Technical Report: Evacuation Behavior Survey Report

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1. EXECUTIVE SUMMARY

The NIMSAT Institute at the University of Louisiana at Lafayette is currently developing a Fuel Demand Estimation model for the Louisiana's department of Natural Resources. The fuel demand and evacuation traffic to a large extent relies on the behavior of evacuees; therefore it is imperative to study some important behavioral factors during evacuation. The NIMSAT Institute in collaboration with the department of Sociology at the University of Louisiana at Lafayette has conducted a survey to understand the evacuation behavior on various coastal parishes in the state of Louisiana between October 2010 and December 2010. This report provides a summary of the survey results on *how*, *when* and *where* people have evacuated in the past, how many vehicles they took and how many gallons of fuel they filled up for four major hurricane tracks.

2. BACKGROUND

Human behavior and decision making process under hurricane risk is a complex issue influenced by various factors. There has been a lot of research in understanding human behavior before and during an event through studies on factors influencing human behavior during an event [1][2]. There have also been various attempts to model the decision-making process by conceptualizing the reasoning process on the perception of hurricane risk [4] based on demographic and socioeconomic profiles for a given geographical region. There are also studies done by FEMA across the nation to study evacuee behavior that are incorporated into HURREVAC [3], an evacuation modeling tool. But we have not found any studies or data that we could use for our evacuation model. Hence we have taken up this study.

The general goal of this survey was to obtain data on household evacuation response and understand how people have evacuated in the past and how they filled up their tanks during these events. The survey was conducted by Dr. Robert Gramling and Dr. George Wooddell from the department of Sociology and the report is prepared by Dr. Raju Gottumukkala of the NIMSAT Institute.

People involved

The following people were involved in the design of the survey

1. Dr. Robert Grambling, Professor, Department of Sociology, UL Lafayette
2. Dr. Ramesh Kolluru, Executive Director, NIMSAT Institute, UL Lafayette
3. Dr. George Wooddell, Associate Professor, Department of Sociology, UL Lafayette
4. Dr. Raju Gottumukkala, Computational Scientist, NIMSAT Institute, UL Lafayette
5. Dr. Mark Smith, Associate Professor, Department of Management, UL Lafayette
6. Dr. Xiaoduan Sun, Professor, Civil Engineering, UL Lafayette
7. Mr. Dean Mallory, Assistant Director, NIMSAT Institute

3. METHODOLOGY

As part of this study, we have collected data via telephone interviews with coastal Louisiana residents. The data was collected for 14 previous storm tracks and 27447 people were surveyed out of which we received 4298 responses.

Hurricane Track	Frequency	Percent
Andrew	92	2.1
Cindy	7	0.2
danny85	16	0.4
danny97	1	0.0
Dennis	6	0.1
Georges	62	1.4
Gustav	1346	31.3
Humberto	6	0.1
Ike	301	7.0
Ivan	77	1.8
Juan	5	0.1
Katrina	1676	39.0
Lili	96	2.2
Rita	607	14.1
Total	4298	100

Table 1 Percentage of Respondents for various hurricane tracks

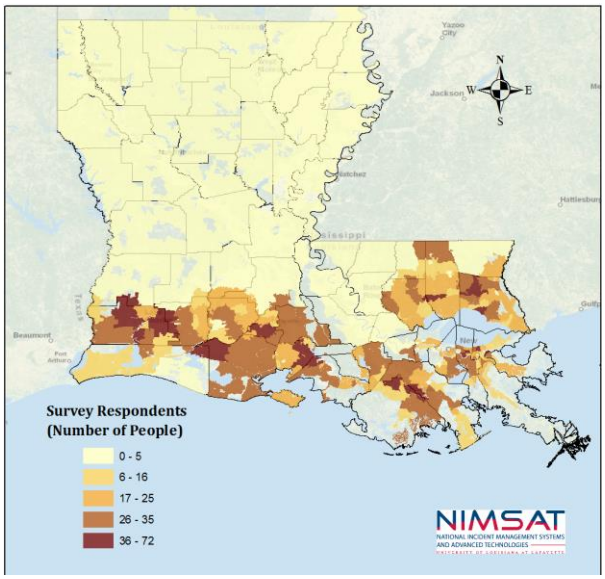

Figure 1 Survey respondents by Zipcode

Table 1 shows the frequency and percentage of respondents for various hurricanes. 31.3% of the survey respondents have evacuated for Gustav, 39% have evacuated for Katrina 14.1% have evacuated for Rita and 7% have evacuated for Ike. Considering that these four tracks have the highest sample sizes, we have chosen to study the evacuation behavior for these four tracks. The data was collected by Zipcode. Figure 1 shows the survey respondents by the number of people across various zip codes.

The survey was designed to collect data on the following:

1. The percentage of household evacuations for various hurricane tracks
2. How long before the storm did the household evacuate
3. What destination did they leave to
4. How many vehicles did the evacuees take
5. What highways did they use
6. How many gallons of fuel they filled up

Sampling strategy

From a complete list of land lines in coastal area codes we generated a stratified random sample from which we obtained approximately three thousand of our completed calls. Another group of mobile phone numbers was generated by random dialing within cell phone exchanges. Approximately one thousand completed calls were derived from that mobile phone list. We drew from each exchange a sample of numbers proportional to the total number of phones in the exchange.

4. SURVEY RESULTS

This section provides a preliminary analysis and discussion of the of the evacuation behavior survey response. Each of the below analysis would include a comparison of the results for four hurricane tracks.

4.1 Household evacuations

a. Hurricane Katrina

Hurricane Katrina made landfall on August 29 2005 in southeast Louisiana and was the most deadly storms in recent decades. Approximately 1.2Million residents of the gulf coast were issued an evacuation order that includes most of the parishes in southeast Louisiana and coastal areas of Mississippi and Alabama. A more comprehensive discussion on the timeline and the scope of the storm can be found in [5].

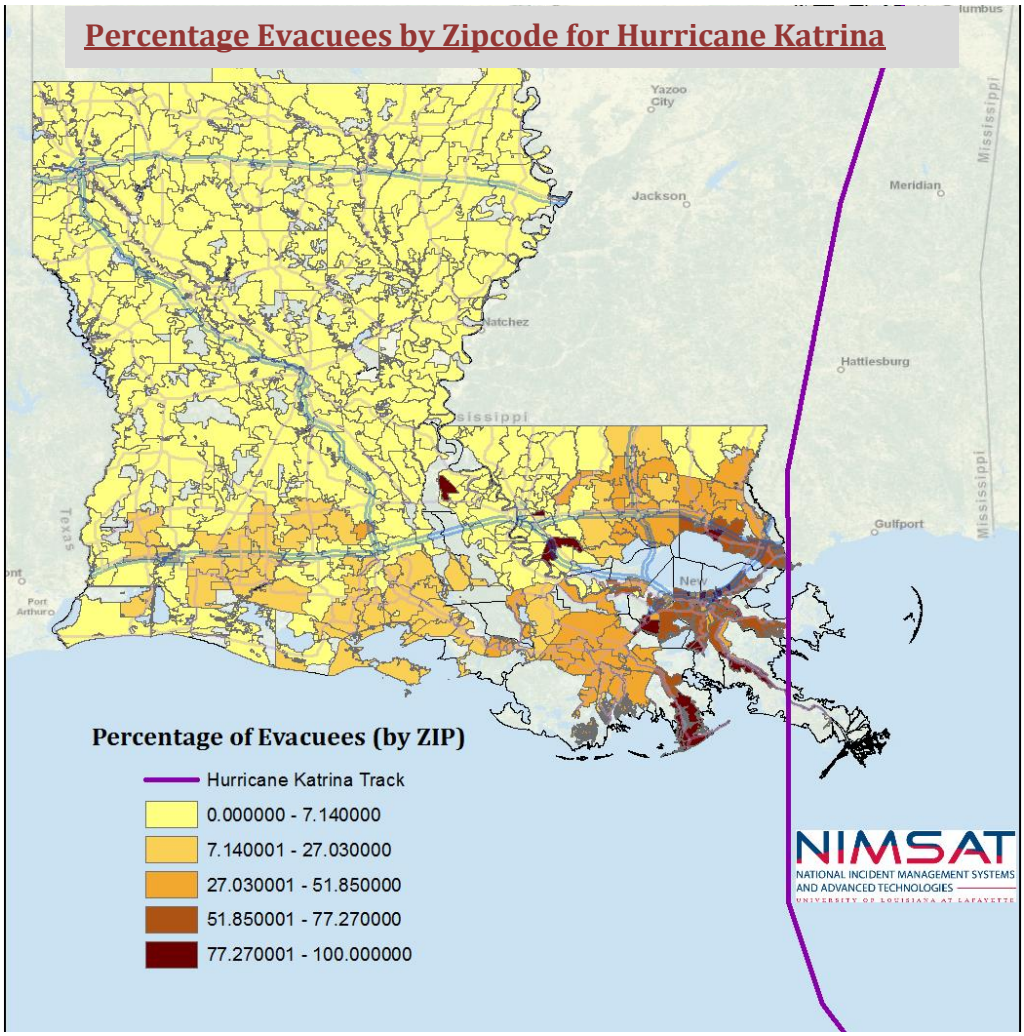

Figure 2 Respondents that evacuated for Katrina

Figure 2 shows the percentage of survey respondents that evacuated for hurricane Katrina by zip code. In the sample survey of 4298 respondents, 39% have evacuated for hurricane Katrina. One can see that a majority of evacuees fall in the range of hurricane.

b. Hurricane Gustav

Hurricane Gustav made landfall on August 31 2008 as a category 2 hurricane along Louisiana coast. Approximately 1.9 Million people evacuated from southern Louisiana [7], with 200,000 being residents of New Orleans. This was the largest evacuation in the history of Louisiana. More details on hurricane Gustav timeline and scope can be found in [6].

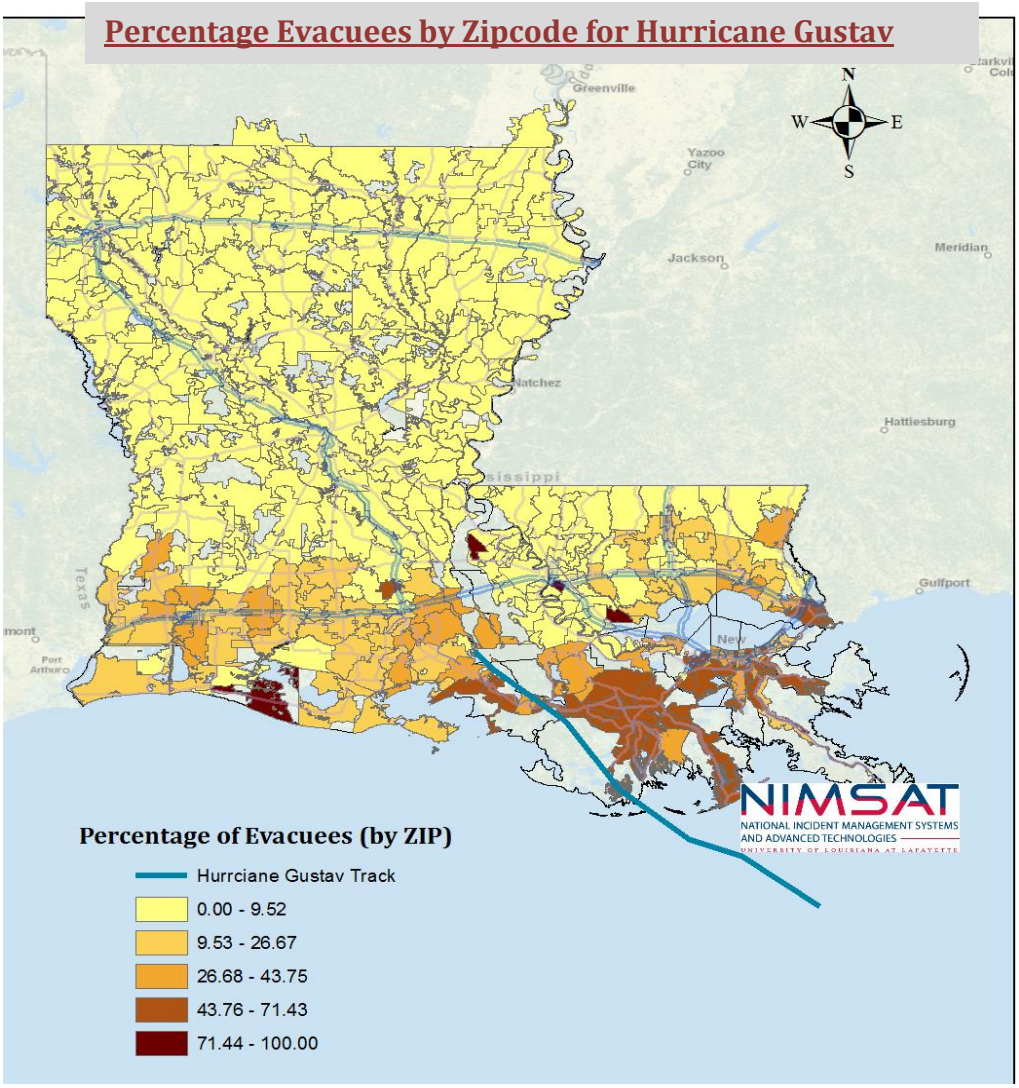

Figure 3 Respondents that evacuated for hurricane Gustav

Figure 3 shows the percentage of survey respondents that evacuated for hurricane Gustav by zip code. 31.3% of respondents have evacuated for hurricane Gustav out of 4298 responses. It is evident that a majority of respondents in the coastal evacuation zones and new Orleans have evacuated.

c. Hurricane Rita

Hurricane Rita made landfall on September 23 as a category 3 hurricanes between the border of Texas and Louisiana and more than 1.3 Million people have evacuated for Rita in Texas and Louisiana. More details of the storm can be found in [8].

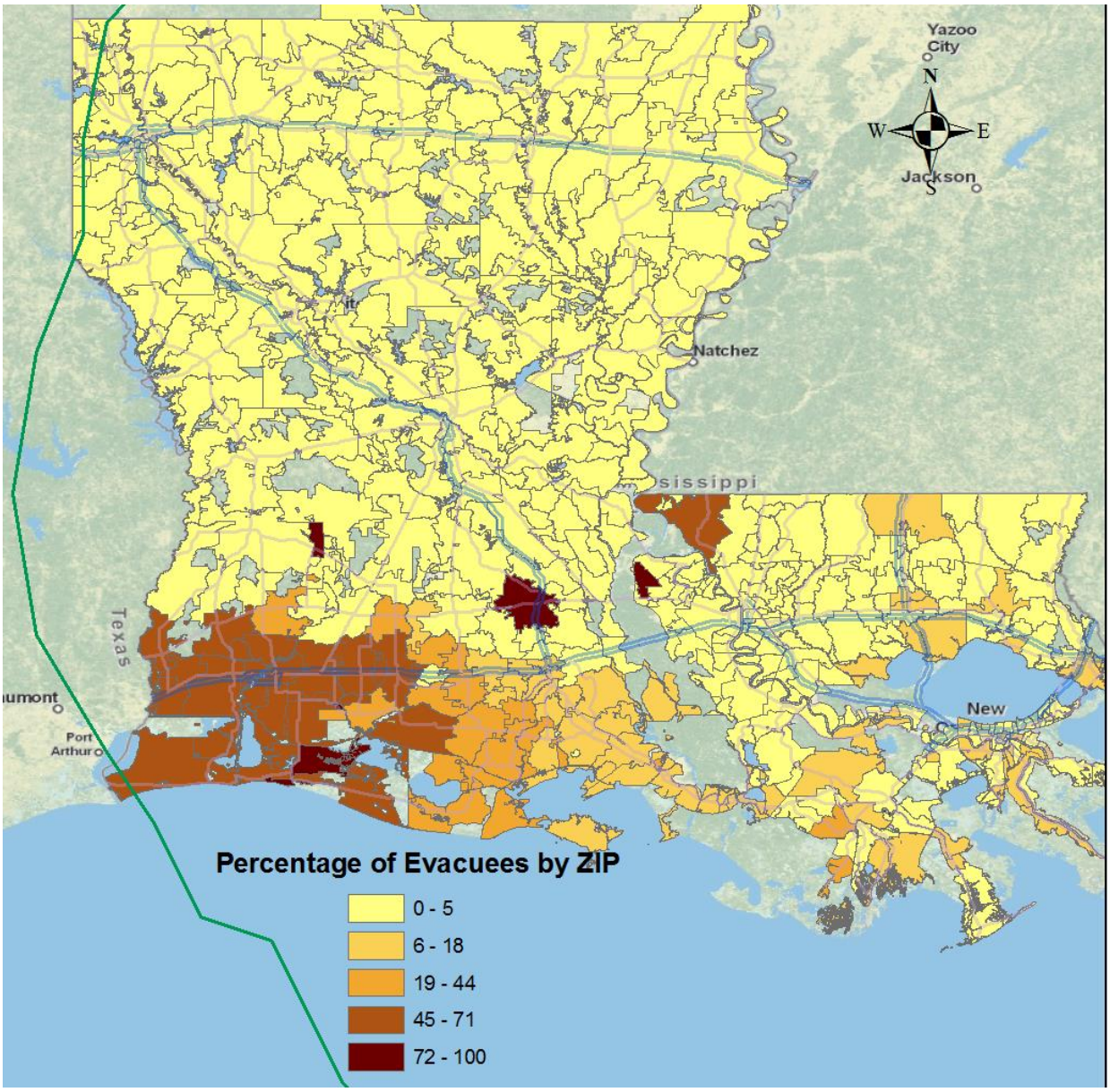

Figure 4 Respondents that evacuated for hurricane Rita

The map in Figure 4 shows the percentage of survey respondents who evacuated for hurricane Rita by zip code. We can observe that a majority of south west Louisiana has evacuated. Out of the total number of respondents, about 14.1% of them have evacuated for hurricane Rita.

d. Hurricane Ike

Hurricane Ike made landfall on September 13 in Galveston Texas as a category 2 hurricane. Mode details on the storm can be found in [9].

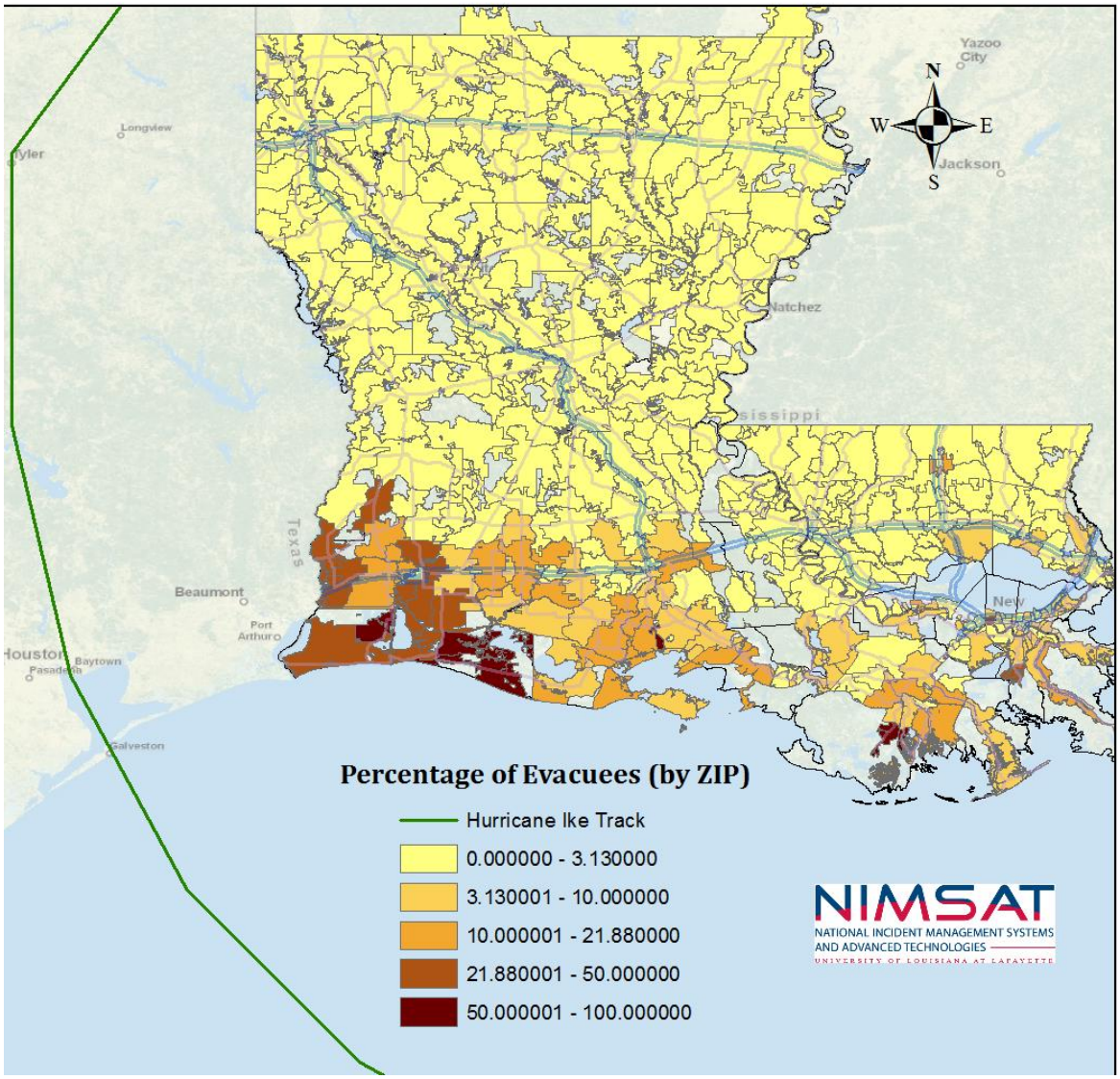

Figure 5 Respondents that evacuated for hurricane Ike

The above map shows the percentage of survey respondents that evacuated for hurricane Ike by zip code. The map in Figure 4 shows the percentage of survey respondents who evacuated for hurricane Rita by zip code. We can observe that a majority of south west Louisiana has evacuated. Out of the total number of respondents, about 7% of them have evacuated for hurricane Ike.

4.2 Evacuation times

Figure 6 illustrates a summary of evacuation times for four different hurricane tracks over a 5 day period prior to landfall, where H-0 is the day of the landfall. The respondents were asked how many days ahead they evacuated for a particular track, and at what times. A majority of them responded with morning, afternoon or evening as the possible times of days that they evacuated, therefore any data that was in hours was truncated to morning, afternoon and evening.

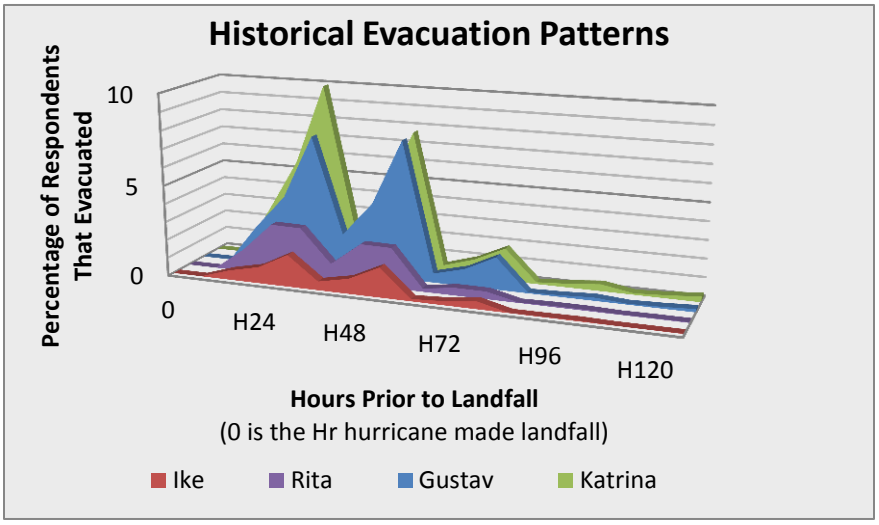

Figure 6 Evacuation Times for various hurricane tracks

Out of the total number of respondents (both that have evacuated and not evacuated), the graphic in Figure 6 shows the percentage of people that have evacuated on various days (in interval of 8 hours times). This graphic also illustrates an interesting pattern on the loading pattern of evacuees over a 5 day period onto the evacuation network.

4.3 Evacuee destinations

One of the inputs for the hurricane evacuation traffic estimation model is the origin and the destination choice of the evacuees. A significant percentage (about 60%) of the surveyed data has the destination cities; which is useful for the evacuation model. For this report, we have confined our analysis of destination choices at the state level but plan to incorporate the destination parishes/cities in the future model.

The graphic in Figure 7 shows the destination choices of various evacuees for various hurricane tracks. The spatial distribution of evacuee destination is pretty sparse, this is evident from our survey data that showed that for hurricane Katrina, people evacuated to as many as 26 different states. During Gustav, they evacuated to 23 different states, 15 states for Rita and 12 states for Ike. However, a majority of the evacuated population (about 47% for Katrina, 36% for hurricane Gustav, 63% for hurricane Rita and 57% for hurricane Ike) actually evacuated to other places within Louisiana. Texas and Mississippi were the second and third major destination choices.

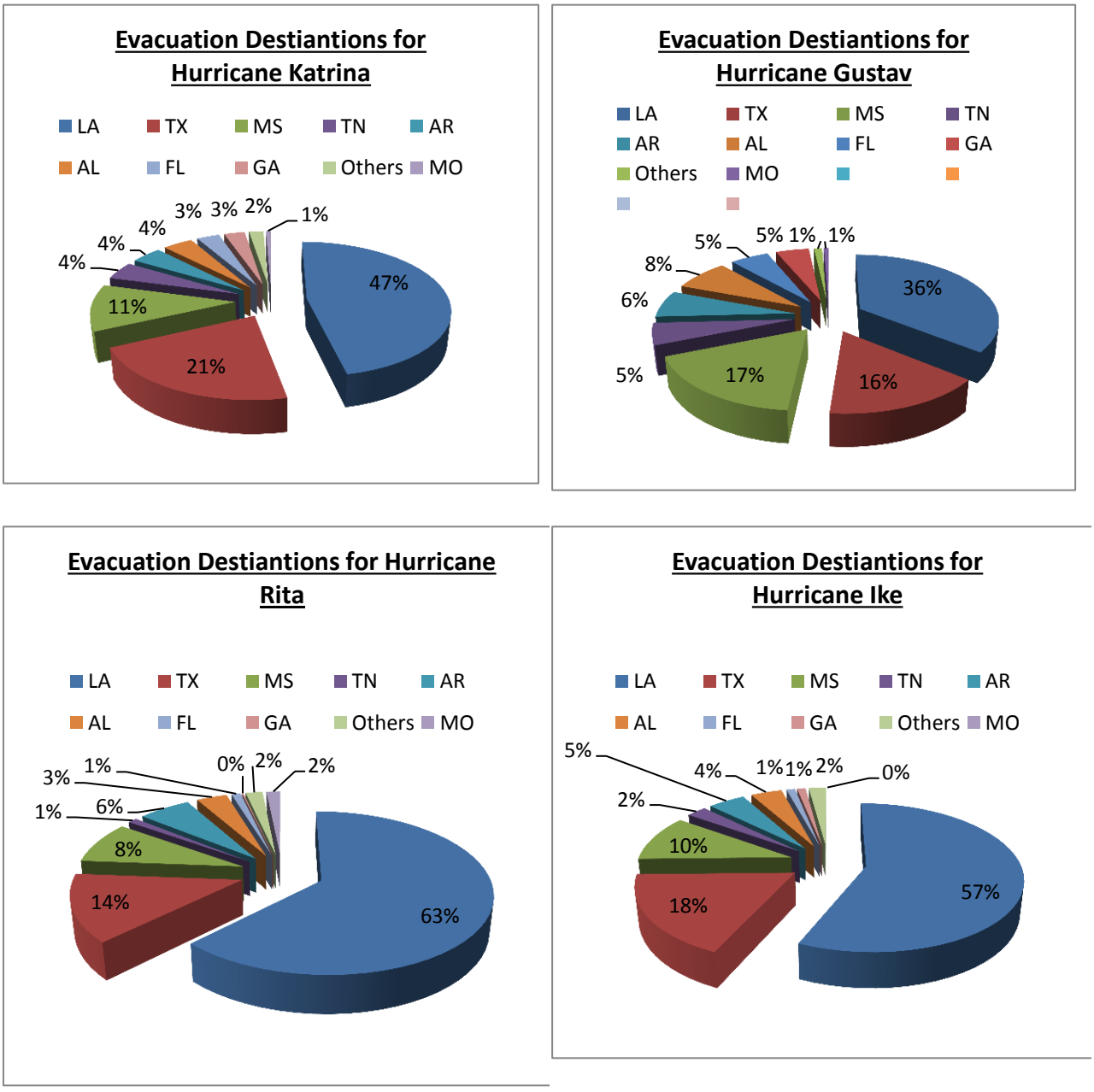

Figure 7 Evacuation destination choices for various evacuees

4.4 Number of vehicles

The traffic volume along the evacuation highway and the fuel demand is directly related to the number of vehicles that each household take during evacuation. It is well known that not all households will leave in one vehicle. In order to attribute the number of vehicles to the household data, we have studied the number of vehicles that people have taken with them during evacuation.

We observed that for each household took 1.65 vehicles during evacuation, 1.7 for Ike, 1.6 for Katrina and 1.73 for hurricane Rita.

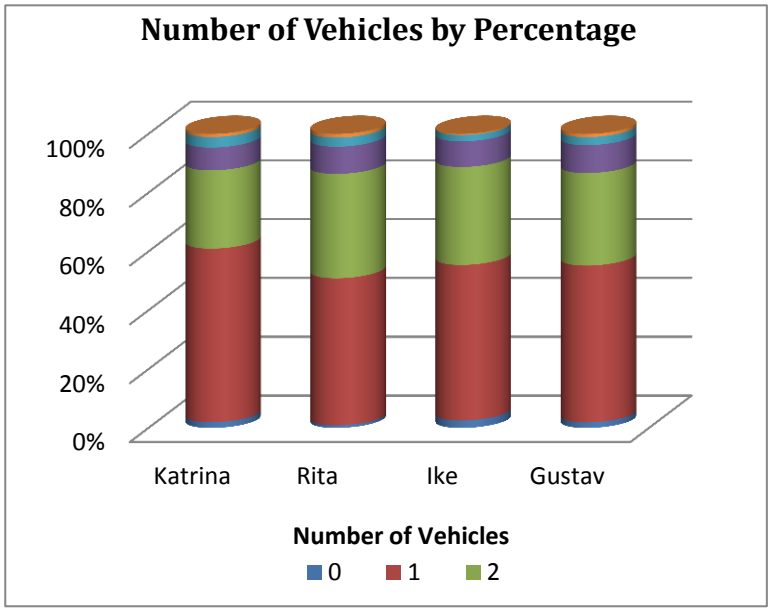

Figure 8 Number of vehicles evacuees take for various hurricanes

Also, the graphic in Figure 8 shows the number of vehicles that evacuees have taken for four different hurricane tracks. About 50 to 60% of the evacuees take one vehicle, 26 to 30% take two vehicles and about 7% take three vehicles.

4.5 Mode of Evacuation

A majority of the evacuees (approximately 70%) of evacuees relied primarily on Interstate and 29% relied on two lane highways (LA and US highways) and 1% relied on public transportation to evacuate.

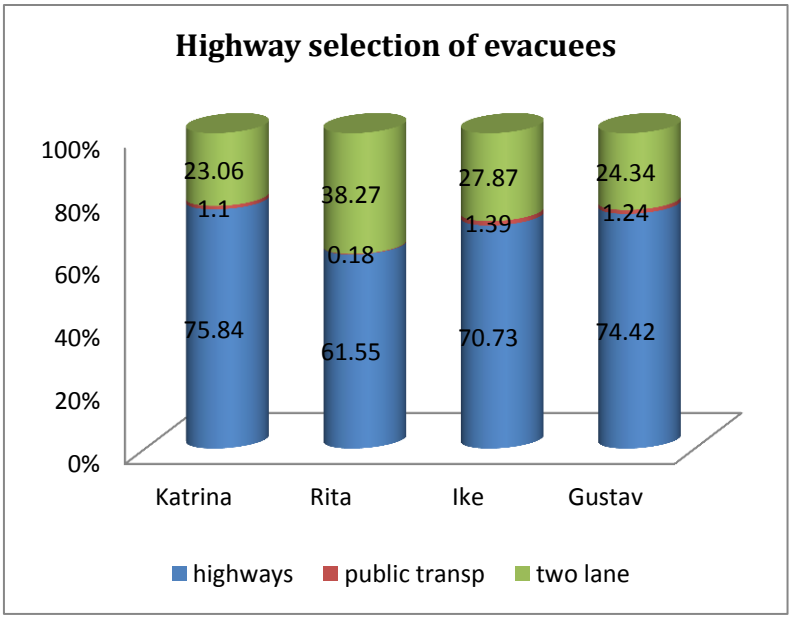

Figure 9 Route selection for evacuees

4.6 Fuel Consumption

In order to understand fuel consumption during an evacuation, we wanted to understand how people filled up their tanks before they evacuated. Therefore, we asked the respondents how many gallons of fuel they filled up prior to leaving. An interesting observation is that on the average each household fills up about 25 to 30 gallons of fuel.

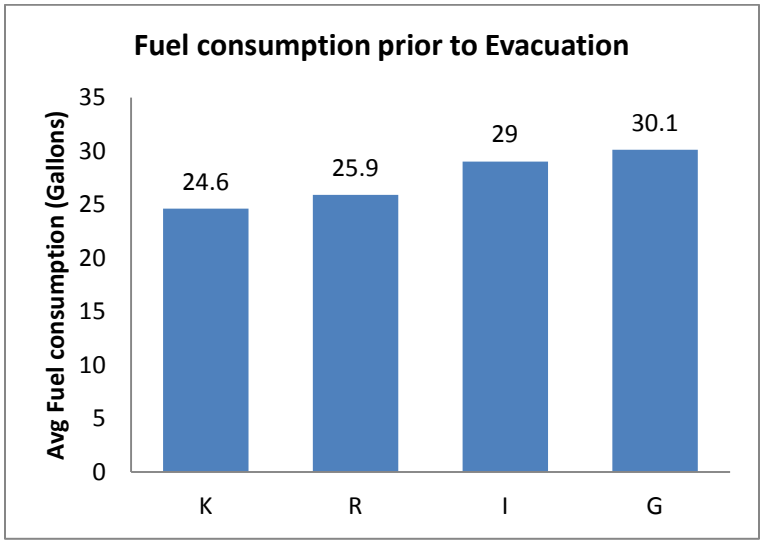

Figure 10 Fuel Consumption during an Evacuation

5. STUDY LIMITATIONS & FUTURE WORK

The main objective of this study is to get a preliminary understanding of evacuation behavior and serve as a general guideline to instantiate our model. However, this is by no means a comprehensive evacuation behavior study. We seek to further refine this data, perform a more thorough statistical analysis on this data to improve its validity. For instance, one thing we intend to study is identify the sampling error to understand how the observed sample values deviate from the actual population.

This study gives us idea on what people have done in the past, but does not necessarily provide the intended behavior of people.

GOHSEP in collaboration with FEMA have undertaken a major evacuation behavior study across the state of Louisiana. We will work with researchers that are part of this study to validate and further improve our behavioral model that drives the fuel demand estimation model.

6. REFERENCES

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7. APPENDIX: SURVEY INSTRUMENT

1. Has your household ever evacuated because of a hurricane?

IF NO SKIP TO # 9

2. Which one(s)? Or what is the name(s) of the hurricane for which you evacuated?

3. From which zip code did you evacuate?

4. About how long before the storm came ashore did you evacuate?
We can have a DAYS AND AN HOURS BOX and take whatever they give us and calculate the other. If we have this, and the time the particular storm came ashore, we can calculate the traffic curve. I suspect that we will find that most evacuations happen between early morning and mid afternoon.

5. Do you remember about what time of the day it was?

6. Where did you go?

7. How many vehicles did you take?

8. When you evacuated did you use mostly major highways like interstates or mostly two lane roads?

REPEAT 3 – 8 FOR EACH HURRICANE EVACUATION

9. Did you fill up your vehicles with gas or diesel fuel before the last hurricane?

IF YES:
10. How many vehicles?

11. Did you fill up other containers with gas or diesel before the last hurricane?

IF YES
12. How many gallons

13. What is your current zip code?