Water supply and water disruption

A census-block j can have weekly disruptions in water supply. These disruptions are assumed to be caused by failures of the infrastructure system, v. We also assumed that water supply can only be delivered within each municipality by either the pipe system, v_P, or by distribution by mobile sources, v_T, such as trucks. Formally, we define the weekly supply of water to census-block j using system v_P as, s_{jv_Pt}.

Accordantly, the risk of exposure to water supply disruption from the network of pipes P, is assumed to be associated to the condition of the system. Formally we assumed that the average number of days in a week that a census-block is without clean water service from pipes is represented by:

$$\varkappa_{jt} = \check{\varkappa}_{\mathcal{M}} + b_1\left(\hbar_j\right) + b_2\varphi \text{ (8)}$$

Where $\varkappa_{jt}$ is the mean number of days in a week without piped water, $\check{\varkappa}_{\mathcal{M}}$ is the estimated average number of days without piped water in a municipality $\mathcal{M}$ (A parameter estimated using available survey data). Parameter b_1 represent the local correction factor for altitude differences of census-block j from the mean altitude of the municipality $\mathcal{M}$, such that:

$$\hbar_j = h_j - \bar{h}_{\mathcal{M}} \quad , \quad \forall\, j\colon \mathcal{M}_j = \mathcal{M} \quad (9)$$

Where, $h_j$is the altitude in census-block j, and $\bar{h}_{\mathcal{M}}$ is the mean altitude of municipality $\mathcal{M}$.

Parameter b2 represent the additional number of days without piped water due to specific disruptions associated with the condition of the pipes. To represent a specific disruption we use variable φ with $\varphi = \{0,1\}$ such that

$$\varphi = \begin{cases} 1 \text{ if } \left(1 - c_{jvt}\right) > X \sim U([0,1]) \\ 0 \qquad\qquad \text{otherwise} \end{cases}$$

Thus, when the condition of infrastructure system v is lower than a random number drawn from a uniform distribution, there are b_2 extra days census-block j will suffer from disruption.

We simulate stochastic realization of days with water per week per census-block using a Poisson process, truncated between 0 and 7:

$$s_{jv_Pt} = 7 - pois(\varkappa_{jt}) \text{ (10)}$$

Thus, the amount of water delivered by the pipe system to census-block j is

$$W_{jv_Pt} = s_{jv_Pt} P_j \eta_{jv_Pt} w \quad (11)$$

Where W_{jv_Pt} is the volume of water supplied to census-block j by the pipe system, v_P. P_j is the number of people in census-block j,and η_{jv_Pt} is the proportion of population connected to the system of pipes v_P. Parameter w is the consumptive use of water per person, in units of volume, and parametrized using minimum water requirements per person. Therefore it is assumed that water is delivered by pipes is proportional to the population usage and the coverage of supply infrastructure system v_P.