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Changes in travel behavior during flood events in relation to transport modes: the case of Metro Manila, Philippines

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Abstract

Adverse weather conditions like flooding results in changes in travel behavior. The study investigated the behavior of travelers during the last flood event they experienced with respect to the primary mode of travel they used. Variations in their usual travel routine were manifested by a change in departure time, change in mode or route taken, or cancellation of travel. Data were collected from commuters using traditional pen-and-paper questionnaire survey implemented through convenience sampling along major transport corridors in Metro Manila, Philippines. Statistical results showed a significant difference in travel time between normal and disrupted conditions. Tests of independence and binomial models showed that travel behavior change depends on flood characteristics such as location and duration. Developed binomial logit models showed that travelers mainly using road-based transit services are more likely to change travel behavior than their rail counterpart. Succeeding models revealed that the propensity of changing travel behavior also differs depending on the type of mode the traveler primarily uses. The analyses presented in the paper resulted in different recommendations for each transport service to minimize the impacts of disruptions in travel caused by floods.

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Keywords: flooding; travel behavior; Metro Manila; choice modeling

1. Introduction

Public transportation is vital in connecting vast urban areas and maintaining economic and civic activities through the provision of a mobility option that is highly beneficial to the population (Cervero, 1998; Schwanen, 2002; Tao, Corcoran, Rowe, et al., 2018; Vuchic, 2005). The essential role that public transport plays and its countless benefits

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stress its importance to operate and meet the needs of travelers. However, just like any other system, transport services are vulnerable to incidents ranging from natural hazards to targeted attacks. As transportation systems are critical infrastructure and have a significant impact to the well-being of a community (Kim, Pant, & Yamashita, 2017), the importance of understanding the influence of hazards to these services are paramount.

Public transit systems are affected by variations in weather conditions (Böcker, Dijst, & Prillwitz, 2013) as the majority of its assets are exposed to the environment (Miao, Feeney, Zhang, et al., 2018). Adverse weather conditions disrupt operations, lower service quality, degrade passenger satisfaction, and affect transit ridership (Arana, Cabezudo, & Peñalba, 2014; Changnon, 1996; Hine & Scott, 2000; Hofmann & O'Mahony, 2005; Kashfi, Bunker, & Yigitcanlar, 2016). Because of these effects, travelers adapt to the changes in travel conditions which are caused by poor weather conditions.

The importance of understanding the changes in behavior caused by extreme weather events have caught the attention of many researches (M Cools, Moons, Creemers, et al., 2010; Mario Cools & Creemers, 2013; Khattak & De Palma, 1997; Koetse & Rietveld, 2009; Kontou, Murray-Tuite, & Wernstedt, 2017; Liu, Susilo, & Karlström, 2015b; Lu, Zhang, & Rahman, 2017; Sakamoto & Fujita, 2015). Understanding these changes in travel behavior is vital especially in analyzing network performance as trips may be rescheduled, rerouted, or canceled. Lu et al., (2014) noted that the accuracy of the results of network analysis and the efficiency of network scans would be affected if travel behavior during disruption events is overlooked. But, the majority of these studies were conducted in western countries, and only a few studies have exhibited the relationship of weather and transit services in the context of an Asian city (Li, Li, Chen, et al., 2017; Lu et al., 2014). Cools & Creemers (2013), Khattak & De Palma (1997), and (Böcker et al., 2013) noted that findings of travel behavior vary across spatial and temporal contexts and may not automatically apply to other countries. Despite extensive studies discussing travel adaptation in the event of disrupted travel, the influence of the mode primarily taken by the traveler during poor weather conditions to travel behavior adaptation has received minimal attention.

These motivated the authors to conduct a travel behavior research in a developing Asian country that is significantly affected by climate change-induced variability of rainfall. Specifically, this research addresses the gap by unraveling the influence of the travel mode taken by passengers in the event of weather-disrupted travel (i.e., a flood). The authors believe that flooding events severely weakens transport operations and reveals areas needed for improvement. Hence, aside from the actual flood conditions, the type of mode taken may affect the decision-making of travelers. With this, the authors aim to identify which aspects of transit operations in Metro Manila, the Philippines that should be addressed to increase the resiliency of the transport system.

The remainder of the paper is structured as follows. Section 2 provides a review of the effect of weather disturbances to travel behavior and transit ridership. Section 3 discusses the study area, the research design, and the methodology. Section 4 shows relevant statistics and formulated models. Section 5 concludes the paper.

2. Literature Review

Adverse weather conditions and flooding are known to affect traffic conditions, network performance, travel behavior, and transit ridership. In effect, both automobile and transit users adapt their behavior in anticipation of the disruption resulting from the poor travel conditions. Some forms of adaptive behavior include changing of departure time (earlier or later), changing of mode or route taken during travel, or canceling of trip.

Khattak & De Palma (1997) revealed that severe weather conditions strongly influenced changes in departure times than in-route or mode choice changes for automobile commuters. Shiting to public transport modes by car drivers was also observed when roads become congested because of heavy precipitation (Koetse & Rietveld, 2009; Liu, Susilo, & Karlström, 2015a). Zanni & Ryley (2015) evaluated long-distance travel behaviors and showed that car travel for non-business purposes and being a car passenger showed a lower inclination to change long-distance travel plans. Meanwhile, the findings of Anta et al., (2016) showed that poor weather conditions and congested traffic conditions increased the utility of rail modes.

Travel behavior also varied depending on the spatial context. In the United States, Kontou et al., (2017) noted that transit commuters have changed modes, canceled trips and changed departure times to deal with the disruptions caused by Hurricane Sandy. In Northern Sweden, Liu et al., (2015b) reported that in some cases heavy precipitation might discourage public transport use. Japanese commuters were more likely to shift departure times earlier to avoid the effects of congestion during afternoon peak hours (Sakamoto & Fujita, 2015). Cools et al., (2010) also observed trip timing changes due to storm and heavy rains. Meanwhile, Madre et al., (2007) noted that some travelers had canceled trips on a regular day due to snow, rain, and strong wind. A similar finding was observed by Koetse & Rietveld (2009) wherein trips were postponed until the rains have stopped.

Studies analyzing the impacts of severe weather conditions on travelers in Metro Manila were also conducted just recently. Ibasco (2016) studied the travel behavior of university students in Metro Manila in the event of a class suspension. He noted that Filipino university students were more likely to choose their usual path in their to-home trip. Sunga et al. (2017) studied the mode-shifting behavior of Filipino travelers in a central business district in Ortigas, Philippines. Their findings concluded that shifting to a different travel mode resulted in changes in fare, travel time, waiting time, reliability, comfort, and safety. Lastly, an analysis of inter-city travel behavior of commuters in two Philippine cities revealed that flood events, bus users, ankle-level flood heights, and short travel distances were significant for travelers who did not change their behaviors in the event of a flood (Abad, Fillone, & Schwanen, 2017).

Overall, the changes in behavior lead to changes in network performance and transit ridership. In the study of Suarez et al. (2005), a flood in the Boston Metro Area resulted in increases in vehicle miles- and vehicle hours traveled. In the work of Arana et al., (2014), a regression model showed that public bus trips for leisure, shopping, and personal business have decreased because of rain, wind, and rises in temperature. Kashfi et al., (2016) included season, daily weather variations, and whole-day rainfall as variables in their regression model to show localized area ridership in Australia. Outwater et al. (2011) found that 12% of transit riders in Salt Lake City avoided transit during unfavorable weather conditions. Furthermore, variation in ridership between days within the week was observed by Li et al. (2017). Tao et al. (2018) extended the analysis and argued that the effects of weather on hourly bur ridership also varied across trip destinations.

The findings in the literature present a strong case on the impact of severe weather events such as flooding to travel behavior and transit ridership. However, these findings do not consider the travel mode used by travelers as a factor affecting travel behavior. This paper looks at this perspective with respect to their behavior in the event of a flood. If such relationship is proven to exist, potential remedies shall be provided to anticipate losses in ridership when services have deteriorated.

3. Methodology

3.1. Study Area

Metro Manila, also known as the National Capital Region (NCR), is the seat of the Philippine national government. NCR is composed of 4 districts with 17 local government units. As of 2015, the metropolis has a population of about 12.9 million. Transportation needs in the region are provided by buses, jeepneys, AUVs (Asian Utility Vehicles or UV Express), and the rail systems (LRT1, LRT2, MRT3, and PNR). The extent of transit service coverage is shown in Fig. 1.

Buses in Metro Manila operate along trunk road networks and designed for inter-city travels. Among all road-based public transit services, buses have the largest seating capacity. However, analysis of its operations revealed low travel speeds averaging only 20 kilometers per hour (Department of Transportation and Communications, 2012). Jeepneys also operate inter-city routes with smaller vehicle capacities. This transport mode is the most patronized public transit mode because of its extensive network. On the average, operating speeds barely reach 15 km/hr because of frequent stopping for boarding and alighting passengers at non-designated stops along the route (Department of Transportation and Communications, 2014). AUV services thrived to fill the gaps between bus and jeepney services by providing end-to-end services (mostly between central business districts and residential areas) along a flexible route. Among all other road-based transit services, AUVs have the fastest average speed within the day ranging from 20 to 30 km/hr.

Topping the hierarchy of transport modes in Metro Manila are its 4 main rail lines. These are the Light Rail Transit 1 (LRT1), Light Rail Transit 2 (LRT2), the Mass Rapid Transit (MRT3), and the commuter line of the Philippine National Railways (PNR). Majority of the light rail stations are above grade except the stations located at Ayala and Buendia in Makati City. All rail services operate along major transport corridors in the central portion of the metropolis. In recent years, these services are rehabilitated and improved to accommodate the increasing number of patrons.

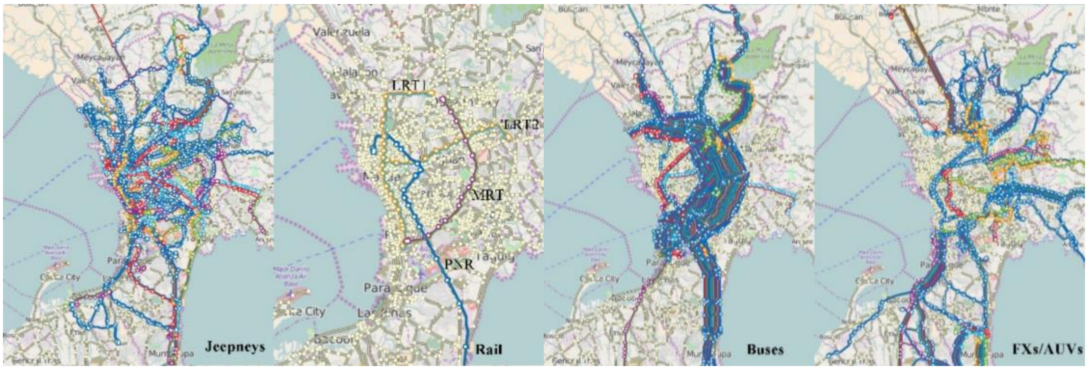

Fig. 1 Coverage of transit services in Metro Manila

All transit services in the study area are faced with existing operational issues. First, bus and jeepney services tend to have lower frequencies during afternoon peak periods than in the morning peak periods. Hence, there exists a service imbalance wherein vehicle occupancies were higher during afternoon periods.

Safety issues also hound the transport service industry. Vehicles are outdated and do not have safety equipment on-board. Also, road-based transit vehicles have design issues. Access to vehicles often require stepping up to board the vehicle. Safety is also compromised because drivers are paid on a commission basis. In turn, there is a very competitive transport services market and drivers often engage in unsafe practices to maximize their earnings.

Road-side transport facilities and designated transit stops along the route are severely lacking in Metro Manila. Access to rail services is inadequate as pedestrians are often forced to walk on narrow footpaths that are obstructed by trees, posts, vendors, or furniture. While there are some rail stations connected to shopping malls that provide excellent access facilities, these were designed in a way to make it easy for passengers to enter malls, not the other way around.

These transport-related issues in the region are compounded due to frequent, climate change-induced variability of rainfall. These events have become recurrent in Metro Manila because of its topographical conditions and poorly maintained flood management facilities. Flooding events not only damage existing infrastructure but also affect individual daily routines like traveling. This paper aims to find out if differences in travel behavior during a flood exist with respect to the primary travel mode trip makers use.

3.2. Data Collection

Two batches of questionnaire surveys were conducted through convenience sampling last March 2016 and September to October of 2017. The questionnaire was administered to travelers who were waiting for public transport at ten different locations within and around Metro Manila and who experienced disruptions in their travel due to a flood. A total of 1,250 samples were targeted for the survey. Survey forms that were incomplete and contained unreliable data (e.g., inaccurate travel information) were removed from the data set. Of the remaining 1,113 samples, the final dataset was further reduced to 819 as this study focused on flood-disrupted commute trips.

The questionnaire was designed to determine the changes in travel conditions due to a flood and to identify characteristics of the flood that affect travel behavior with respect to the primary travel mode used by the respondent. Specifically, details regarding previous flood experience like the depth of the flood in relation to the respondent's body parts, the location of the flood, and the duration of the flood. Additional information regarding the details of the most recent flood-affected commute was collected, including the origin and destination, trip purpose, time of departure, the travel time. To establish the impact of flooding to travel conditions, normal travel conditions were also elicited from the respondent. Information regarding the travel cost, travel time, queues, and traffic conditions, respondents typically experience on a normal day were collected. Finally, socio-demographic conditions like age, gender, civil status, educational attainment, and income were collected to characterize the respondents.

This paper focused on the main or primary travel mode of Metro Manila commuters. The primary mode of travel was defined in this study as the mode wherein the traveler spent the most substantial amount of time during his/her entire trip.

3.3. Statistical Analysis

The analysis focused on identifying statistically significant variables affecting the likelihood to adapt travel behavior in response to flooding. Specific attention was given to the variation in travel behavior depending on the respondent's primary mode of travel. Aside from descriptive statistics and bivariate analysis, binomial logit choice models were also developed with a dichotomous dependent variable consisting of 'change in travel behavior' and 'no change in travel behavior or travel as usual' as the two options.

For the bivariate (Chi-Square) analysis, Cramer's V was used to provide an acceptable measure of the strength of association. The value falls between 0 (no association) and 1 (maximum association). A weak relationship exists if the coefficient has a value of 0.1 or less. A moderate and strong relationship is exhibited when coefficients are between 0.11 to 0.30 and higher than 0.30, respectively. On the other hand, the binomial logit models were evaluated using a log-likelihood ratio test and the informal goodness-of-fit measure, pseudo-ρ^2 (Ben-Akiva & Lerman, 1985). For Hensher, Rose, & Greene (2005), a pseudo-ρ^2 value between 0.3 and 0.4 is a fairly decent model equivalent to a linear models with an R^2 value between 0.6 and 0.8.

As the study only investigates the effect of flood and the transport mode with the propensity to adapt behavior, it only considers flood-related and transport mode variables in the models. Models were then grouped according to the respondent's main mode of travel. The grouping investigates the different significant flood-related variables in travel behavior between primary modes of travel.

4. Data Analysis

The characteristics of the respondents comprising the sample are shown in Table 1. Overall, there were more male respondents than females (sex ratio of 1.59) and majority of the respondents were between 25 and 34 years of age (average of 33). At the time of the survey, there were more respondents who were single and almost 60% have completed at least a tertiary education. Finally, the average monthly income of the respondents is around ₱22,380 (est. US$ 430; US$ 1 ≈ ₱ 52).

The sample reflects some similarities to regional labor statistics. According to the Philippine Statistics Authority (2017), the majority of the labor workforce is composed of males (sex ratio of 1.38), is aged between 25 to 34 years old, and have received a college degree. Compared to the regional labor force, the sample tends to be overrepresented by men and higher-educated individuals. The oversampling could be a result of error in sampling due to how the survey was conducted (convenience sampling).

Respondents reported higher individual monthly income. Considering that the samples were taken in the metropolitan region were wages are generally higher than anywhere in the country, the result from the survey is expected. Then again, it may also hint on biases arising from the employed sampling method.

4.1. Details of the last flood event reported by the respondent

The travel decision of the respondents was classified into two (2) groups as shown in Table 2. A change in travel behavior was observed when the respondent changed their behavior in their last flood-affected trip. Adjustments may be in the form of shifting their departure time (earlier or later), changing their travel mode or route taken, or canceling their trip. Majority of the respondents in the sample have changed their travel behavior during the last flood event that they experienced.

Table 1. Characteristics of the respondents (n=819)

Characteristic		Travel behavior during last flood event		Test of Independence	
		No change in behavior (%)	Change in behavior (%)	χ2 (p-value)	Cramer's V
Age	Below 25 years	38 (44.71%)	47 (55.29%)	7.10 (0.418)	0.093
	25 to 29 years	104 (38.66%)	165 (61.34%)		
	30 to 34 years	76 (44.19%)	96 (55.81%)		
	35 to 39 years	48 (42.86%)	64 (57.14%)		
	40 to 44 years	40 (48.19%)	43 (51.81%)		
	45 to 49 years	33 (50.77%)	32 (49.23%)		
	50 years and above	17 (51.52%)	16 (48.48%)		
Gender	Male	211 (42.03%)	291 (57.97%)	0.89 (0.347)	0.033
	Female	143 (45.4%)	172 (54.6%)		
	Did not say	2 (100%)			
Civil Status	Single	200 (45.98%)	235 (54.02%)	2.52 (0.120)	0.055
	Married	155 (40.47%)	228 (59.53%)		
	Did not say	1 (100%)			
Educational attainment	Secondary	73 (46.2%)	85 (53.8%)	1.46 (0.481)	0.046
	Tertiary	241 (50.31%)	238 (49.69%)		
	Vocational	30 (44.12%)	38 (55.88%)		
Individual monthly income	*Average*	₱ 22,380.95		72.16 (0.00)	0.297

Table 2. Travel behavior of respondents during the last flood event experienced

Travel decision on last flood event	Count	Proportion (%)
Did not change travel behavior (traveled as usual)	356	43.5
Changed travel behavior	463	56.5

Tables 1 to 3 show the resulting bivariate (Chi-square) analysis testing which variables are strongly associated with travel behavior adaptation. Chi-square tests revealed that among socio-demographic factors, only individual monthly income affects behavioral adaptation in the last flood event experienced. This was seconded by the Cramer's V stating it has a moderate association with the dependent variable. The finding implies that personal income may be crucial in the decision-making of individuals when traveling during a flood. The finding also highlights that the adaptive capacity of the traveler may depend on their financial capacity.

Table 3 shows the characteristics of the flood event reported by the respondents. It revealed that about ¾ of the respondents experienced a flood that reached their ankles, occurred less than an hour, and happened within their origin or destination of the trip. The survey data suggests that the flood levels are shallow and temporary indicating that these floods may be localized and due to a poorly functioning drainage system.

The values in Table 3 reveal how various flood characteristics affect the travel decisions of individuals. First, it can be noted that as flood depths increase the proportion of respondents who changed their behavior increased. It implies that travelers were sensitive to increasing flood depths. A different finding was found for flood duration. The results suggest that as an area stay flooded for prolonged periods of time, travelers were less inclined to adapt their travel behavior. Finally, there were more respondents that changed their behavior when the flood was located at either their origin or destination. The result implies that people are more able to adapt their travel when the flood is located at their place of origin or destination. The results above show that the respondents in the sample were most likely to change their behavior when flood depths are higher but shorter in duration. Otherwise, they become more resigned to the situation and travel as they normally would.

Among the sample, the most recent flood occurred more on the way to work than on the return-home journey. The results in Table 3 indicates that more than half of the respondents adapted their commuting routine more on the trip to work (60.5%) than on the return-home (51.2%). The results show that the commuters in the sample adapted their behavior if they were affected by flood on the way to work as it may be a critical activity for them.

Tests of independence revealed that the duration and location of the flood, along with the type of commute trip they took, are significant in travel behavior changes. The result is significant as the flood-related variables are used in modeling traveling behavior change.

Table 3. Characteristics of the last flood event

Characteristic		Travel behavior during last flood event		Test of Independence	
		No change in behavior (%)	Change in behavior (%)	$\chi 2$ (p-value)	Cramer's V
Flood height	Ankle level	266 (43.46%)	346 (56.54%)	0.461 (0.927)	0.024
	Knee level	80 (43.96%)	102 (56.04%)		
	Waist level	7 (36.84%)	12 (63.16%)		
	Chest level	3 (50%)	3 (50%)		
Flood duration	Less than an hour	239 (40.58%)	350 (59.42%)	10.55 (0.014)	0.114
	1 to 3 hours	96 (48.24%)	103 (51.76%)		
	3 to 5 hours	17 (65.38%)	9 (34.62%)		
	More than 5 hours	3 (75%)	1 (25%)		
Flood location	at origin/destination	69 (34.5%)	131 (65.5%)	8.660 (0.004)	0.103
	along the travel route	287 (46.37%)	332 (53.63%)		
Trip purpose during flood				7.047 (0.008)	0.093
	Home to Work	187 (39.53%)	286 (60.47%)		
	Work to Home	169 (48.84%)	177 (51.16%)		

Table 4. Details of travels that were affected by flood (n=819)

Characteristic		Count	Proportion (%)
Travel distance	(Average)	16.06 km	
Number of modes used during travel (Average)		1.69	
Main mode of travel	Bus	379	46.3
	Jeepney	322	39.3
	AUV/UV Express	88	39.3
	Rail	29	3.5
Time spent in heavy traffic due to flood			
	Less than 30 minutes	264	32.2
	30 minutes to an hour	344	42.0
	1 to 2 hours	181	22.1
	More than 2 hours	30	3.7

4.2. Travel details of the respondent during their last flood event

This section discusses the travel details of the most recent flood event respondents have experienced. On the average, respondents traveled about 16.06 kilometers and made at least one (1) transfer in between transport modes during their flood-affected travel. Analyses of the individual travels are showed in Table 4. Almost half the respondents have the bus as their primary mode of travel. Meanwhile, rail services have the lowest share of respondents who used this as their main mode of travel. This could be attributed to the fact that the network coverage of rail services is limited to four corridors within the study area. An additional test of independence reveal that the main mode of transport used by the respondent is moderately associated with their travel behavior (Pearson's Chi-Square = 10.453, p=0.033, Cramer's V=0.113). The result presents a strong case that behavioral adaptation also depends on the travel mode respondents primarily use in traveling.

Travel time usually increase when flood waters disrupt existing transport operations. Respondents reported that about seven out of every ten (70%) respondents spent no more than an hour in poor traffic conditions. On the average, respondents travel time have increased by about 48 minutes because of roadside floods. From the data collected, Table 5 reports that travel times have increased by about 42 minutes between normal (undisrupted) and flooded travel conditions. The differences between the two are significant at a 0.05 level.

Table 5. Changes in travel time between normal and flooded travel conditions

Travel time	Minimum (mins)	Maximum (mins)	Average (mins)	t-stat (p-value)
Normal travel conditions	5	300	91.67	-26.192 (0.000)
Flooded travel conditions	20	375	134.11	

Despite that most travelers used the bus as their primary mode of travel, most of these travelers have also used other modes to complete their journeys as indicated by the average number of transfers. Table 6 showed that travelers spent a minimum of 10 minutes of their journeys waiting for or using a jeepney. Specifically, 44%, 28%, and 34% of travelers who used the bus, AUV, and light rail as their main mode of travels have used the jeepney (at least once) in their travels. Respondents who primarily used the AUV and rail transit had the lowest shares of travel time using other transit modes. The findings in Table 6 provide valuable insight to the importance of the jeepney not only as a primary mode of travel but also as a feeder mode to other modes. Hence, it can be said that jeepney services are crucial to the reliability of the overall public transport network in Metro Manila, Philippines.

Also, Table 6 revealed that among all primary modes of travel, it was the rail mode that provided the least travel time. The result is expected since rail modes are separate from mixed traffic thereby avoiding poor traffic conditions when there is a flood. However, since rail services do not have an extensive network coverage, travelers may also find difficulty in accessing these services especially when they use other modes to get to its stations.

Table 6. Distribution of travel time with respect to main mode of travel

Main mode of travel	Average travel time for each mode (minutes)			
	Bus	Jeepney	AUV	Rail
Bus	112	21	2	3
Jeepney	6	85	1	3
AUV	9	10	106	5
Rail	4	13	3	52

Given the details of the flood and travel conditions that respondents have experienced, this paper would investigate the potential variations in travel behavior depending on the mode of transport that travelers mainly use. It was premised that travel adaptation to flooding would vary based on the type of mode. At the same time, this may also reflect how travelers of each mode are affected by flood events. It is envisioned that changes in behavior would vary depending on the public transit service they mainly use in the event of a flood. Since travel adaptations are done to reduce the impact of floods in their travels, the differences in operating characteristics between travel modes may be crucial in the propensity to adapt travel behavior.

4.3. Result of Binomial Models

The variables used in discrete choice models focused on the flood characteristics the traveler experienced. These were the only variables considered based on the test of independence results in the previous section. Results of the base model, shown in Table 7, (Model 1) revealed similar results with ankle-level flood dissuading travelers from adapting their travel behavior. Both flood location (at origin or destination of the traveler) and duration are positive and increase the propensity of travel behavior change. The negative sign implies that ankle-level floods may imply that, at this level, travelers may find these conditions acceptable for travel. Hence, adaptation is not necessary. The coefficients in Table 7 confirm the findings in the previous section – adaptation of travel behavior is likely when floods are shorter in duration and are located near the respondent's origin or destination. It implies that travelers respond to the changes in travel conditions when the flood is near them and when the flooding has just started.

Table 7. Binomial model results

	Model 1: Flood-related variables	Model 2: Flood-related and main mode variables
Variable	Coefficient	Coefficient
Constant	0.0167	-0.7267*
Flood at origin/destination	0.4398**	0.4488***
Flood less than one hour	0.5089***	0.4726**
Ankle-level flood	-0.2941	-0.2694
Main mode: Bus		0.6186
Main mode: Jeepney		0.9336**
Main mode: AUV		0.9033
Main mode: Rail (reference)		
2LL	17.7484	26.392
Test-statistic (d.o.f.)	7.8147 (3)	12.5916 (7)

** - p<0.1, ** - p<0.05, *** - p<0.01*

When the main mode of travel was considered in Model 2, it was shown that only 'jeepney' is the only significant variable pertaining to the main mode of travel. One possible explanation could be is that most of the travelers in the dataset have used the jeepney in any portion of their trip (64%). Further evaluation of Model 2 reveals that travelers who mainly use road-based public transit are more likely to change their behaviors. Among road-based public transit options, travelers who use the bus as their primary mode of travel had the lowest coefficient indicating inclination to adapt commuting behavior. Lastly, as with the base model, ankle-level floods discourage travelers from making any sort of travel behavior change.

Subsequent models aimed to evaluate the taste variations of travelers based on their main mode of travel. The models in Table 8 showed different significant variables depending on the respondent's main mode of travel. Further, different senses also suggest which flood characteristic increases the likelihood of a change in travel behavior.

All flood characteristics for travelers who used the jeepney as their primary mode are significant at the 0.05 level. For the bus mode, only floods located at either origin or destination were considered significant to the model. Flood characteristics were insignificant for travelers that predominantly used AUVs or rail modes for travel.

Evaluation of the taste variations according to predominant mode of transport has produced some significant findings regarding travel behavior adaptation of respondents. Travelers mainly using the jeepney and AUV have a higher probability of changing their behavior if a flood event occurred for less than an hour. This may suggest that they are highly sensitive to floods that have just started by the time they observe the flood.

Table 8. Binomial model results based on the main mode of travel

	Main mode: Jeepney	Main mode: Bus	Main mode: AUV	Main mode: Rail
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Constant	-0.1686	0.0985	-0.2617	-0.3290
Flood at origin/destination	0.5854**	0.4482**	-0.0492	0.7558
Flood less than one hour	1.4407***	-0.0645	0.6355	-1.1825
Ankle-level flood	-0.7753**	-0.0508	0.2270	0.3291
2LL	21.1765			
Test-statistic (d.o.f.)	21.0261 (12)			

** - p<0.1, ** - p<0.05, *** - p<0.01*

The characteristics of the flood do not significantly influence travel behavior adaptation for travelers predominantly using AUVs or rail transit. Presumably, these are the two transit modes that are least affected by a flood. As mentioned in the previous section, rail services are mostly above-grade level making them less susceptible to inundations. Hence, users of the rail mode usually enjoy protection from floodwaters while they travel. AUV users, on the other hand, are not much affected by the flood because services are usually point-to-point. But, looking at the coefficients, floods that are located along its route, no more than an hour in duration, and ankle-level in depth, motivate travelers to change their travel behavior. It may imply that the onset of floods (because of its low depth and short duration) are crucial periods for AUV users. Also, AUV users are also likely to adapt behavior when floods are located along the route. The finding may imply that users of this mode are concerned of the possible changes in traffic conditions. Both findings indicate that travelers are concerned to the changes in travel conditions since they may miss the service, or they would have not enough seats to accommodate the travel demand.

Travelers predominantly using the bus will not change their travel behavior if the flood is located at their origin/destination. A possible implication of the finding is bus users are affected by access and egress issues during flood events. Noting that most of the services operate along major corridors or trunk roads, it is likely that travelers may need to use other modes or walk from their origins or to their destinations which may be flooded. Floods more than an hour in duration and above ankle-level in depth also increase the likelihood of commute adaptation. However, duration and depth are insignificant in the model.

Jeepney users adapt their commute behavior when floods are located at either origin or destination, less than an hour in duration, and above ankle depth. All variables relating to flood characteristics are significant indicating that travelers who predominantly use this mode are most sensitive to the flood. Just like AUV users, jeepney users are more likely to change their commute behavior when they experienced floods that are not more than an hour in duration. Floods located at either origin or destination is also positively correlated to propensity to adapt behavior. It may also hint at situations wherein travelers find difficulty in accessing to or egressing from this vehicle. Last, flood depths above ankles may hinder operations of jeepney services as they may not be able to traverse inundated roads. In effect, travelers may need to compensate by adapting their behavior to ensure that they would not be disrupted.

The results from the binomial logit models showed that flooding has varied effects depending on the travel mode commuters primarily use. It also exposed areas of concern that could improve public transit services in Metro Manila. For example, jeepney and AUV users adjust their travels at the onset of a flood. This may hint at issues that may be related to availability of services and travel-time related issues. Since travel times for these two modes are more than an hour, respondents adjust their travels in anticipation of the effects of flood to travel time. Next, commuters primarily using bus modes change their behavior if the flood is located at their origin/destination. A flood at the origin/destination of the traveler may cause difficulties in access or egress of the bus mode. Hence, ensuing adjustments are made to avoid a significant impact to travel. The same could be said for commuters mainly using jeepneys as their travel mode.

The results show that the behavior of individuals during a flood event also depends on the type of mode they generally use for travelling. Travelers are aware of the weaknesses of the transport mode they predominantly use. These weaknesses are exacerbated in the event of disruptions such as natural disasters or in this case, a flood. Therefore, travelers also alter their travel arrangements not only because of the general effect of the flood on them but also because of how travel conditions would deteriorate while using a travel mode. The findings in this study revealed the weaknesses of specific transport modes in Metro Manila which can be addressed by local transport operators. Although the ideal solution would be to improve flood management systems in the area, adjustments in operations would be a significant step towards reducing the impact of flood disruptions to transport services.

5. Conclusion

This paper used collected data from a survey of 819 commuters in Metro Manila, Philippines to explore the changes in travel behavior of commuters during the last flood event they experienced. Evaluation of the travel details of the respondents showed a significant difference between travel times during normal and flooded conditions. Subsequent analysis showed that travelers, on the average, experience an additional 42 minutes in travel time because of poor traffic conditions.

The study also unraveled the effects of various flood characteristics to travel behavior change of commuters in NCR. Binomial logit models revealed that floods at origin/destination and occurred less than an hour is significant and increase the propensity of travel behavior change. Meanwhile, ankle-level floods dissuade passengers from adjusting their travels. When main modes of travel were considered, it was revealed that passengers using road-based transit are more likely to change travel behavior. This suggests that these services are severely affected by floods that its patrons need to alter their travel behavior to limits its effect to their respective travels. Finally, a significant finding of this study showed that travel behavior also varies with respect to the travel mode they predominantly use. The results show that travelers that use different modes also have different significant variables that may affect travel behavior change in the event of the flood.

This work contributes to the knowledge of travel adaptation to flood events in a developing country that is affected by climate change. The paper veered away from the conventional approach to understanding changes in travel behavior due to an extreme weather event. Instead, it focused on the main travel mode that passengers used to identify gaps in its operations. The results showed that different flood conditions have different travel behavior responses based on the primary mode of travel passengers used. This way, policy makers or transport groups can craft programs or changes in operations to minimize the effect of the disruption to individual travels.

The findings in this study could provide recommendations to local transport groups in terms of modifications in their operations, especially during severe weather disturbances. As jeepneys and AUV users are profoundly affected by flood durations not more than an hour, it is recommended to provide services at the onset of worsening weather conditions. Specifically, jeepney and AUV operators may need to provide additional services earlier than usual to accommodate those who changed their departure times to ensure that services are still available. Since bus users adjust their travels when floods are located at the origin or their destination. it is recommended to review access and egress modes of those who mainly travel by bus. Furthermore, an assessment of existing bus routes could be performed to see if network coverage of buses could be improved. Lastly, jeepney services are sought for improvements by providing weather-proof facilities and improved service coverage as there is a heavy reliance towards this mode of transport. These proposals are to minimize the effect of flooding on different transport users. Finally, one of the difficulties in addressing these travel-related issues during a flood is the lack of an overall transit operating authority in Metro Manila. It would be advantageous if there would be a body that will overlook public transit operations to ensure that services are maintained even during disruptions. Likewise, this operating body would be useful in providing real-time information that would be beneficial to travelers during disruptions. Overall, an improvement in the flood management system would provide significant relief to the transportation system in times of disasters.

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