

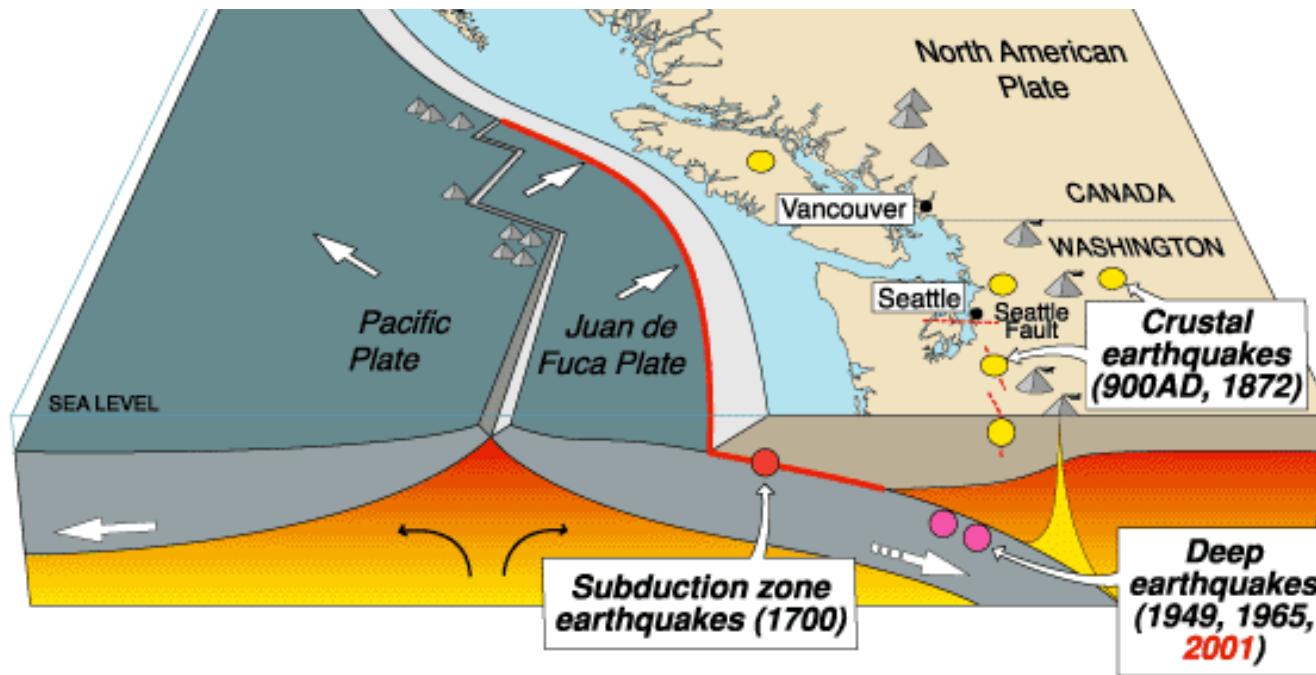
# Optimal location of Disaster Support Centres in Vancouver

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# Motivation

## 1. Cascadia subduction zone



Source	Affected area	Max. Size	Recurrence
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2. Flood (The city of Richmond)
3. Existing disaster supporting centre

# Mathematical Models and Applications

We begin with dividing the map of the city of Vancouver into  $m \times n$  grid cells

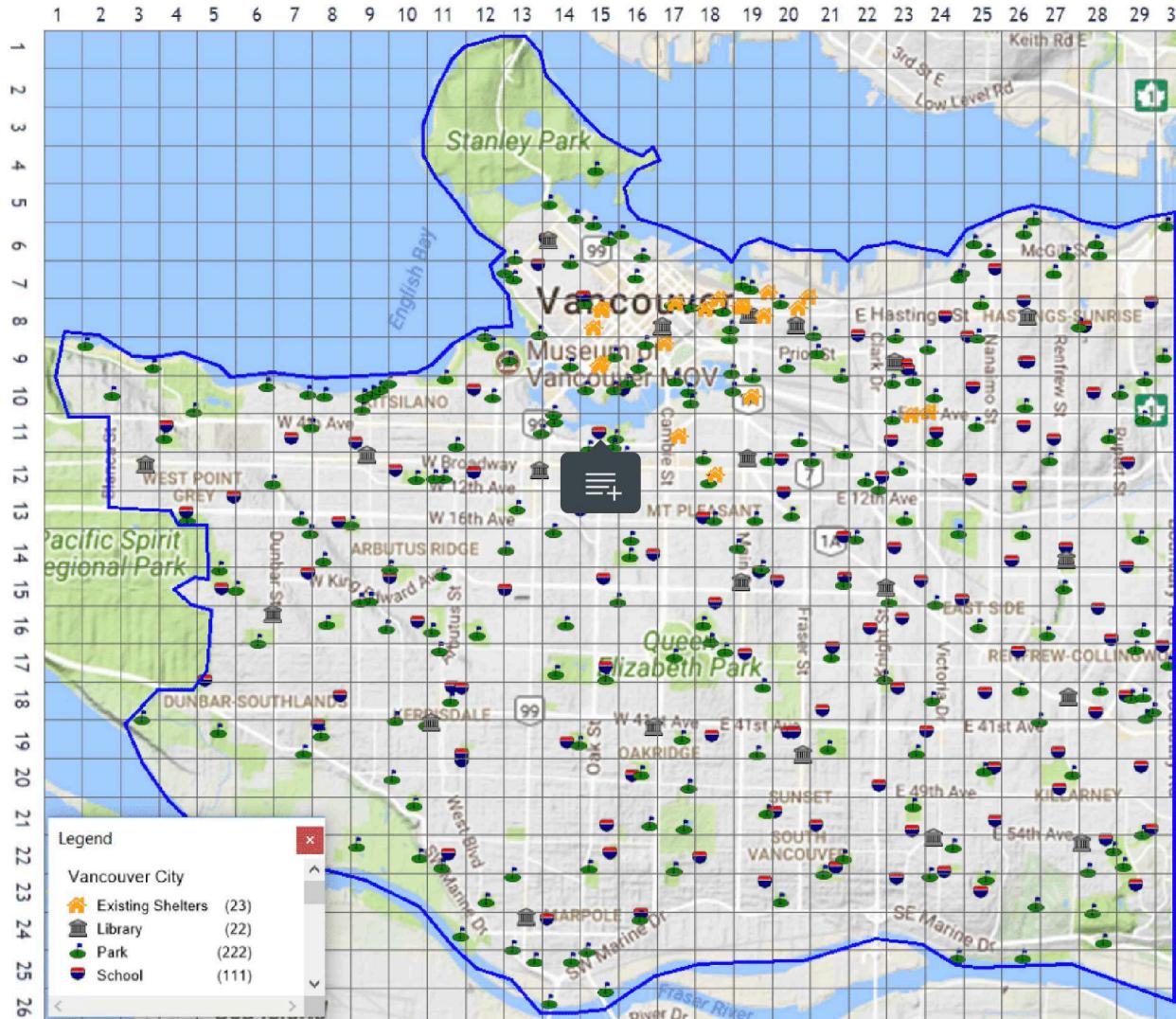


Fig. 1: City of Vancouver with potential facility locations divided into  $26 \times 30$  grid cells with  $500 \text{ m}^2$  area for each grid

# Mathematical Models and Applications

## Model I: Maximizing Weight Scores

$$\text{Maximize } Z_I = \sum_{(i,j) \in S} w_{ij} x_{ij} \quad (7)$$

such that

$$w_{ij} = \sum_{i=2}^{i+2} \sum_{j=2}^{j+2} (w_p P_{ij} + w_r R_{ij}) \quad (8)$$

$$w_p + w_r = 1 \quad (9)$$

$$\sum_{(i,j) \in D_k \cap S} x_{ij} \geq 1 \quad (10)$$

$$\sum_{(i,j) \in S} x_{ij} \leq 25 \quad (11)$$

$$\mu_{ij} = \sum_{i=2}^{i+2} \sum_{j=2}^{j+2} \rho_{ij} \quad (12)$$

$$\mu_{ij} x_{ij} \leq \text{Cap}_{x_{ij}} \quad (13)$$

$$x_{ij}, y_{ij} \in \{0, 1\} \quad (14)$$

# Mathematical Models and Applications

## Model II: Multiple Objective Model

$$\text{Minimize } d_1^+ + d_2^+ + \sum_{z=3}^{254} (d_z^+ + d_z^-)$$

subject to:

$$\sum_{(i,j) \in S} x_{ij} - d_1^+ \leq \mathcal{D} \quad (\text{Facility Demand Target}) \quad (15)$$

$$\sum_{(i,j) \in S} w_{ij}x_{ij} + d_2^- \geq Z_I^* \quad (\text{Score Target}) \quad (16)$$

$$\mu_{ij}x_{ij} + d_z^- - d_z^+ = Cap_{x_{ij}}y_{ij} \quad \forall (i, j), z \text{ (Capacity Utilization Goal)} \quad (17)$$

$$x_{ij} = y_{ij} \quad (18)$$

$$\sum_{(i,j) \in D_k \cap S} x_{ij} \geq 1 \quad \forall k \text{ (District Requirement)} \quad (19)$$

$$x_{ij}, y_{ij} \in \{0, 1\} \quad (\text{Binary}) \quad (20)$$

# Data Collection

1. <http://vancouver.ca>

The screenshot shows the City of Vancouver's website. At the top, there is a navigation bar with links for Green Vancouver, Your government, About Vancouver, Parks, recreation, and culture, Home, property, and development, People and programs, Streets and transportation, and Doing business. Below the navigation bar is a search bar with a magnifying glass icon and a 'How to ...' dropdown menu. A blue banner at the top right says '3-1-1'. The main content area features several sections: 'Empty Homes Tax' with a house icon, 'Parking tickets' with a car and parking meter icon, 'Garbage collection' with a trash bin icon, and 'More online services' with a laptop icon. A large image shows a street scene with cars, a bus, and a pedestrian crossing sign. A text overlay on the image reads: 'Construction has started on 10th Avenue. Allow extra time traveling to Vancouver General Hospital'. On the left, a sidebar titled 'I want to...' lists various services like Apply for a job, Find garbage schedules, Get parking ticket info, Buy a residential parking permit, Register for a class, Visit Stanley Park, Use VanMap, Access online services, and Share your ideas. The 'Share your ideas' section includes a photo of a man's face. On the right, there are three columns: 'Latest news' (Housing Vancouver strategy to address speculation in real estate), 'Find an upcoming event' (View event calendar), and 'What is important to you?' (City of Vancouver, FortisBC working together to tackle climate change).

2. <http://www.statcan.gc.ca/eng/start>

## Subjects

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# Data Collection

TABLE I: Vancouver city data along with rank and risk factors

Sr. No.	Area	Population	Population_Rank	Locations Density	Density_Rank	Altitude (m)	Risk Factor
1	West Point Grey	12795	2	10	2	50	5
2	Dunbar Southlands	21745	4	12	2	90	2
3	Kitsilano	41,375	8	25	7	25	8
4	Arbutus Ridge	15,910	3	17	5	75	3
5	Kerrisdale	14,735	2	15	4	20	9
6	Stanley Park	0	0	4	0	30	8
7	West End	44,540	8	12	2	33	7
8	Downtown	54,690	10	36	9	25	8
9	Fairview	31,440	6	10	2	20	9
10	Shaughnessy	8,810	1	9	1	89	2
11	South Cambie	7,680	1	7	1	85	2
12	Oakridge	12,440	2	11	2	78	3
13	Marpole	23,835	4	16	4	25	8
14	Downtown Eastside	27,305	5	13	3	9	9
15	Strathcona	12,165	2	17	5	5	10
16	Mount Pleasant	26,400	5	20	5	51	5
17	Riley Park	21,795	4	12	2	80	2
18	Kensington Cedar Cottage	47470	9	18	5	62	4
19	Sunset	36285	7	15	4	81	2
20	Hastings Sunrise	33990	6	38	10	50	5
21	Renfrew Collingwood	50505	10	30	8	97	1
22	Victoria Fraserview	30710	6	16	4	87	2
23	Killarney	28450	5	16	4	103	0

# Data Collection

$$PopulationRank/RiskFactor = \frac{k_{max} - k_{min}}{\tau}; \quad k \in \{P, R\}$$

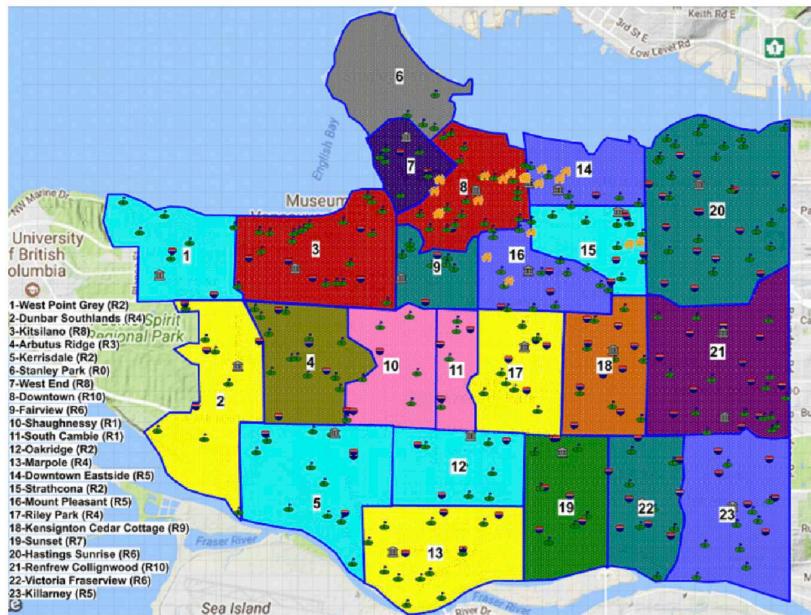


Fig. 2: Vancouver map depicting population density

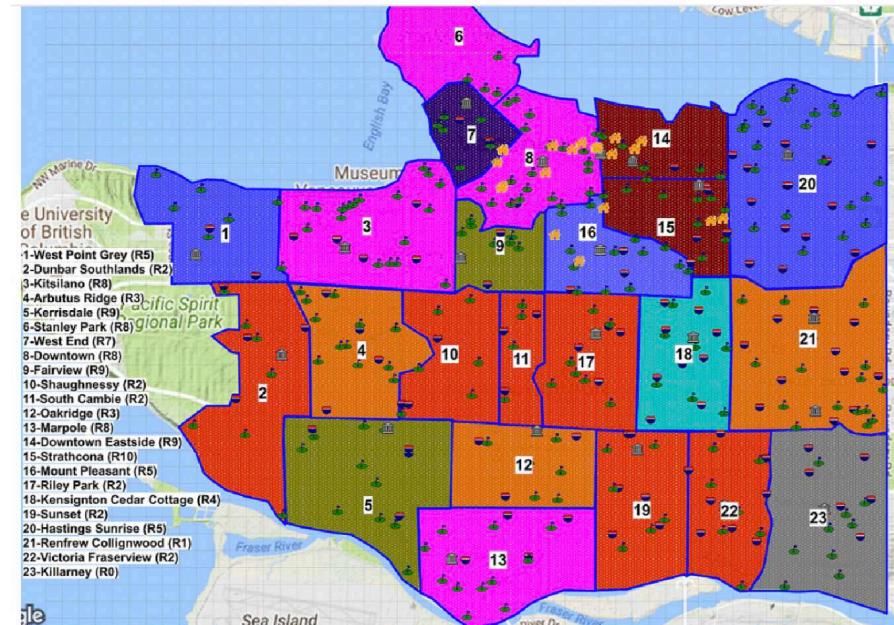


Fig. 3: Vancouver map depicting flood risk factors

# Data Collection

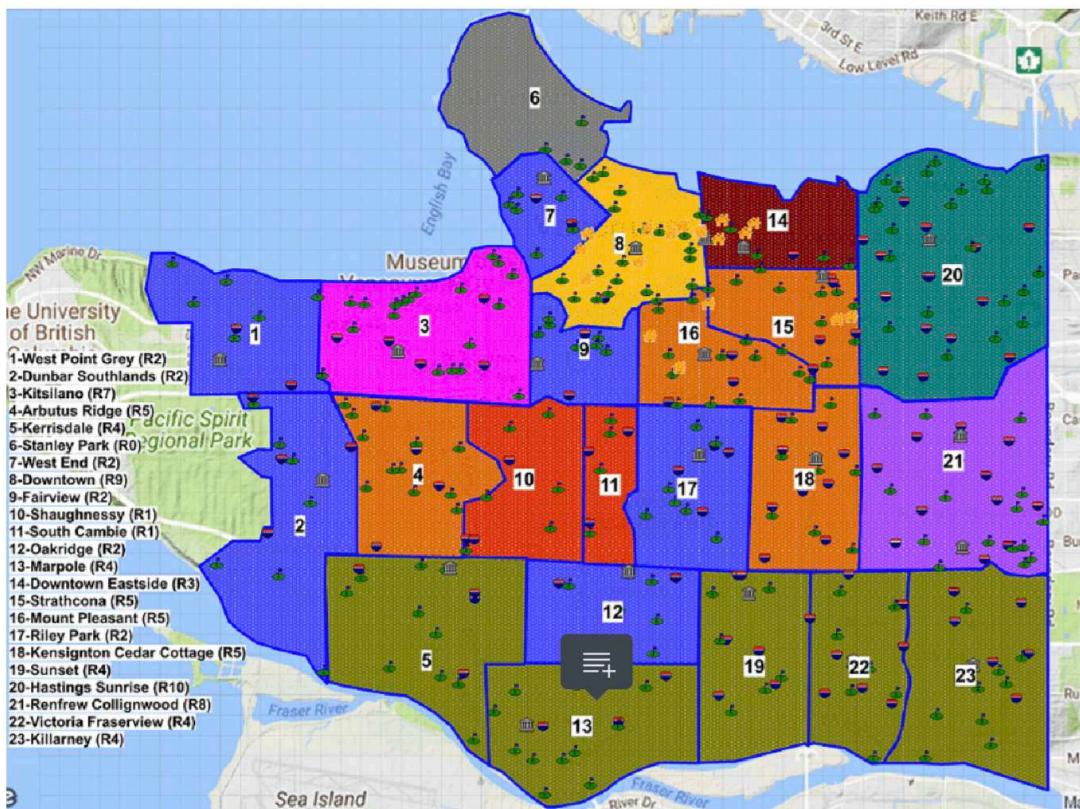


Fig. 4: Vancouver map depicting potential locations density

# Data Mapping and Generation

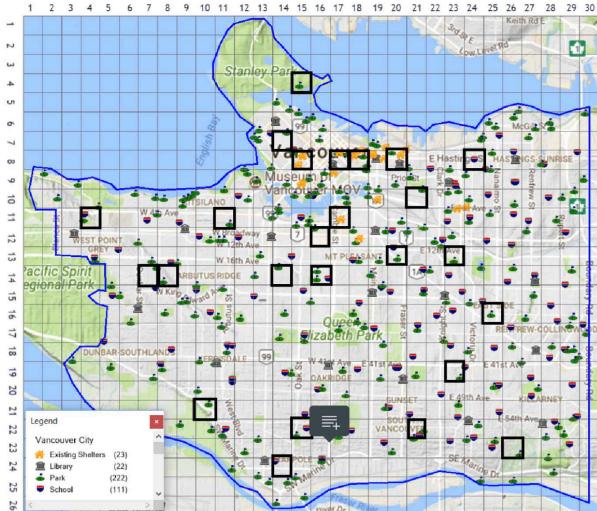


Fig. 5: Optimal facility locations for the original model with risk and population weight scores of (risk score weight, population score weight) =  $(\frac{1}{3}, \frac{2}{3})$

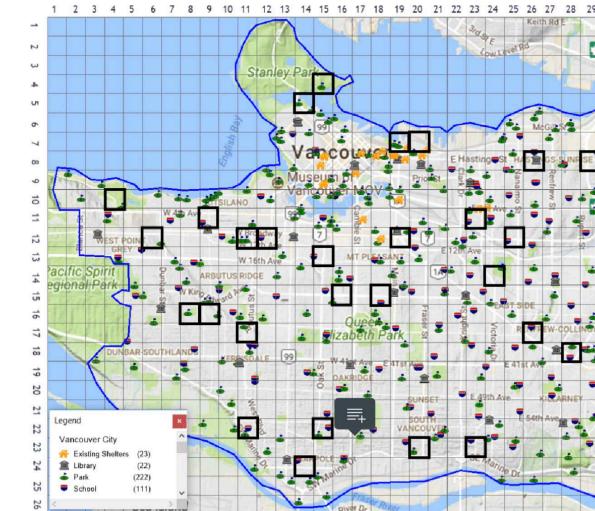


Fig. 6: Optimal facility locations for the second model with risk and population weight scores of (risk score weight, population score weight) =  $(\frac{1}{3}, \frac{2}{3})$

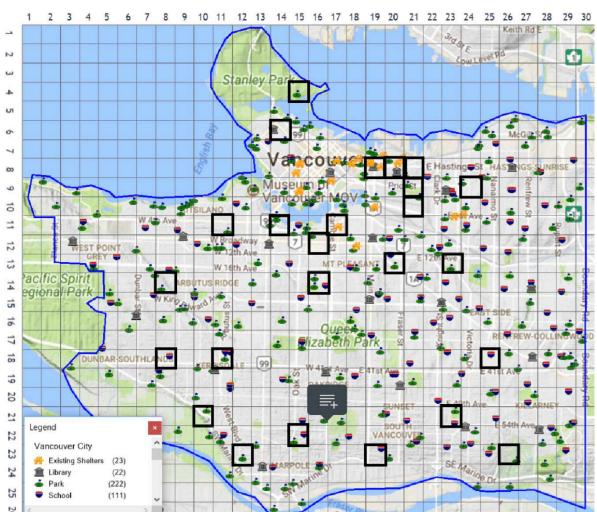


Fig. 7: Optimal facility locations for the original model with risk and population weight scores of (risk score weight, population score weight) =  $(0, 1)$ .

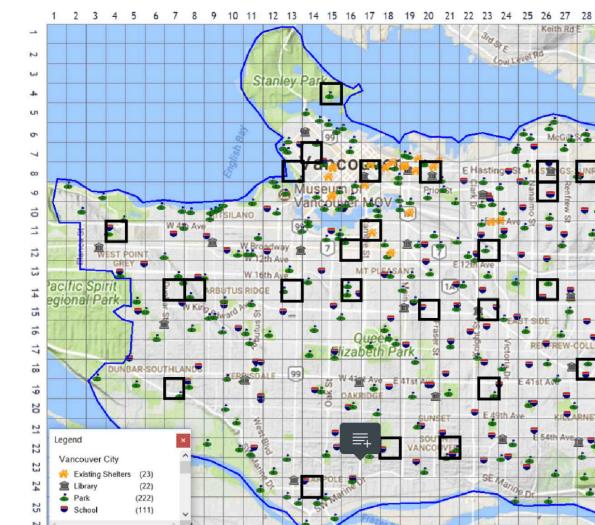


Fig. 8: Optimal facility locations for the original model with risk and population weight scores of (risk score weight, population score weight) =  $(1, 0)$ .

# Data Mapping and Generation

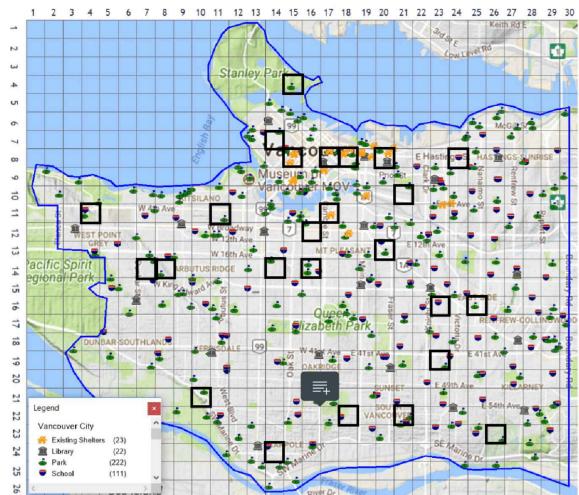


Fig. 9: Optimal facility locations for the original model with risk and population weight scores of (risk score weight, population score weight) =  $(\frac{1}{2}, \frac{1}{2})$ .

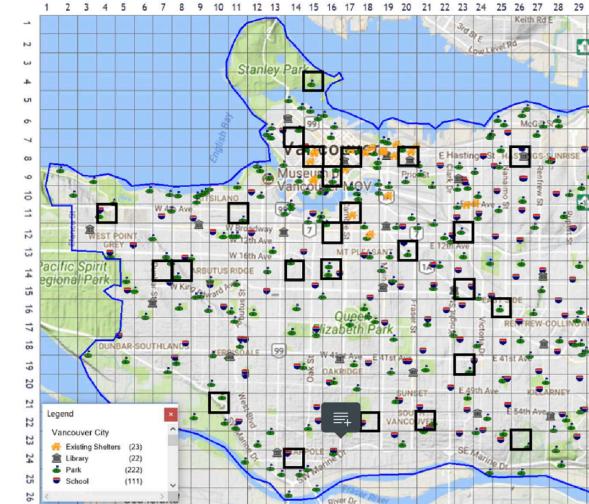


Fig. 10: Optimal facility locations for the original model with risk and population weight scores of (risk score weight, population score weight) =  $(\frac{2}{3}, \frac{1}{3})$

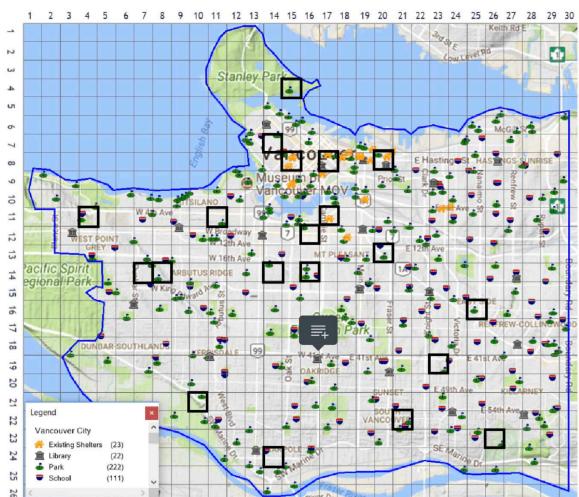


Fig. 11: Similar optimal facility locations of the two different variants and the original model formulation

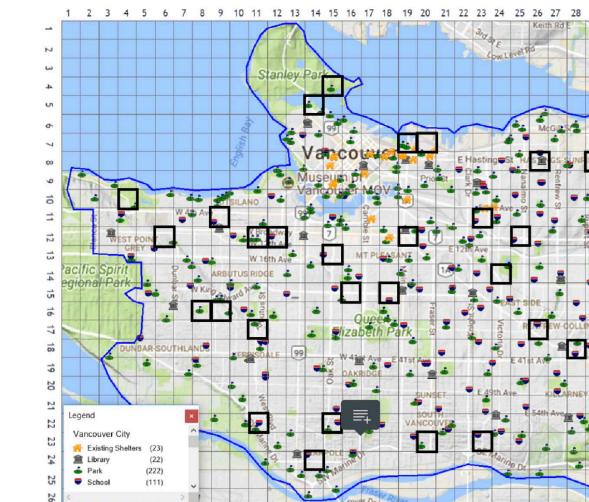


Fig. 12: Optimal facility locations for the second model with risk and population weight scores of (risk score weight, population score weight) =  $(\frac{1}{3}, \frac{2}{3})$

# Data Mapping and Generation

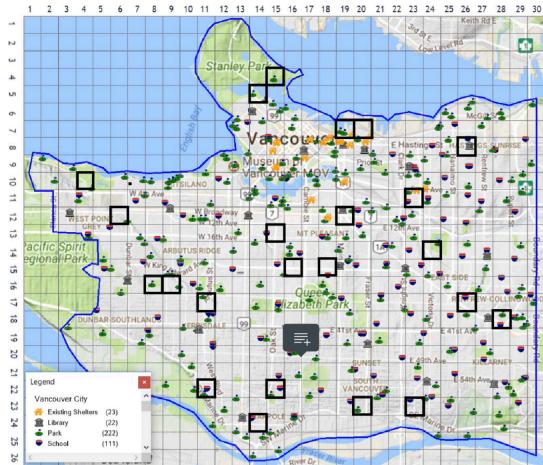


Fig. 13: Optimal facility locations for the second model where the main priority is the maximization of the capacity of each chosen facility

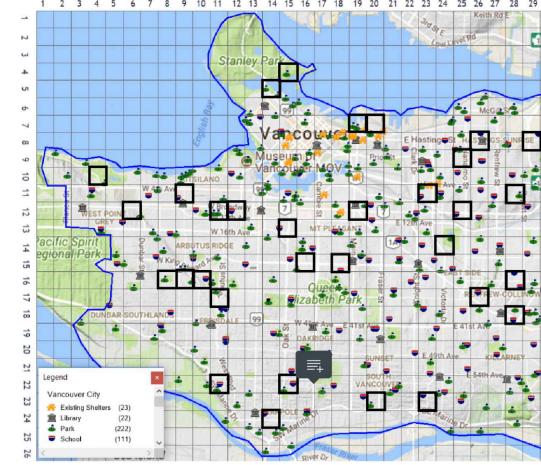


Fig. 14: Optimal facility locations for the second model where the main priority is the minimization of the negative deviation of the total score from the goal of 33,336

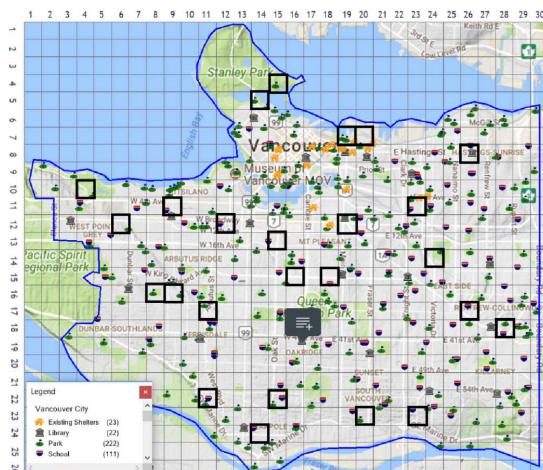


Fig. 15: Optimal facility locations for the second model where the main priority is the minimization of the number of facilities over 25

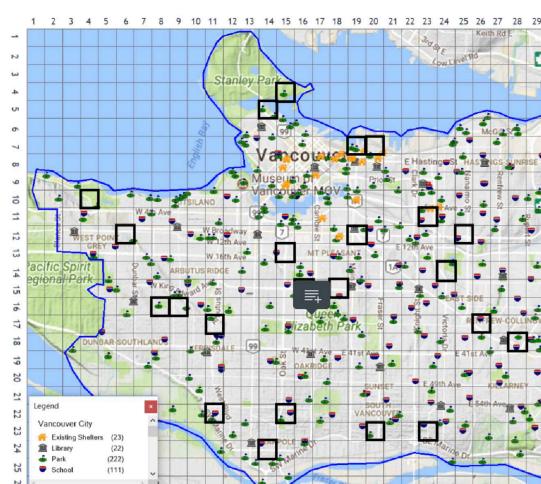


Fig. 16: Similar facility locations among the three variants and the original model formulation

# Conclusion

We have considered two different models.

1. Maximize the total sum of weights given the population and risk levels of each district.
2. find an optimal location for the facilities given three separate goals.

# References

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