**Decision Analytics for Business and Policy**

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The possible shelter locations are indexed by *j* = 1,…,40 and the residential areas are indexed by *i* = 1,…,200.The following parameters and decision variables are introduced.

**Parameters**

**Decision Variables**

The model is formulated as follows. Equation (1) formulates the objective function for Model 1. Equation (2) defines the resource constraint that there are only enough resources for 10 shelters to be built. Equation (3) defines the requirement that all residential areas are assigned a shelter. Equation (4) defines the requirement that no areas are assigned to a location where a shelter is not built. Equation (5) defines the constraint that the sum of people within all residential areas assigned to a shelter cannot exceed the shelter capacity. Equation (6) sets the objective function for Model 2 as a new variable, z, defined above. Equation (7) sets the constraint that all distances from areas to shelters are less than or equal to the maximum distance. Statement (8) clarifies that Model 2 is also subject to the constraints of Model 1, represented in Equations (2-5).

**Model 1**

(1)

**Model 2**

(6)(7)(8)

**Computational Results**

Please see the accompanying code for computation implementation of Models 1 and 2.

*Model 1*

**Total Distance across all residents = 190586.4681171801 distance units** (190586.47 rounded)

*Model 2*

**Maximum Distance between residential areas and shelters = 5.3438 distance units** (5.34 rounded)

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| --- | --- |
| **Mean: 2.38561**  **Range: (0.4185 – 6.4539)** | **Mean: 3.524111**  **Range: (0.3306 – 5.3438)** |

This problem demonstrates a trade-off between efficient and equitable distribution of resources. In this case, the resource in question is a limited number of emergency shelters. Model 1, which achieves the smallest total distance required for all residents to travel to their respective shelters, is arguably the most *efficient* allocation. Since this is the smallest total distance possible, this allocation also results in the smallest *average* distance between residential areas and their respective shelter. (The average is 2.386 units). However, the efficient allocation is not always the most equitable allocation. Model 2 demonstrates an arguably more equitable distribution of shelters. In this model, there are no individuals that have to travel more than 5.34 distance units, while in Model 1 there appear to be about 4 residential areas (and several thousand individuals) that have to travel more than this distance. Model 2 is able to achieve a smaller maximum distance by moving the location of shelters, ensuring everyone is at least within 5.34 distance units, but this comes at the cost of increasing the total distance between residential areas and shelters, meaning more people will need to travel further than would have had to travel in Model 1. This means the average distance requirement increases from 2.39 distance units to 3.52 distance units. Thus, this problem demonstrates a trade-off between efficiency and equity.

**Appendix:**

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| --- | --- |
| Model 1: Histogram of Distances by Residential Area  **Mean: 2.386343**  **Range: (0.4185 – 6.4539)** | Model 2: Histogram of Distances by Residential Area  **Mean: 3.522408**  **Range: (0.3306 – 5.3438)** |