Residence and Job Location Change Choice Behavior under Flooding and Cyclone Impacts in Bangladesh

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ABSTRACT

Bangladesh is one of the most climate vulnerable countries in the world. With the increasing impacts resulted from the changing climate, many people in Bangladesh have been forced to leave from their home and/or changed their jobs. Unfortunately, little has been known about how people’s residence and job location change choice behavior is affected by the changing climate. Such a behavioral understanding is essential for transportation planners and adaptation decision makers. As an additional effort to existing literature on climate-induced adaptation issues, the main purposes of this paper are to investigate people’s residence and job location change choice behavior and look into the behavioral differences between coastal and inland people under flooding and cyclone scenarios in future Bangladesh. Questionnaire data were collected from 14 coastal and inland cities of Bangladesh based on a stated preference survey. A cross nested logit model is adopted to address the research purposes of this work. Results of this study indicate that flooding/cyclone factors and income, land owned, and number of family members significantly affect people’s location change choices, and people living in coastal areas are also significantly affected by the quality of life affected in previous flooding/cyclone events. Furthermore, road connection plays an important role when people choose to change residence locations in coastal areas. It is also found that if there are changes in flooding impacts the inland people would first consider to change their job locations, while the coastal people would consider both job and residence location changes. Results of this work are expected to support decision makers’ adaptation decision making and transportation modeling and performance analysis under flooding and cyclone impacts.

KEYWORDS: Bangladesh, Residence and job location change, Flooding, Cyclone, Stated preference
1. INTRODUCTION

Climate change is posing serious impacts on transportation infrastructure and system, and thus attracting increasing attention from transportation engineers and planners. Research works focusing on climate change in transportation are usually addressed from two aspects, that is, mitigation and adaptation. Comparing with climate change mitigation efforts, however, climate change adaptation may be more urgent for the transportation sector to construct more resilient transportation infrastructure and system, and for people to prepare for the affected life caused by the increasing impacts. As a result, climate change adaptation has received much more attention from transportation network performance analysis (1-3) to adaptation decision making (4-7). Until recently, travel behavior adaptation to climate change has attracted attention from scholars addressing behavioral changes to adapt to the impacts of climate change, especially adverse weather events, on people’s daily travel (8-11). People’s choice behavior of job and residence locations may also be affected by the climate, especially the increasing intensity and frequency of climate change events such as flood and cyclone. However, the residence and job location change choice behavior under climate change is rarely reported.

It’s important to understand people’s travel behavior changes under climate change impacts because transportation network performance is largely dependent on how travellers respond to traffic conditions (12). The residence and job location change choice behavior under climate change is as important as travel behavior change which changes the traffic generation and distribution and then the transportation network performance. In the network performance analysis literature, great contributions have been made to explore improved analysis methods under climate change disasters (13, 14) or develop more efficient calculation techniques in the application (15, 16). However, people’s residence and job location choice behavior should be addressed in these network performance analyses, neglecting which might lead to inaccurate evaluation results. Residence and job locations might be changed because of frequent or serious flood or cyclone impacts, and thus the traffic demand and volume will change with the choice of residence and job locations. Although recent studies (15, 17) have addressed travel demand uncertainty and demand growth issues, people’s location choice behavior are different towards traffic congestion, adverse weather conditions, and disastrous transportation infrastructure failures. Thus, it’s of great importance to better understand people’s residence and job location change behavior under climate change impacts and include these behavioral changes in the transportation network performance analysis and adaptation decision making.

The residence or job location choice behavior is usually addressed with its relationship with public transport accessibility, travel costs, travel modes and departure time, and so on (18-20). The influences of physiological factors and gender on residence location choice are also investigated in the literature (21, 22). The balance of residence and job location choices is found to be associated with the population pattern of a city and traditional residence and job location policy (23, 24). Arentze and Timmermans find a less significant impact of congestion pricing on residence or job location change than travel behaviour change (25). Mortreux and Barnett conclude factors influencing residence or job location choice into three groups which are factors at the point of origin including environment,
economic factors, and government policies, factors at the destination involving social network, economic factors, and government policies, and intervening obstacle factors such as distance and institutional constraints (26). These factors are proposed for normal location change decisions and may not be directly attributable to changes under climate change.

Climate enters significantly and is shown to be a direct determinant of location decisions (27). With agent-based simulation model, Kniveton et al. find that the migration or residence location change is obviously affected by the environment, that is, dry or wet environment (28). They also suggest that rainfall’s impact on location change choice is expressed via its influence on other drivers such as differential employment opportunities, limited access to natural resources, national policies and incentives, ecological vulnerability, political instability, and infrastructure. After a review of empirical research on migration and climate change, Klaiber confirms that household location change arises due to changes in economic opportunities and climate amenities resulting from climate change (27). Saldana-Zorrilla and Sandberg find that declining incomes, higher educated individuals and increasing numbers of natural disasters lead to higher levels of out-migration under climate-related disasters in Mexico (29). Other studies also investigate factors or reasons affecting the migration or location change decision under climate change impacts, and the identified factors include lack of education, strong attachments to land, age, family size, the availability of transport infrastructure, and so on (26, 30, and 31). With evidence from two communities in Canada, Wolf et al. argue that values such as tradition, freedom, harmony, safety, and unity shape different interpretations and meaning of climate change impacts, and as a result lead to distinct adaptation decision including migration or location change choice (32). Although factors influencing the residence or job location choice decision may vary among countries or observation, there is almost no doubt that people’s location choice behavior is affected by climate change impacts.

Most of the above literature focuses on the household or residence location choice under climate change scenarios. However, not only residence location choice but also job location choice will have impacts on the traffic distribution and transportation network performance. Furthermore, people may consider changing the job location first and then the residence location under climate change impacts. It would be interesting to explore factors affecting both residence location choice and job location choice or the joint choice of residence and job locations. It is agreed that because of the diversities of climate change regimes and culture/habituation in different countries people’s travel behavior and residence and job location choices behavior under climate change are different (9 and 11). Thus, understanding people’s residence and job location choice behavior under climate change in different countries of the world is of great importance especially those developing countries which are more diverse in terms of people’s education, income, and family structure and becoming more vulnerable under the impacts of climate change. Given the uncertainties of climate change, people’s residence and job location change choice decision may also be different under different climate change scenarios and types such as rainfall, river or coastal flooding, and cyclone. All these issues should be addressed with detailed investigation of people’s preference of location choices under different climate change and impact scenarios together with factors describing the household characteristics.

To address the above research gaps, this paper aims to identify flooding and cyclone
factors such as frequency and intensity and impact factors that explain the joint choice of
residence and job location while including personal and family socio-economic factors and
previous experiences in Bangladesh. Particularly, residence and job location change behavior
comparison is evaluated under flooding and cyclone impacts as well as coastal and inland
areas of Bangladesh respectively. The design of the research including data collection and
methodology development are presented in the next section.

2. RESEARCH DESIGN

2.1 Data

Bangladesh is one of the most vulnerable countries in the world threatened by flood and
cyclone due to its geographical location and setting. As a country with high population
density, 10 percent of the Bengalese lives along the coastal areas (33). Floodplains of its three
large rivers cover about 80 percent of the country’s land and three-quarters of the total
population (34), and only 10 percent of Bangladesh is 1-m above the global mean sea level
and one-third is under tidal influence (35). On average, 6000 people die from flooding and
storm each year (36). People's everyday life and daily travel are undergoing great challenges
from flooding and cyclone impacts.

In this regard, we conducted a stated preference questionnaire survey on residence
and job location change choice under flooding and cyclone impacts. Personal information
such as age, income, education degree, occupation, and so on is also investigated. Factors
involved in the analyses are shown in Table 1. Particularly, an orthogonal experiment with
five flooding factors, which are flood frequency or cyclone frequency, flood intensity or
cyclone intensity, permanent/frequent inundation, house is isolated by water, and road to
destination cities are completely destroyed, was designed for the survey. Detailed level
information of the above factors is also presented in Table 1. The factors and levels are
proposed based on the common flooding and cyclone impacts that Bangladesh people are
currently enduring. Based on the orthogonal experiment design results, there are four cards
with four scenarios in each card were created, which is to say that each respondent has to give
choices under four flooding or cyclone scenarios. The four kinds of card are distributed
equally in the total survey samples, that is, each scenario gets a quarter of the total sample.
Each respondent was then asked to give his/her job and residence location choice under the
given scenarios. The respondents have six choices under each scenario, which are same job,
same location, and not reinforce the house (Choice 1: Job0_Res0_Hou0), same job, same
location, but reinforce the house (Choice 2: Job0_Res0_Hou1), switch job, same location,
and not reinforce the house (Choice 3: Job1_Res0_Hou0), switch job, same location, but
reinforce the house (Choice 4: Job1_Res0_Hou1), same job, but shift house location (Choice
5: Job0_Res1), switch job and shift house location (Choice 6: Job1_Res1). People from 14
cities of Bangladesh among which 9 are coastal cities and 5 are inland participated in the
survey. The survey was carried out from the end of January to beginning of March of 2013.
Totally, 942 samples were collected including 580 samples from the coastal areas and 362
samples from the inland. As Bangladesh is more populated in the coastal area than the inland,
the coastal area got a higher sample share. More than 90 percent of the respondents are aged
from 20 to 60 years, and more than half belongs to the 20-40 age group. Usually, male
respondents are the head and decision maker of a family in Bangladesh and can give better answers to the questionnaire, as a result male gets a higher sample share than female. Among the respondents, the poor people such as farmer and fisherman accounts for the most sample share as most of the people in Bangladesh suffering the impacts are poor households which are more vulnerable than rich households once affected. Other occupations of the participants include boatman, rickshaw driver, businessman, government staff, teacher, private job, and so on.

**TABLE 1 Socio-economic and Flooding/Cyclone Factors Included in the Analyses**

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>The surveyed age varies from 18 years old to over 60 years old</td>
</tr>
<tr>
<td>Education level</td>
<td>1: secondary school or below; 2: high school; 3: college; 4: university and above; 5: no education</td>
</tr>
<tr>
<td>Family members</td>
<td>1: no more than 2; 2: 2 to 4 members; 3: 4 to 10 members; 4 more than 10 members</td>
</tr>
<tr>
<td>Living years (categorized by years)</td>
<td>1: no more than 5 years; 2: 5 to 10 years; 3: 10 to 20 years; 4: 20 to 30 years; 5: more than 30 years</td>
</tr>
<tr>
<td>Own land (categorized by areas)</td>
<td>1: no land owned; 2: (0 to 100m$^2$]; 3: (100 to 500m$^2$]; 4: (500 to 1000m$^2$]; 5: more than 1000m$^2$</td>
</tr>
<tr>
<td>Annual income</td>
<td>It is grouped into 12, 36, 60, 84, 120 thousands Bangladesh Taka (BDT) based on the wage levels in Bangladesh</td>
</tr>
<tr>
<td>Quality of life (QOL) affected in the past</td>
<td>QOL affected 1 completely; QOL affected 2 seriously; QOL affected 3 slightly; QOL affected 4 not at all</td>
</tr>
<tr>
<td>Recover independently in the past</td>
<td>Level 1 completely disagree; Level 2 slightly disagree; Level 3 Neural; Level 4 slightly agree; Level 5 completely agree</td>
</tr>
<tr>
<td>Move or not before disaster comes</td>
<td>Level 1 no action; Level 2 move temporarily; Level 3 move permanently; Level 4 other actions</td>
</tr>
<tr>
<td>Consider flooding/cyclone impact in new job</td>
<td>Level 1 yes; Level 2 probably yes; Level 3 no; Level 4 probably no</td>
</tr>
<tr>
<td>Flood frequency (levels 1-3)</td>
<td>Level 1: once each year; Level 2: once every 2 years; Level 3: once every 3 years</td>
</tr>
<tr>
<td>Flood intensity (levels 1-3)</td>
<td>Level 1: reach knees; Level 2: reach waist; Level 3: reach chest and above</td>
</tr>
<tr>
<td>Cyclone frequency (levels 1-3)</td>
<td>Level 1: once every 2 years; Level 2: once every year; Level 3: twice a year</td>
</tr>
<tr>
<td>Cyclone intensity (levels 1-3)</td>
<td>Level 1: some structural damage to house; Level 2: some complete house structure failure; Level 3: complete failure on may houses</td>
</tr>
<tr>
<td>Frequent inundation</td>
<td>Level 1: Yes (0); Level 2: No (1)</td>
</tr>
<tr>
<td>Salinity intrusion</td>
<td>Level 1=Yes (0); Level 2=No (1)</td>
</tr>
<tr>
<td>Isolated by water</td>
<td>Level 1=Yes (0), living place is isolated by water; Level 2=No (1), living place is not isolated by water</td>
</tr>
<tr>
<td>Roads are destroyed</td>
<td>Level 1=Yes (0), there is no road connection; Level 2=No (1), there is no road connection after flood/cyclone</td>
</tr>
</tbody>
</table>
2.2 Methodology

This study deals with a discrete choice phenomenon: each respondent is asked in the SP survey to choose one alternative from a choice set consisting of six alternatives. To represent such a discrete choice behavior, the multinomial logit (MNL) model, developed based on the random utility maximization principle, has been widely applied because of its straightforward mathematical structure and ease of estimation. Applying the MNL model, we can build people’ residence and job location change choices as well as choice of reinforcing their houses under different flooding and cyclone scenarios as follows.

\[ U_{in} = \alpha_i + \sum_{k=1}^{K} \beta_k x_{ink} + \varepsilon_{in} \]  

(1)

where, \( U_{in} \) indicates the utility that decision maker \( n \) derives from choosing alternative \( i \) in choice set, \( X_{ink} \) is the \( k \)th explanatory variable, which may include all the assumed SP attributes and the socioeconomic characteristics of the decision maker in this study. \( \alpha_0 \) and \( \beta_k \) are the unknown parameters: the former is an alternative-specific constant term and the latter is the parameter of \( X_{ink} \). The error term \( \varepsilon_{in} \) captures the influence of all omitted factors and is assumed to follow an independent and identical Gumbel distribution across all samples.

Based on the random utility maximization principle, a decision maker \( n \) will select alternative \( i \) if and only if the utility derived from choosing alternative \( i \) is the largest, among all alternatives in a choice set. With the above assumption, the MNL model can be easily derived. However, the representation of choice behavior may result in biased estimations and incorrect predictions in the MNL model when the assumed independent and identical distribution across all samples is violated.

Looking at all the six alternatives in the SP survey, each alternative is a combination of changes in residential location and job as well as reinforcing house: Choice 1 (Job0_Res0_Hou0), Choice 2 (Job0_Res0_Hou1), Choice 3 (Job1_Res0_Hou0), Choice 4 (Job1_Res0_Hou1), Choice 5 (Job0_Res1), and Choice 6 (Job1_Res1). Such mixed combinations may not be well represented using the MNL model, at least because of the overlapping parts of the six alternatives. To relax the assumption of error terms in the MNL model, to date, various logit-type choice models (e.g., NL, GE, PCL, NPCL) have been developed. At first sight, a nested logit (NL) or NL-equivalent model might be applicable. As seen in FIGURE 1, it is difficult to exclusively separate the three choice elements, i.e., residence, job, and reinforcing a house. To represent the cross-nested choice structure, a cross nested logit (CNL) model might be applicable. The CNL model allows for flexible correlations among the error terms and as a result the correlation between the choice nests of residence, job, and house reinforce will be captured. The CNL model is described below.
FIGURE 1 Structure of the CNL model.

The CNL model is derived by assuming the cumulative extreme-value distribution described in equation (2). Based on McFadden (37), the probability of alternative i to be chosen in the CNL model is formulated in equation (3), which is a closed-form formula. In the following equations, the notation n of decision maker is omitted for simplification.

\[ F(e_i) = \exp \left\{ - \sum_m \left( \sum_{i \in N_m} (\alpha_{im} e_i^{-\epsilon_i})^{1/\mu_m} \right) \mu_m \right\} \]  \hspace{1cm} (2)

\[ P_i = \sum_m p_m p_m = \sum_m \left( \frac{\left( \sum_{i \in N_m} (\alpha_{im} e_i^{\epsilon_i})^{1/\mu_m} \right) \mu_m}{\sum_{i \in N_m} \left( \sum_{i \in N_m} (\alpha_{im} e_i^{\epsilon_i})^{1/\mu_m} \right) \mu_m} \right) \]  \hspace{1cm} (3)

where, \( \mu_m \) is a nest dissimilarity parameter, and \( \alpha_{im} \) is an allocation parameter \( \alpha_{im} \).

As shown in Figure 1, the CNL mode structure includes six nests and six alternative choices. The joint choice of multiple nests results in one choice of the alternatives. In the CNL model, the dissimilarity parameter \( \mu_m (0 < \mu_m \leq 1) \) describes the correlation between alternatives sharing the same nest m, and the correlation will decrease with the increase of the parameter. The allocation parameter \( \alpha_{im} (0 \leq \alpha_{im} \leq 1) \) indicates the proportion of alternative \( i \) belonging to nest \( m \), and all the allocation parameters of an alternative \( i \) sum to 1 over nests.

Based on Bierlaire (38), the CNL model is estimated with a maximum likelihood approach, using BIOGEME (39).

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis Results
Results of the descriptive analysis of people’s stated residence and job location change choices in Bangladesh are presented in Figure 2. Percentages of the six residence and job location change choices are counted for inland flooding, coastal flooding, and coastal cyclone, separately. Among the results of location change choices in coastal and inland regions, more people would choose changing house location than changing job location to respond to flooding and cyclone impacts, which underlines the serious impacts that people’s houses are enduring. Under the proposed flooding scenarios, more people from inland regions chose no response or just to reinforce the house, and people selecting the two choices almost reach half of the total inland observation. However, more coastal people would choose to change residence location in response to flooding impact. This indicates that coastal people suffer more from flooding impacts than the inland people and changing residence location may be their best choice to adapt to coastal flooding impacts. Inland people might experience less flooding events and not need to worry about it or just reinforce their houses to respond. In the coastal areas, people’s location change choices are much similar under flooding and cyclone impacts. But more people chose to change residence location under cyclone impacts than those under flooding. This is the truth considering the more disruptive damage of cyclone than flooding, and that reinforce the house to respond to cyclone may be less effective.

FIGURE 2 Residence and job location change choices under flooding and cyclone.

3.2 Discrete Choice Model Analyses

3.2.1 MNL Model Estimation Results

As disclosed by the descriptive analysis results, people’s choice behaviors under flooding and cyclone impacts are different in coastal and inland regions. These differences might be related to the characteristics of flooding or cyclone and socio-economic attributes of the respondents. The MNL models are estimated for the three groups of observation to explore factors that affect the different choice behavior. Estimation results are shown in Table 2 for inland flooding, coastal flooding, and coastal cyclone, respectively.

Results of the coastal flooding case are shown in Table 2, in which only significant factors are presented. It can be seen that socio-economic factors such as income and amount of land owned, family factor of number of family members, previous flooding experiences of QOL affected, and flooding factors have significant impacts on people’s residence and job.
location change choice. Particularly, flooding factors such as frequency, intensity, and salinity intrusion are almost significant at the 1 percent level for all the choice alternatives. The income of a household has positive effects on the location choice behavior, and the higher income leads to more probability to change job or residence location. But there is no significant effect of income on Choice 2 (only house reinforcement) showing that most of the people in coastal Bangladesh could afford the house reinforcement whatever income levels. Coefficients of family member and land owned are negative for all the choices denoting that with the increase of number of family member and amount of land people would like to choose Choice 1 instead of other choices, which tells that households with more people and land would not like to change job or residence location. Negative impacts are also reported for previous flooding and cyclone experiences, that is, people who think that his or her QOL is seriously affected would be more likely to change job or residence location or reinforce the house. With the increase of flood frequency and intensity significant impacts of people’s location change behavior could be observed, and people would like to change job location followed by residence location and then both the job and house locations as bigger coefficient values are calculated for Choices 5 and 6. Under salinity intrusion, people would also like to change job or residence location. If connecting roads are destroyed because of flooding or cyclone people may also want to change job and residence locations as could be learnt from the negative significant coefficients of the road destroy factor for Choices 5 and 6.

TABLE 2 Model Estimation Results of Coastal People’s Location Choice Change Behavior under Flooding Impacts (Reference Alternative: Choice 1)

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Choice 2</th>
<th>Choice 3</th>
<th>Choice 4</th>
<th>Choice 5</th>
<th>Choice 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>-</td>
<td>0.195**</td>
<td>0.189**</td>
<td>0.199***</td>
<td>0.222***</td>
</tr>
<tr>
<td>Family member</td>
<td>-</td>
<td>-</td>
<td>-0.402**</td>
<td>-0.367**</td>
<td>-0.476**</td>
</tr>
<tr>
<td>Land owned</td>
<td>-0.200**</td>
<td>-0.212*</td>
<td>-0.407***</td>
<td>-0.218**</td>
<td>-0.310**</td>
</tr>
<tr>
<td>QOL affected in the past</td>
<td>-0.462***</td>
<td>-0.267*</td>
<td>-</td>
<td>-0.336**</td>
<td>-0.439**</td>
</tr>
<tr>
<td>Flood frequency</td>
<td>0.712***</td>
<td>0.577***</td>
<td>0.949***</td>
<td>1.316***</td>
<td>1.237***</td>
</tr>
<tr>
<td>Flood intensity</td>
<td>0.392***</td>
<td>-</td>
<td>0.465***</td>
<td>0.912***</td>
<td>0.956***</td>
</tr>
<tr>
<td>Salinity intrusion</td>
<td>-0.470**</td>
<td>-0.600**</td>
<td>-0.695***</td>
<td>-0.636***</td>
<td>-1.086***</td>
</tr>
<tr>
<td>Road destroy</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-0.651***</td>
<td>-0.450**</td>
</tr>
</tbody>
</table>

Final log-likelihood: -3485

Number of observations: 2320

* denotes the factors are not significant.
*significant at 10% level; **significant at 5% level; ***significant at 1% level.

Similar to the coastal flooding observation, the location change choice of inland people under flooding is also the most significantly affected by the flood frequency and intensity. This means that responses to flooding factors such as frequency and intensity are similar between coastal and inland people. Income and amount of land owned are also among
significant factors affecting inland peoples’ location choice decision. However, previous experience of QOL affected is almost insignificant for all the choices. This could be interpreted that different from coastal observation the inland households experience less flooding events and have less knowledge about how their QOL could be affected by flooding, and thus the QOL affected factor appears as an insignificant factor. Significant factors and significance levels of the location change choice of coastal people under cyclone are the same with those of coastal flooding observation. Cyclone frequency, intensity, and salinity intrusion are the most significant factors in people’s location choice, and income, land owned, and number of family member are significant socio-economic factors. The QOL affected in previous cyclone experience is also shown as a significant factor influencing people’s location choice. The same as it is under flooding, road destroy appears as a significant factor only under Choices 5 and 6 both of which include residence location change. As a result, a conclusion could be drawn that road connection under flooding and cyclone is important for people’s residence location change decision in coastal areas.

3.2.2 CNL Model Estimation Results
With the above the MNL model results, significant factors for inland flooding, coast flooding, and coastal cyclone are selected for the CNL analysis based on the structure of Figure 1. Factors included in the analysis are shown in Table 3. The CNL model estimation results are also presented in Table 3 with a comparison with outputs of the MNL model. Overall, the CNL model outperforms the MNL model with lower absolute log likelihood values and higher adjusted $\rho^2$ values in both inland and coastal observations. Comparing with the MNL estimation results, there is not too much change in the significance levels of the proposed factors in the CNL model results, but most absolute values of the coefficients in the CNL model are smaller. This shows that the influences of the factors on the location choice behavior of the three groups of observations decrease in the CNL model. In the CNL model results, flood/cyclone frequency and intensity, number of family member, income, and QOL affected are all statistically significant factors. The inland flooding observations have fewer significant factors than the coastal samples, demonstrating that the inland people are experiencing less or un-obvious flooding events than the coastal people and sensitive to less influencing factors. The salinity intrusion turns out to be an insignificant factor in the CNL model under coastal flooding. As a result, it is concluded that it’s flooding or cyclone frequency and intensity, family attributes, and previous experiences significantly affecting people’s job and residence location choice behavior in the coastal area, and inland people are only significantly consider flood attributes and economic factors when making location choice decisions.
TABLE 3 A Comparison between CNL and MNL Models

<table>
<thead>
<tr>
<th>Model type</th>
<th>CNL</th>
<th>MNL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inland flooding</td>
<td>Coastal flooding</td>
</tr>
<tr>
<td>Income</td>
<td>0.020**</td>
<td>0.017**</td>
</tr>
<tr>
<td>QOL affected</td>
<td>-</td>
<td>-0.252***</td>
</tr>
<tr>
<td>Land owned</td>
<td>-0.023</td>
<td>-0.022</td>
</tr>
<tr>
<td>Family member</td>
<td>0.003</td>
<td>0.107***</td>
</tr>
<tr>
<td>Flood/cyclone frequency</td>
<td>0.012</td>
<td>0.104***</td>
</tr>
<tr>
<td>Flood/cyclone intensity</td>
<td>0.124***</td>
<td>0.089**</td>
</tr>
<tr>
<td>Salinity intrusion</td>
<td>-</td>
<td>-0.028</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-556.698</td>
<td>-878.497</td>
</tr>
<tr>
<td>Adjusted $\rho^2$</td>
<td>0.394</td>
<td>0.295</td>
</tr>
</tbody>
</table>

Number of observation inland 1448; coastal 2320

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"-" denotes that the factor is not included in the analysis.

*significant at 10% level; **significant at 5% level; ***significant at 1% level.

The allocation parameters of the six nests are estimated in Table 4. Under the inland flooding observation, people who choose changing job and residence locations assign almost the same weight on changing job and residence since $\alpha_{A6}$ almost equals to $\alpha_{C6}$ with high significance levels. However, other alternatives with significant allocation parameters assign small portions to the nests. As for the location change choice under coastal flooding, most parameters in nest D (not change residence location) are significant, and $\alpha_{D4}$ almost reaches to 1 showing that people choose Choice 4, that is, changing job location and reinforce the house, mainly because that they do not want to change their residence locations. Similarly, from the values of $\alpha_{D1}$ and $\alpha_{D3}$, Choice 1 and Choice 3 have major impacts on nest D which represents that people would not like to change their house locations. The allocation parameters of Choice 4 under coastal cyclone are all statistically significant, and values of the parameters demonstrate that people select this choice assign the most weight to changing job location and followed by not changing residence location. The differences of choice behavior could be observed that people under coastal flooding choose Choices 1, 3, and 4 mainly consider that they would not like to change their residence locations, while inland people may depend more on that they do not want to change their jobs when choosing Choice 1. When choosing Choice 3, coastal people under cyclone depend more on not reinforcing houses, but inland people under flooding just because they are willing to change job locations.
### TABLE 4 Estimated Allocation and Dissimilarity Parameters of CNL Model

<table>
<thead>
<tr>
<th>Inland flooding</th>
<th>Coastal flooding</th>
<th>Coastal cyclone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>T value</td>
<td>Value</td>
</tr>
<tr>
<td>Estimated allocation parameters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha_{A3}$</td>
<td>0.125***</td>
<td>-11.68</td>
</tr>
<tr>
<td>$\alpha_{A4}$</td>
<td>0.201***</td>
<td>-4.93</td>
</tr>
<tr>
<td>$\alpha_{A6}$</td>
<td>0.531**</td>
<td>-2.31</td>
</tr>
<tr>
<td>$\alpha_{B1}$</td>
<td>0.990</td>
<td>-0.02</td>
</tr>
<tr>
<td>$\alpha_{B2}$</td>
<td>0.992</td>
<td>-0.04</td>
</tr>
<tr>
<td>$\alpha_{B5}$</td>
<td>0.994</td>
<td>-</td>
</tr>
<tr>
<td>$\alpha_{C5}$</td>
<td>0.006</td>
<td>-</td>
</tr>
<tr>
<td>$\alpha_{C6}$</td>
<td>0.469***</td>
<td>-2.62</td>
</tr>
<tr>
<td>$\alpha_{D1}$</td>
<td>0.001*</td>
<td>-1.92</td>
</tr>
<tr>
<td>$\alpha_{D2}$</td>
<td>0.005***</td>
<td>-7.72</td>
</tr>
<tr>
<td>$\alpha_{D3}$</td>
<td>0.703</td>
<td>-0.16</td>
</tr>
<tr>
<td>$\alpha_{D4}$</td>
<td>0.767</td>
<td>-</td>
</tr>
<tr>
<td>$\alpha_{E2}$</td>
<td>0.003***</td>
<td>-71.67</td>
</tr>
<tr>
<td>$\alpha_{E4}$</td>
<td>0.032</td>
<td>-</td>
</tr>
<tr>
<td>$\alpha_{F1}$</td>
<td>0.009***</td>
<td>-9.42</td>
</tr>
<tr>
<td>$\alpha_{F3}$</td>
<td>0.172</td>
<td>-0.46</td>
</tr>
</tbody>
</table>

Estimated dissimilarity parameters

| Nest A | 0.458 | 0.35 | 0.001 | - | 0.663 | 1.38 |
| Nest B | 0.164** | 1.70 | 0.853** | 1.44 | 0.126* | 1.88 |
| Nest C | 0.078 | - | 0.001 | - | 0.041 | 0.01 |
| Nest D | 0.001 | 0.03 | 0.911** | 1.57 | 0.053 | - |
| Nest E | 0.032*** | 5.42 | 0.001 | - | 0.001 | - |
| Nest F | 0.001 | - | 0.002 | 0.05 | 0.011 | - |

"-" means no T value available.

*significant at 10% level; **significant at 5% level; ***significant at 1% level.

Table 4 also presents the dissimilarity parameters for each nest of the CNL model structure. Nests B get significant values under the three observations, Nest D has significant value under the coastal flooding observation, and Nest E receives dissimilarity parameter under the inland flooding observation with the highest significance level. In the case of inland flooding, Nest B has a bigger dissimilarity parameter but lower significance level than Nest E, which means that alternatives in Nest B have low correlation and low substitutability. When the utility variables change, for example, flooding impacts deteriorating, the inland people are willing to change the not changing job location decision first. Both Nests B and D have big dissimilarity parameters under the coastal flooding observation denoting the nest of not changing job location and not changing residence location have low substitutability. When
1. the utility variables alter, people would change the not changing job or residence location first.

4. CONCLUSIONS

This work addressed the residence and job location change choice behavior under flooding and cyclone impacts. Efforts were made on investigating significant factors influencing people’s location choice behavior in coastal and inland areas of Bangladesh and exploring the joint choice behavior among residence and job locations and house reinforcement through a proposed CNL model structure. Results of this study confirms the serious impacts that flood and cyclone are imposing on coastal and inland Bangladesh people, and more than 80 percent of the respondents would like to make changes to their houses or jobs under the proposed flooding and cyclone scenarios. Flooding and cyclone attributes such as frequency and intensity turn out to be the most significant factors affecting people’s choice behavior, and income, number of family member, amount of land owned also show significant effects on the location change choices which confirms with results of previous studies. Different from the coastal observations, the inland people may be less affected by flood, and thus previous experiences such as QOL shows insignificant influence when making location change choice. Road connection plays an important and significant role when people choose to change residence locations in coastal areas. The CNL model shows better model fitting results than the MNL model and could give more insights into people’s location choice behavior. Under flooding or cyclone impacts, people would like to change their job locations and then the residence locations. It is also found that if there are changes in flooding impacts the inland people will first consider to change their job locations, while the coastal people would consider both job and residence location changes.

Results of this work add to the knowledge of location change choice behavior adaptation to flooding and cyclone impacts in a developing and seriously affected country. As disclosed by the study, there is an obvious change of residence or job location in both coastal and inland areas under proposed scenarios. This location change behavior should be addressed in the transportation network performance analysis under climate change impacts, and failing to include these location change behavior might neglect changes in travel demand, travel attraction, and route choice resulting in accurate analysis results. The study also sheds light on policy suggestions for local governments and households adapting to climate change adaptation. People with high income, less land, and fewer family members are encouraged to migrate to safety places, and coastal households are suggested to go to shelters or change job and residence locations under the cyclone threat since reinforcing the house is not a significant factor in the analysis. It’s important to guarantee accessible road infrastructure under flooding or cyclone failing of which might significantly lead to people’s residence location change.

Future research efforts are suggested to include factors at the target job or residence locations to be moved and social or economic connections with the target locations in the model to improve the accuracy of the results. It’s better to include more flooding and cyclone scenarios, socio-economic factors, family attributes, and choice alternatives such as going to shelters, exploring more detailed behavioral characteristics of people’s choice behavior under climate change. The location change behavior analyses under other climate changes such as
heavy rainfall, extremely hot or cold weather, and sea-level rise are also favorable so as to comprehensively understand people’s behavioral responses to climate change. Finally, comparative analyses of people’s residence and job location change choice behavior response between regions or nations with different climate, flooding and cyclone impacts, living traditions, and adaptive capacity are also preferable.

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