Short-Term Public Shelter Algorithm: A Modified HAZUS Approach*

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(hrrc.arch.tamu.edu/publications/research reports/08-06R Short-Term Shelter Needs Algorithm.pdf)

Short-Term Public Shelter Algorithm: A Modified HAZUS Approach

After a destructive disaster event, many dislocated households will need to seek alternative housing for a temporary period of time. Post-disaster housing includes a variety of forms: mass care facilities, public shelters, tents, travel trailer, doubling up with friends, family, or relatives, or alternative lodging at hotels or alternative housing of a variety of forms. Among these different forms of post-disaster housing, providing the public shelters is generally considered the responsibilities of government or designated NGOs such as the Red Cross. Furthermore establishing these shelters must be undertaken in a timely fashion during the immediate aftermath of an event.

Given the immediate needs for establishing shelters in a timely fashion, having good estimations of households and people that will need to seek some form of short-term public shelter is important for disaster response and recovery decision-making. Furthermore, since households and individuals that are likely to be in need of public shelters are often disadvantaged and have difficulty to find alternative shelters based upon their financial resources or social networks, it will be equally important to identify areas of a community likely to generate households with these needs given different disaster scenarios.

The purpose of this algorithm is to provide an initial estimation of short-term public shelter needs applying the current HAZUS logic into the MAEViz computational environment which is utilizing the more refined damage assessment fragilities and algorithms, highly detailed building inventory data, and much more refined socio-demographic data available at the block group level.

I. Base data requirements:

There are two data sources: the total number of dislocated households in a block group and several neighborhood characteristics at block group level. The total mummer of dislocated households of a block group (DisHh_{bg}) is obtained from the dislocated household algorithm, and the neighborhood characteristics at block group level are from US Census.

Variable name	Va	riable definition
• DisHh _{bg}	\rightarrow	Total number of dislocated households
(Variable above is	s obta	ained from the dislocation algorithms)
• TOTPOP	\rightarrow	Total Population
• TOT_HH	\rightarrow	Total No. of Households
• HI_LT10	\rightarrow	No. of Households earning less than \$9,999

• HI_1015 \rightarrow No. of Households earning between \$10,000 and \$14,999

- HI_1520 \rightarrow No. of Households earning between \$15,000 and \$19,999
- HI_2025 \rightarrow No. of Households earning between \$20,000 and \$24,999
- HI_2530 → No. of Households earning between \$25,000 and \$29,999
- HI 3035 \rightarrow No. of Households earning between \$30,000 and \$34,999
- H_OWN \rightarrow No. of Owner-occupied Housing Units
- H_RNT \rightarrow No. of Renter-occupied Housing Units

(Variables above are available from the Shelby Census data prepared by Dr. French)

- P004002 → Total population: Hispanic or Latino
 P004005 → Total population: Not Hispanic or Latino; Population of one race; White alone
- P004006 → Total population: Not Hispanic or Latino; Population of one race; Black or African American alone
- P004007 → Total population: Not Hispanic or Latino; Population of one race; American Indian and Alaska Native alone
- P012003 \rightarrow Total population: Male; Under 5 years
- P012004 \rightarrow Total population: Male; 5 to 9 years
- P012005 \rightarrow Total population: Male; 10 to 14 years
- P012006 \rightarrow Total population: Male; 15 to 17 years
- P012020 \rightarrow Total population: Male; 65 and 66 years
- P012021 \rightarrow Total population: Male; 67 to 69 years
- P012022 \rightarrow Total population: Male; 70 to 74 years
- P012023 \rightarrow Total population: Male; 75 to 79 years
- P012024 \rightarrow Total population: Male; 80 to 84 years
- P012025 \rightarrow Total population: Male; 85 years and over
- P012027 \rightarrow Total population: Female; Under 5 years
- P012028 \rightarrow Total population: Female; 5 to 9 years
- P012029 \rightarrow Total population: Female; 10 to 14 years
- P012030 \rightarrow Total population: Female; 15 to 17 years
- P012044 \rightarrow Total population: Female; 65 and 66 years
- P012045 \rightarrow Total population: Female; 67 to 69 years
- P012046 \rightarrow Total population: Female; 70 to 74 years
- P012047 \rightarrow Total population: Female; 75 to 79 years
- P012048 \rightarrow Total population: Female; 80 to 84 years
- P012049 \rightarrow Total population: Female; 85 years and over

(Variables above are available from Download Center of Census Website, http://factfinder.census.gov/servlet/DownloadDatasetServlet?_lang=en)

II. HAZUS short-term shelter needs assumption

In HAZUS shelter model, it uses census tract level as the unit of analysis. The algorithm considers five factors, including dislocated population, income, ethnicity, tenure, and age pattern to estimate the number of population who need public shelter. The formulas to calculate the population requiring short-term shelter requirements is:

$$STP = \sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{o=1}^{2} (\alpha_{lmno} \times (DisHh_{tr} \times TOTPOP_{tr} / TOT _ HH_{tr}) \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o})$$
(1)
$$\alpha_{klmn} = (IW \times IM_{l}) + (EW \times EM_{m}) + (OW \times OM_{n}) + (AW \times AM_{o})$$
(2)

where	STP Nun	ber of people requiring short term housing
	lphaklmn	Coefficient defined by demographic characteristics
	HI_{l}	Percentage of population in the ith income class
	HE_m	Percentage of population in the jth ethnic class
	HO_{n}	Percentage of population in the kth ownership class
	HAo	Percentage of population in the lth age class
	DisHh _{tr}	Dislocated household in census tract
	TOTPOP _{tr}	Population in census tract
	TOT_HH_{tr}	Household in census tract
	IW	Income weighting factor
	EW	Ethnic weighting factor
	OW	Ownership weighting factor
	AW	Age weighting factor
	IM_1	Income modification factor
	$\mathrm{E}\mathrm{M}_\mathrm{m}$	Ethnic modification factor
	OM_n	Ownership modification factor
	AMo	Age modification factor

Class	Description	Default	
IW	Income Weighting Factor	0.73	
EW	Ethnic Weighting Factor	0.27	
OW	Ownership Weighting Factor	0.00	
AW	Age Weighting Factor	0.00	

 Table 1:
 Shelter Category Weights

Table 2: Shelter Relative Modification Factors

Class	Description	Default	
Income			
IM ₁	Household Income < \$10000	0.62	
IM ₂	\$10000 < Household Income < \$15000	0.42	
IM ₃	\$15000 < Household Income < \$25000	0.29	
IM ₄	\$25000 < Household Income < \$35000	0.22	
IM ₅	\$35000 < Household Income	0.13	
Ethnic			
EM ₁	White	0.24	
EM ₂	Black	0.48	
EM ₃	Hispanic	0.47	
EM ₄	Asian	0.26	
EM ₅	Native American	0.26	
Ownership			
OM ₁	Own Dwelling Unit	0.40	
OM ₂	Rent Dwelling Unit	0.40	
Age			
AM ₁	Population Under 16 Years Old	0.40	
AM ₂	Population Between 16 and 65 Years Old	0.40	
AM ₃	Population Over 65 Years Old	0.40	

Due to the data limitations when using census data, there are two basic assumptions in the algorithm (1). First it must be assumed that the demographic characteristics of the dislocated population are the same as the characteristics of the whole census tract. Secondly that there is no correlation (interdependency) among income, ethnicity, tenure, and age characteristics, which means the proportion of certain demographic combinations, can be estimated by simply multiplying the proportions of items.

The short-term shelter coefficient α is the function of the weighting factors and modification factors shown in Table 1 and Table 2. By default, the OW and AW are 0, which means only income and ethnicity characteristics determine the dislocated population likely to be using or needing public shelters.

If demographic data at household level are available, the short-term shelter needs for a household in a single-family structure or a multi-family structure k can be

$$SHP_{sfk} = \alpha \times HhD_{sfk} \times HhSize_k \times HI_l \times HE_m \times HO_n \times HA_o$$

$$SHP_{mfk} = \alpha \times HhD_{sfk} \times HhSize_k \times HI_l \times HE_m \times HO_n \times HA_o$$

where $\alpha = (IW \times IM) + (EW \times EM) + (OW \times OM) + (AW \times AM)$

However, when using public versions of census data the demographic characteristics are usually only available at block (on a limited basis) or block group, tract or higher level of census spatial aggregation, not at household level. Hence, the application of HAZUS approach for short-term shelter needs for households within a single family or multifamily structure becomes

$$STP_{sfk} = \sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{3} (\alpha_{lmno} \times (HhD_{sfk} \times TOTPOP / TOT _ HH) \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}) \text{ or }$$

$$STP_{mfk} = \sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{o=1}^{2} \sum_{o=1}^{3} (\alpha_{lmno} \times (HhD_{mfk} \times TOTPOP / TOT _ HH) \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o})$$

For the household within a same block group, the short-term shelter coefficient,

$$\sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{5} (\alpha_{lmno} \times HI_l \times HE_m \times HO_n \times HA_o), \text{ is constant. Therefore, the total number of}$$

individual in single family requiring short-term shelter becomes

$$\left(\sum_{k=1}^{K_{sf}} HhD_{sfk}\right) \times \left(TOTPOP / TOT _ HH\right) \times \left(\sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{3} \left(\alpha_{lmno} \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}\right)\right).$$
 The total

number of individual in multifamily family requiring short-term shelter is

$$\left(\sum_{k=1}^{K_{sf}} HhD_{mfk}\right) \times \left(TOTPOP/TOT_HH\right) \times \left(\sum_{l=1}^{5}\sum_{m=1}^{5}\sum_{n=1}^{2}\sum_{o=1}^{3}\left(\alpha_{lmno} \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}\right)\right).$$

When aggregating to block group level, the number of individual requiring short-term shelter needs becomes:

$$STP_{bg} = \left(\sum_{k=1}^{K_{sf}} HhD_{sfk} + \sum_{k=1}^{K_{mf}} HhD_{mfk}\right) \times \left(TOTPOP / TOT _ HH\right) \times \left(\sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{3} \left(\alpha_{lmno} \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}\right)\right)$$

or $STP_{bg} = \left(DisHh_{bg}\right) \times \left(TOTPOP / TOT _ HH \times \left(\sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{3} \left(\alpha_{lmno} \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}\right)\right)$

This number of individual requiring short-term shelter is the function of dislocated households, average household size, and income, ethnic, homeownership, and age characteristics of a neighborhood – which in our approach would be the block group. Although there are different approaches in estimating dislocated household, the formulas for calculating number of individual requiring short-term shelter in a block group are identical to all of the dislocation procedures.

III. Process for estimating short-term shelter needs for block group level

- 1. Prepare the HAZUS demographic factors for the block group
- 1.1. Calculate the proportion of income category HI_l ($l = 1 \sim 5$) for every block group. HI_l are the income categories; where HI_1 is the proportion of household with earning equal to or less than \$9999, HI_2 is the proportion of household with earning between \$10000 to \$14999, HI_3 is the proportion of household with earning between \$15000 to \$24999, HI_4 is the proportion of household with earning between \$25000 to \$34999, and HI_5 is the proportion of household with earning between \$35000.
 - $HI_1 = HI_LT10 / TOT_HH$
 - $HI_2 = HI_1015_i / TOT_HH$
 - $HI_3 = (HI_1520 + HI_2025) / TOT_HH$
 - HI₄ = (HI_2530 + HI_3035) / TOT_HH
 - $HI_5 = 1 HI_1 HI_2 HI_3 HI_4$
- 1.2. Calculate the proportion of individuals in each ethnic category HE_m ($m = 1 \sim 5$) for every block group. In the description of original HAZUS algorithm, it only considers the population of White, Black, Hispanic, Asian, and Native American. However, this taxonomy in HAZUS is inconsistence with Census. In HAZUS, ethnic category does not include Native Hawaiian and Other Pacific Islander, other races, and two or more races; however, these are shown in Census data. The algorithm here collapses the populations of Native Hawaiian and Other Pacific Islander, other races, and two or more races into HE4, and changes this sub-category to Asian and other. Hence, HE_1 is the proportion of White,

 HE_2 is the proportion of Black, HE_3 is the proportion of Hispanic, HE_4 is the proportion of Asian and other, and HE_5 is the proportion of Native American.

- HE₁ = P004005 / TOTPOP
- HE₂ = P004006 / TOTPOP
- HE₃ = P004002 / TOTPOP
- HE₅ = P004007 / TOTPOP
- $HE_4 = 1 HE_1 HE_2 HE_3 HE_5$
- 1.3. Calculate the proportion of ownership category HO_n ($n = 1 \sim 2$) for every block group. HO_1 is the proportion of owner occupied dwelling unit, and HO_2 is the proportion of renter occupied dwelling unit
 - $HO_1 = H_OWN / TOT_HH$
 - $HO_2 = H_RNT / TOT_HH$
- 1.4. Calculate the proportion of age category HA_o ($o = 1 \sim 3$) for every block group. HA_1 is the proportion of population equal to or under 15 years old, HA_2 is the proportion of population between 16 and 65 years old, and HA_3 is the proportion of population more than 65 years old.
 - HA₁ = ((P012003 + P012004 + P012005 + (P012006 / 3)) + (P012027 + P012028 + P012029 + (P012030 / 3))) / TOTPOP
 - $HA_3 = ((P012020 + P012021 + P012022 + P012023 + P012024 + P012025) + (P012044 + P012045 + P012046 + P012047 + P012048 + P012049)) / TOTPOP$
 - $HA_2 = 1 HA_1 HA_3$

2. Set the shelter needs coefficients by user

In this part, MAEViz should provide an environment to promote user to accept or modify the shelter category weights (as Table 1) and shelter relative modification factors (see Table 2) to estimate short-term shelter needs coefficient α .

- 2.1. Accept or modify the shelter category weights, IW, EW, OW, and AW by user. The values of IW, EW, OW, and AW must satisfy the following conditions
 - The values of IW, EW, OW, and AW are between 0 and 1
 - IW + EW + OW + AW must equal to 1
- 2.2. Accept or modify the shelter relative modification factors, IM, EM, OM, and AM by user. The values of IM, EM, OM, and AM are between 0 and 1
- 3. Calculate short-term shelter needs for each block group

3.1. Calculate the population requiring short-term shelter for each block group

•
$$STP_{bg} = (DisHh_{bg}) \times (TOTPOP / TOT _ HH \times (\sum_{l=1}^{5} \sum_{m=1}^{5} \sum_{n=1}^{2} \sum_{o=1}^{3} (\alpha_{lmno} \times HI_{l} \times HE_{m} \times HO_{n} \times HA_{o}))$$

where $\alpha_{lmno} = (IW \times IM_{l}) + (EW \times EM_{m}) + (OW \times OM_{n}) + (AW \times AM_{o})$

the default values of IW, EW, OW, AW, IM_1 , EM_m , OM_n , and AM_o are listed in Table 1 and Table 2. User can also modify the values as step 2.

3.2. Calculate the percentage of population who needs short-term shelter (P_SHP_{bg}) for block group bg

- $P_SHP_{bg} = (SHP_{bg} / TOTPOP) \times 100\%$
- 3.3. Calculate the total number of individual requiring short-term shelter for the whole county or study area, *TotSHP_j*
 - $TotSHP_j = \sum SHP_{bg}$
- 3.4. Calculate the county population (*CNTYPOP_j*)and the percentage of population requiring short-term shelter (*P_CNTYSHP_j*) for the whole county or study area
 - $CNTYPOP_j = \sum TOTPOP$
 - $P_CNTYSHP_j = (TotSHP_j / CNTYPOP_j) \times 100\%$

IV. Expected output

- 1. A report expressing the numbers and proportions of population who need short-term shelter by census block group and aggregated to county level.
- 2. A map showing the population who need short-term shelter by block group.
- 3. A map showing the proportion of population who need short-term shelter by block group.

Appendix 1. Variable List

Variable Name	Description	Note		
DisHh	Total number of dislocated households	From dislocation algorithm		
ТОТРОР	Total Population	2000 Census (from Dr. French)		
TOT_HH	Total No. of Households	2000 Census (from Dr. French)		
HI_LT10	No. of Households earning less than \$9,999	2000 Census (from Dr. French)		
HI_1015	No. of Households earning between \$10,000 and \$14,999	2000 Census (from Dr. French)		
HI_1520	No. of Households earning between \$15,000 and \$19,999	2000 Census (from Dr. French)		
HI_2025	No. of Households earning between \$20,000 and \$24,999	2000 Census (from Dr. French)		
HI_2530	No. of Households earning between \$25,000 and \$29,999	2000 Census (from Dr. French)		
HI_3035	No. of Households earning between \$30,000 and \$34,999	2000 Census (from Dr. French)		
H_OWN	No. of Owner-occupied Housing Units	2000 Census (from Dr. French)		
H_RNT	No. of Renter-occupied Housing Units	2000 Census (from Dr. French)		
P004002	Total population: Hispanic or Latino	2000 Census		
P004005	Total population: Not Hispanic or Latino; Population of one race; White alone	2000 Census		
P004006	Total population: Not Hispanic or Latino; Population of one race; Black or African American alone	2000 Census		
P004007	Total population: Not Hispanic or Latino; Population of one race; American Indian and Alaska Native alone	2000 Census		
P012003	Total population: Male; Under 5 years	2000 Census		
P012004	Total population: Male; 5 to 9 years	2000 Census		
P012005	Total population: Male; 10 to 14 years	2000 Census		
P012006	Total population: Male; 15 to 17 years	2000 Census		
P012020	Total population: Male; 65 and 66 years	2000 Census		
P012021	Total population: Male; 67 to 69 years	2000 Census		
P012022	Total population: Male; 70 to 74 years	2000 Census		
P012023	Total population: Male; 75 to 79 years	2000 Census		

Variable Name	Description	Note		
P012024	Total population: Male; 80 to 84 years	2000 Census		
P012025	Total population: Male; 85 years and over	2000 Census		
P012027	Total population: Female; Under 5 years	2000 Census		
P012028	Total population: Female; 5 to 9 years	2000 Census		
P012029	Total population: Female; 10 to 14 years	2000 Census		
P012030	Total population: Female; 15 to 17 years	2000 Census		
P012044	Total population: Female; 65 and 66 years	2000 Census		
P012045	Total population: Female; 67 to 69 years	2000 Census		
P012046	Total population: Female; 70 to 74 years	2000 Census		
P012047	Total population: Female; 75 to 79 years	2000 Census		
P012048	Total population: Female; 80 to 84 years	2000 Census		
P012049	Total population: Female; 85 years and over	2000 Census		
HI_1	Proportion of Household with Income <	HI_LT10 / TOT_HH		
	\$10000			
HI ₂	Proportion of Household with Income	HI_1015 / TOT_HH		
	between \$10000 and \$15000			
HI ₃	Proportion of Household with Income	(HI_152 + HI_2025) / TOT_HH		
	between \$15000 and \$25000			
HI ₄	Proportion of Household with Income	(HI_2530 + HI_3035) / TOT_HH		
	between \$25000 and \$35000			
HI ₅	Proportion of Household with Income over	$1 - HI_1 - HI_2 - HI_3 - HI_4$		
	\$35000			
HE ₁	Proportion of White	P004005 / TOTPOP		
HE ₂	Proportion of Black	P004006 / TOTPOP		
HE ₃	Proportion of Hispanic	P004002 / TOTPOP		
HE ₅	Proportion of Native American	P004007 / TOTPOP		
HE ₄	Proportion of Asian	$1-HE_1-HE_2-HE_3-HE_5$		
HO ₁	Proportion of Owner occupied household	H_OWN / TOT_HH		
HO ₂	Proportion of Renter occupied household	H_RNT / TOT_HH		
HA_1	Proportion of Population Under 16 Years	((P012003 + P012004 + P012005 + (P012006 / 20)) + (P012027 + P012022 + P0120		
	Old	5)) + (P012027 + P012028 + P012029 + (P012030 / 3))) / TOTPOP		
HA ₃	Proportion of Population Over 65 Years Old	((P012020 + P012021 + P012022 + P012023 + P012024 + P012025) + (P012044 + P012045 + P012046 + P012047 + P012048 + P012049)) /		

Variable Name	Description	Note		
		ТОТРОР		
HA ₂	Proportion of Population Between 16 and 65	1 - HA ₁ - HA ₃		
	Years Old			
α_{jklm}	Short-term shelter coefficient	$(\mathrm{IW} * \mathrm{IM}_{j}) + (\mathrm{EW} * \mathrm{EM}_{k}) + (\mathrm{OW} * \mathrm{OM}_{l}) + (\mathrm{AW} * \mathrm{AM}_{m})$		
SHP _{bg}	Population needing short-term shelter in the block group	DisHh _{bg} * $\sum_{j=1}^{5} \sum_{k=1}^{5} \sum_{l=1}^{2} \sum_{m=1}^{3} (\alpha_{jklm} * (TOTPOP /$		
		$TOT_HH) * HI_j * HE_k * HO_l * HA_m)$		
P_SHP _{bg}	Percentage of population needing short-term shelter in the block group	$(SHP_{bg}/TOTPOP) \times 100\%$		
TotSHP _j	Population needing short-term shelter in the county	$\Sigma \operatorname{SHP}_{bgi}$		
CNTYPOP _j	Total of population in the county	Σ ΤΟΤΡΟΡ		
P_CNTYSHP _j	Percentage of population needing short-term shelter in the county	$(\text{TotSHP}_j / \text{CNTYPOP}_j) \times 100\%$		

Appendix 2. Example Calculations for population requiring short-term shelter:

Household	Household Size	Dislocation	Income	Ethnic	Tenure	Age	Gender
1	2	Ν	31000	Black	Owner	30	М
				Black		31	F
2	3	Y	75000	White	Owner	32	М
				White		30	F
				White		2	F
3	1	Y	18000	Hispanic	Renter	67	F
4	3	Y	29000	Black	Renter	25	М
				Black		22	F
				Black		2	М
5	1	N	80000	White	Owner	40	М

Assuming in the block group bg, there are 10 persons within 5 households. The following is the hypothetical demographic characteristic for the individuals and households:

In fact, the data is only available at block group or block level unless adopting a further survey. We can get the information at block group level from Census and dislocation algorithm as the followings:

- TOTPOP: 10, TOT_HH: 5
- HI_LT10: 0, HI_1015: 0, HI_1520: 1, HI_2025: 0, HI_2530: 1, HI_3035: 1
- P004005: 4, P004006: 5, P004002: 1, P004007: 0
- H_OWN: 3, H_RNT: 2
- P012003: 1, P012004: 0, P012005: 0, P012006: 0, P012020: 0, P012021: 0, P012022: 0, P012023: 0, P012024: 0, P012025: 0, P012027: 1, P012028: 0, P012029: 0, P012030: 0, P012044: 0, P012045: 1, P012046: 0, P012047: 0, P012048: 0, P012049: 0
- DisHh_{bg}: 3

The calculation procedure is:

1. Prepare the demographic variables for HAZUS model Income: $HI_1 = 0$ (0/5), $HI_2 = 0$ (0/5), $HI_3 = 0.2$ (1/5), $HI_4 = 0.4$ (2/5), $HI_5 = 0.4$ (1-1/5 - 2/5) Ethnic: HE₁ = 0.4 (4/10), HE₂ = 0.5 (5/10), HE₃ = 0.1 (1/10), HE₄ = 0 (1 - 4/10 - 5/10 - 1/10 - 0/10), HE₅ = 0 (0/10) Ownership: HO₁ = 0.6 , HO₂ = 0.4 Age: HA₁ = 0.2 (2/10), HA₂ = 0.7 (1 - 2/10 - 1/10), HA₃ = 0.1 (1/10)

- 2. Accept (or modify) the default HAZUS Shelter Category Weights and Modification Factors to calculate short-term shelter coefficient α. In this example, simply apply the default values shown in Table 1 and Table 2.
- 3. Calculate the population needing short-term shelter. Because the default weights for ownership and age are 0, the demonstration here only uses income and ethnic factors to simplify the calculation (the simplified formula becomes

$$STP_{bg} = (DisHh_{bg}) \times (TOTPOP / TOT _ HH) \times (\sum_{l=1}^{5} \sum_{m=1}^{5} (\alpha_{lmno} \times HI_{l} \times HE_{m}))$$

The number of people requiring short-term shelter in this block group is: $SHP_{gb} = 3 * (10/5) * \\ (((0.73*0.62+0.27*0.24) * 0 * 0.4) + ((0.73*0.62+0.27*0.48) * 0 * 0.5) \\ + ((0.73*0.62+0.27*0.47) * 0 * 0.1) + ((0.73*0.62+0.27*0.26) * 0 * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.62+0.27*0.26) * 0) \\ + ((0.73*0.26+0.27*0.26) * 0) \\ + ((0.73*0.26+0.26) * 0) \\ + ($

$$\begin{aligned} + ((0.73*0.32+0.27*0.26)*0*0) \\ + ((0.73*0.42+0.27*0.24)*0*0) \\ + ((0.73*0.42+0.27*0.47)*0*0.1) \\ + ((0.73*0.42+0.27*0.47)*0*0.1) \\ + ((0.73*0.29+0.27*0.26)*0*0) \\ + ((0.73*0.29+0.27*0.24)*0.2*0.4) \\ + ((0.73*0.29+0.27*0.47)*0.2*0.1) \\ + ((0.73*0.29+0.27*0.26)*0.2*0) \\ + ((0.73*0.29+0.27*0.26)*0.2*0) \\ + ((0.73*0.22+0.27*0.24)*0.4*0.4) \\ + ((0.73*0.22+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.22+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.24)*0.4*0.4) \\ + ((0.73*0.13+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.26)*0.4*0) \\ + ((0.73*0.13+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.26)*0.4*0) \\ + ((0.73*0.13+0.27*0.47)*0.4*0.1) \\ + ((0.73*0.13+0.27*0.26)*0.4*0)) \\ = 0.24795 \end{aligned}$$

The percentage of population requiring short-term shelter in this block group is: $P_SHP_{bg} = (0.24795 / 10) * 100\% = 2.4795\%$

	Pop. Requiring Short-Term Shelter	% of Pop. Needing Short-Term Shelter
Shelby County, TN		
	46914	5%
Block Group		
47157XXXXXXX	38	7%
47157XXXXXXX	45	6%
47157XXXXXXX	49	5%
47157XXXXXXX	23	7%
47157XXXXXXX	67	5%
47157XXXXXXXX	159	6%
47157XXXXXXXX	79	5%
47157XXXXXXX	92	5%
47157XXXXXXX	85	5%

Appendix 3. Example of a fictions report of displaced household by jurisdiction (Shelby county) and by census block group.







