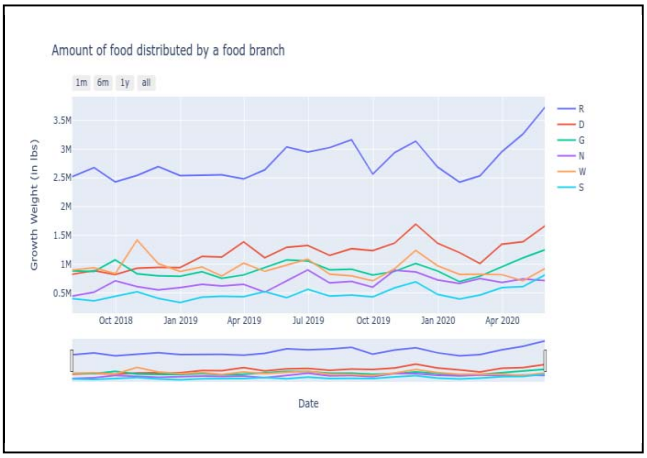

Fig. 2. Interactive dashboard for monthly food distribution at a branch

Figure 3 depicts the interactive dashboard for food distributed daily by each branch for the period from August 2018 - May 2020. There is periodic peak distribution of food for most branches that occurs monthly. Comparing with the visualizations in Figure 2, the monthly time series graph shows a smoothed pattern and no peak distribution could be found.

This is because the variability got lost when aggregate the food distribution on a monthly basis. The flexibility of the interactive dashboard allows the food bank operations managers to interact with the data with ease and can extract the information of a big picture as well as details. Specifically, they can examine the distribution data for each of the three periods.

Figures 4 and 5 are daily and monthly interactive dashboard for food donation at each branch. Like the daily food distribution, the donation also exhibits some periodic peaks/patterns for few branches. The monthly donation shows a sharp decline in donation at from September to October 2018. However, unlike the food distribution that shows an increase in amount of food distribution, food donation at all branches doesn't show much variability- almost the same throughout all times. Food distribution is significantly larger than food donation at all branches.

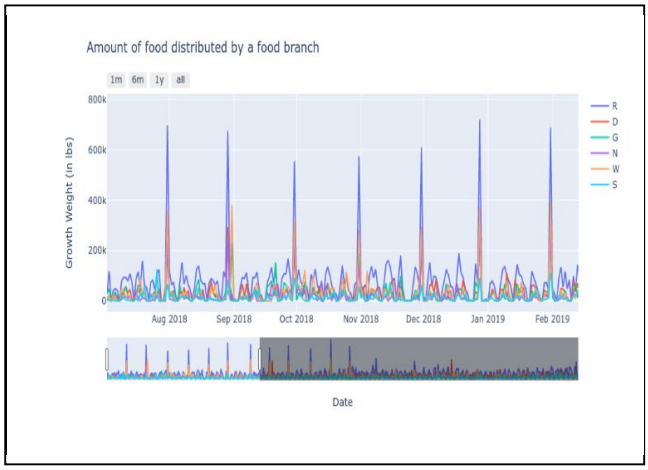

Fig. 3. Interactive dashboard for daily food distribution at branch level

Fig. 4. Interactive dashboard for daily food donation at branch level

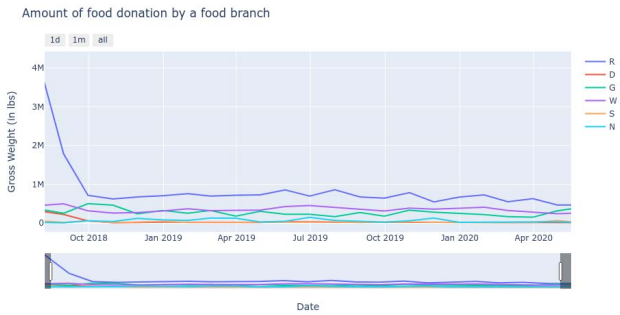

Fig. 5. Interactive dashboard for monthly food distribution at branch level

Figures 6 provides the summary information about the food distribution at preparedness, response, and recovery periods by each branch under the food bank. In agreement with the monthly

plot (Fig.2) above the total food distributed aggerated for each stage is significantly higher for Raleigh branch for all stages.

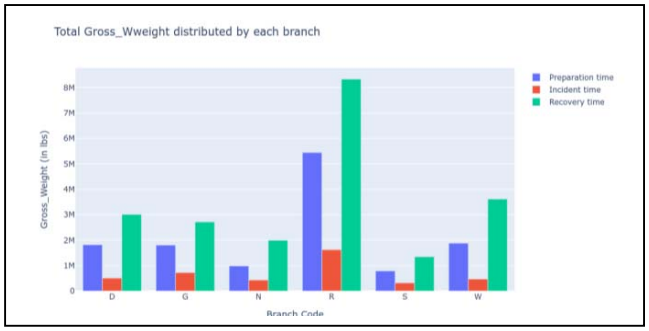

Fig. 6. Total amount of food distributed by each branch for the preparedness, response, and revocery periods

Although there is an overall trend of food distribution dips in response period and bounce back sharply in the recovery period, the difference of food distribution in the three periods vary from one branch to another.

The details of the distribution data can be found in Figure 7. The top figures show the distribution data for the preparedness period. The middle figure describes the food distribution data for the response period. The bottom figure shows the distribution data for the recovery period.

B. Evolution of Food distribution for the three stages

Figure 7 depicts a detailed daily food distribution by each branch for three stages. The top plot is the food distribution pattern for the preparedness period, which shows variability in food donation amount across time. The amount of food distributed peaked between July 29 and August 5, 2018 and August 26 and September 2. The maximum in food distribution happen almost at the same time period interval for all branches, however the amount of food distributed varies across branches and through time. The middle figure is for the response period. Hurricane Florence makes landfall on September 14 on North Carolina, the pattern shows that before it makes landfall food distribution peaks between September 9, and September 13 for all branches and no food distribution during the land fall. The distribution peaks again on around September 21 and dips after a day or two and peaks again on September 26 and 27. Since hurricane Florence was a slow-moving storm it produces a record rainfall and flooding [8], hence resulting in interruption of food distribution. From the middle figure (in fig 7), we can see that the food distribution has stalled or flat for days in the most affected branches that are located near the landfall area, which are Wilmington (W) and Newburn (N).

C. Evolution of Food donation for the three stages

The food donated to each branch during the three stages is depicted in figure 8. The top figure shows the amount of food donated to each branch during the preparedness time. The food donated shows less variability in time as compared to the food distribution discussed in section B above. In addition to that, the amount of food donated is significantly smaller than that of food distributed. The amount of food donated is almost none for most branches except some random donation Greevile branches during the response time (middle figure). For recovery time (bottom figure), the donation pattern for Raliegh and Wilmington branches shows some periodic peaks similar to food distribution. For other branches, food donation is flat or none and doesn't show variability with time.

Fig. 7. The total amount of food donated each brach for the preparedness, response, and recovery periods

D. Food distribution by county for the three stages

Each county's total amount of food is computed by classifying the counties served by the food bank as affected and non-affected, based on the FEMA declaration map [9]. Figure 9 shows the aggregated food distribution by each county for the three stages. Wake county that is not affected by the storm, shows significantly higher food distribution than other counties for all three phases. Studying food distribution by county can help to figure out which counties are more socially vulnerable for food shortage/insecurity during such disaster occurrence and plan according to reach out quickly during an emergency

Fig. 8. The total amount of food donated each brach for the preparedness, response, and recovery periods

IV. SUMMARY AND CONCLUSION

This study examined the impact of Hurricane Florence on local food bank operation and produced an interactive dashboard using the python and plotly package to help foodbank managers to interactively visualize food donation and distribution behavior in three stages of the disaster management and for daily, weekly, and monthly aggregated data. The analysis results showed interruption of food distribution and donation during the response time due to the hurricane caused flooding and road blockage that makes it hard for food banks to access their clients, leading to food insecurity. There is an improvement in food distribution and donation during recovery time, suggesting that after flooding and highway interruption are abated. Future studies should also focus on the analysis of the food kind distributed and donated for the three stages, as the quality of food is also one factor in food security matters.

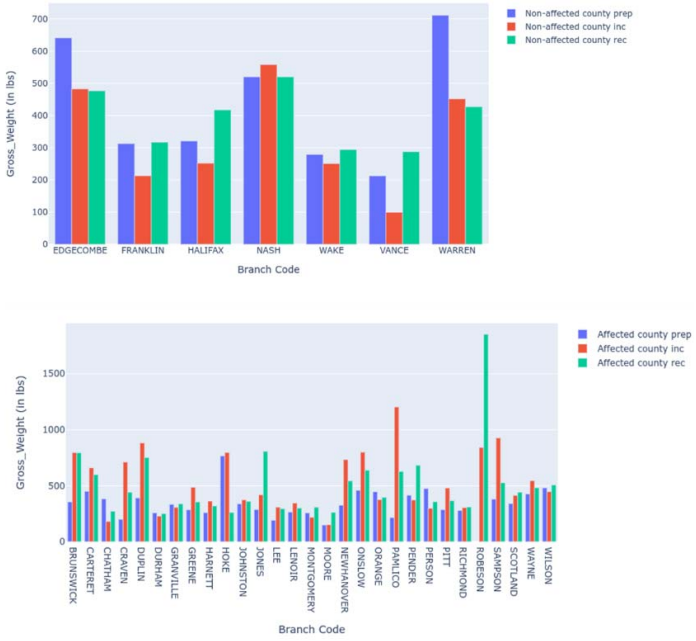

Fig. 9. The total amount of food distributed by county for the preparedness, response, and recovery periods

ACKNOWLEDGMENT

We would like to thank food bank of Central and North Carolina for provide us the dataset used in this study. This project was supported by NSF National Research Traineeship Project Improving Strategies for Hunger Relief and Food Security using Computational Data Science (Award No. DGE-1735258)

REFERENCES

[1] An overview of food security in the United States-definition and key statistics and grapics: [(accessed on 14 October, 2020)]; Available online: https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/].

[2] IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. Cambridge

University Press, Cambridge, UK, and New York, NY, USA, 582 pp

[3] Tirivangasi, H.M., 2018, 'Regional disaster risk management strategies for food security: Probing Southern African Development Community channels for influencing national policy', *Jàmbá: Journal of Disaster Risk Studies* 10(1), a468. https://doi.org/10.4102/jamba.v10i1.468.

[4] Lauren A. Clay, Ashley D. Ross Int J Environ Res Public Health. 2020 Feb; 17(3): 762. Published online 2020 Jan 25. doi: 10.3390/ijerph17030762 PMCID: PMC7036850.

[5] Thompson, K. L., Sugg, M., & Barth, M. M. (2019). The North Carolina food pantry organizational capability and mapping study: Research brief and pilot study. Journal of Agriculture, Food Systems, and Community Development, 9(1), 75–87. https://doi.org/10.5304/jafscd.2019.091.031

[6] Davis L.B., Jiang S.X., Morgan S.D., Nuamah I.A., Terry J.R. (2016). Analysis and prediction of food donation behavior for a domestic hunger relief organization. International Journal of Production Economics, 182 (2016), pp. 26-37

[7] Food Bank of Central and Eastern North Carolina: [accessed on October 14, 2020]; Available online: https://foodbankcenc.org/about-us/our-story/

[8] National Hurricane Center Tropical Cyclone Report-Hurricane Florence (31 Augest-17 September 2018).: [(accessed on 21 September, 2020)]; Available online: https://www.nhc.noaa.gov/data/tcr/AL062018_Florence.pdf.

[9] Paul, S.; Ghebreyesus, D.; Sharif, H.O. Brief Communication: Analysis of the Fatalities and Socio-Economic Impacts Caused by Hurricane Florence. *Geosciences* 2019, *9*, 58.

[10] North Carolina Hurricane Florence (DR-4393-NC)-[Accessed September, 2020]; Available online: https://www.fema.gov/disaster/4393