

Humanitarian Logistics Depot Location Model

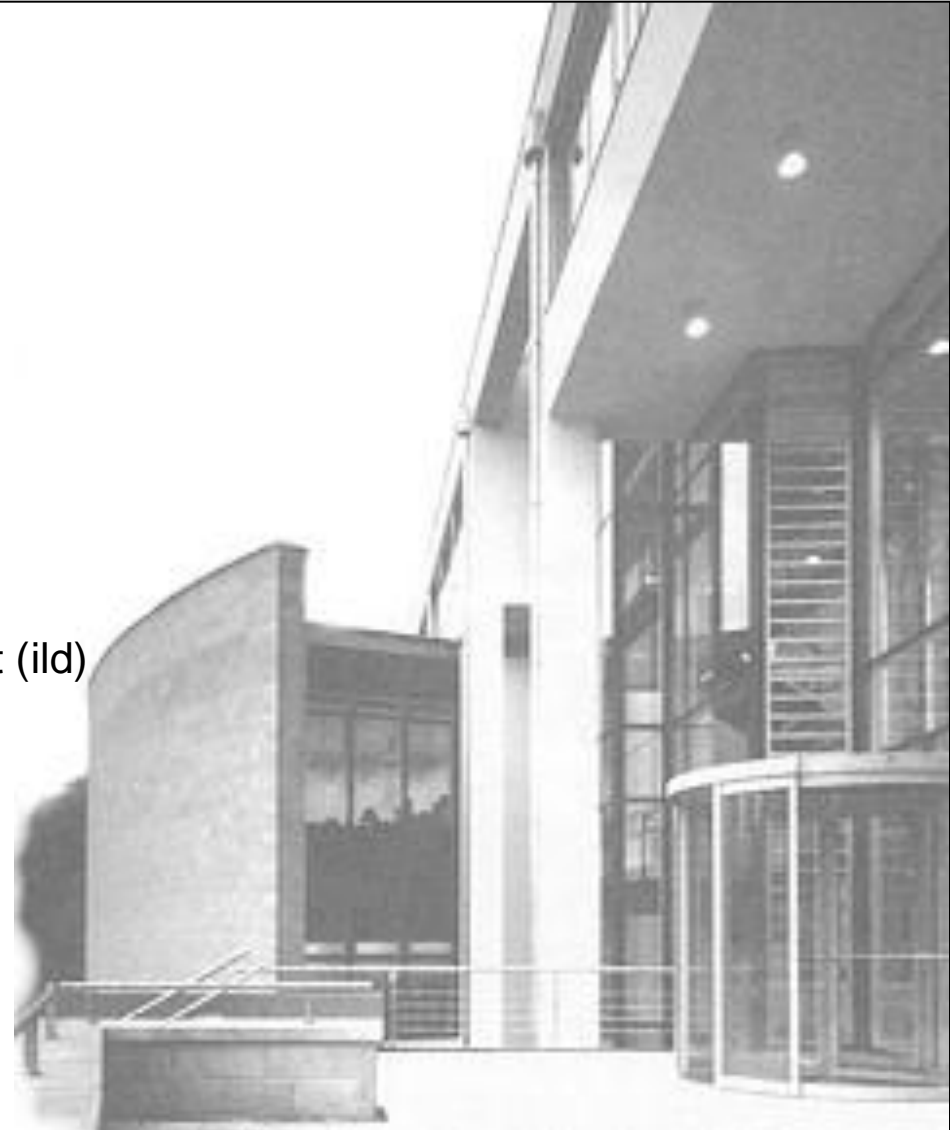
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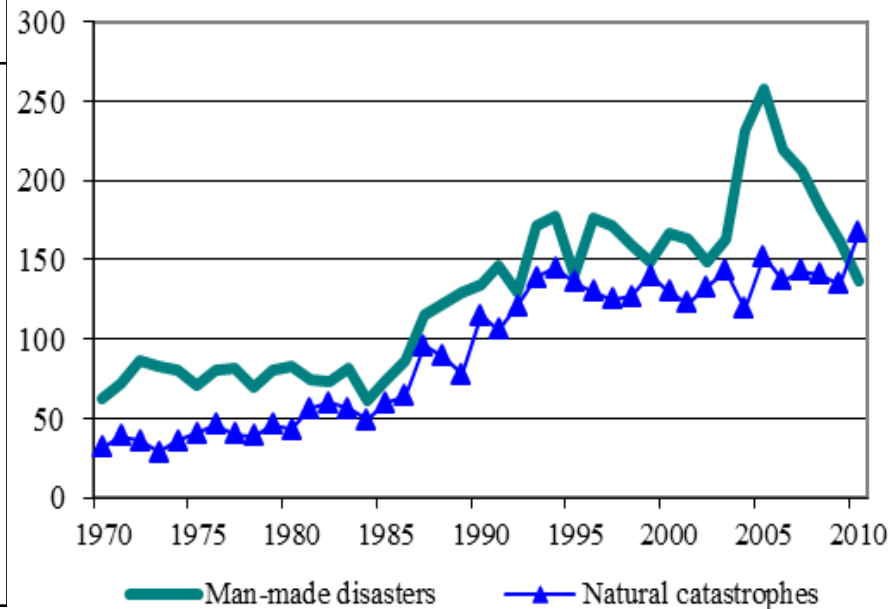


1. Introduction
2. Location model
3. Comparison of humanitarian response depot setup
4. Response depot
5. Future development

- Increasing quantity of natural and man-made disasters
- High economic damage and high number of affected people and deaths
- Challenges in humanitarian logistics in comparison with their commercial counterpart
- Reduction of complexity, increase of service quality and lead times

Biological	Geophysical	Hydological	Meteorological	Climatological
-Epidemic: viral, bacterial, parasitic, fungal, prion infections -Insect infestation -Animal stampede	-Earthquake -Volcano -Mass movement (dry): rockfall, landslide, avalanche, subsidence	-Flood: general flood, flash flood, storm, coastal flood -Mass movement (wet): rockfall, landslide, avalanche, subsidence	-Storm: tropical cyclone, extra tropical cyclone, local storm	-Extreme temperature: heat wave, cold wave, extreme winter condition -Drought -Wildfire: forest fire, land fire

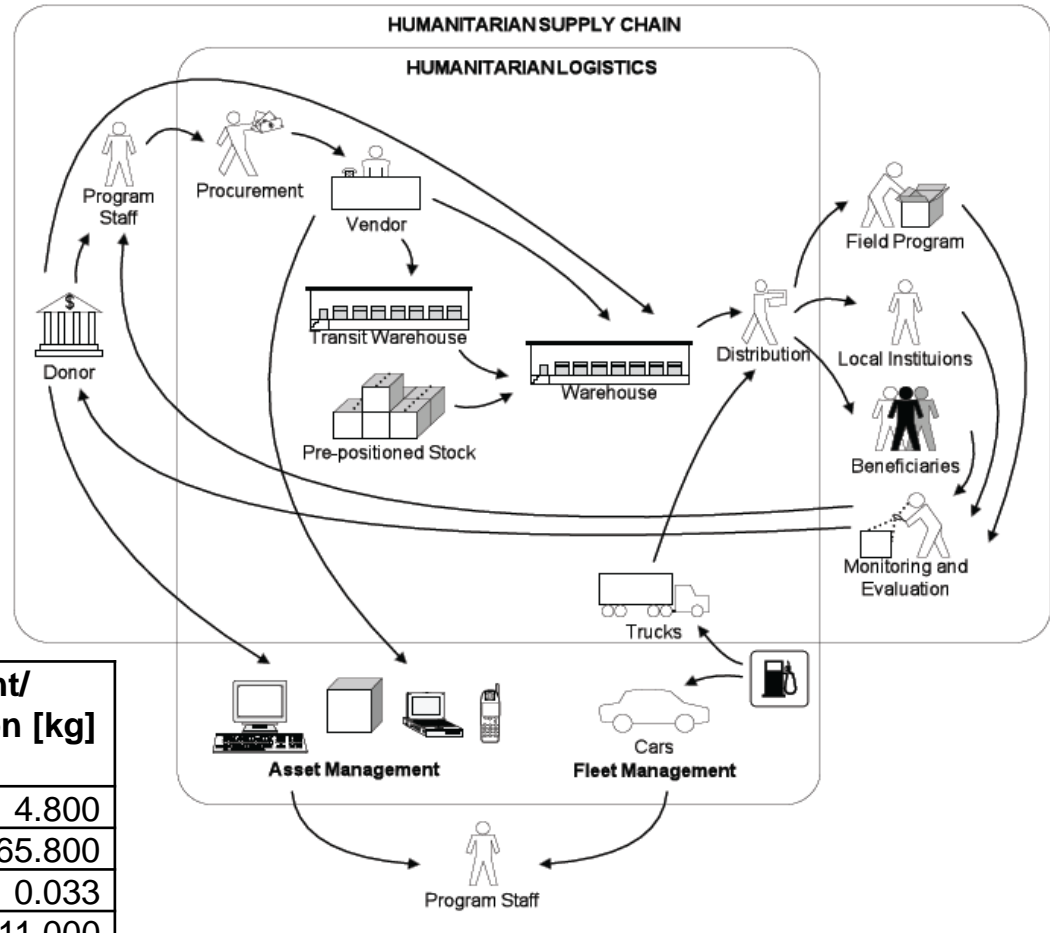
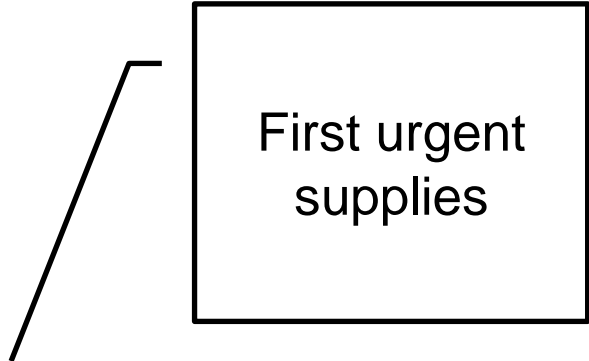
Number of events 1970-2010



Increased importance of humanitarian logistics

Statistical Data (EM-Dat, CRED)	Year 2010
Natural disasters:	385
Total deaths:	296,800 (222,570 earthquake in Haiti, 55,736 heat wave in Russia)
Total affected people:	207 million
Estimated damage:	109 billion US\$ (30 Flood Chile, 18 Flood in China)

2. Location model

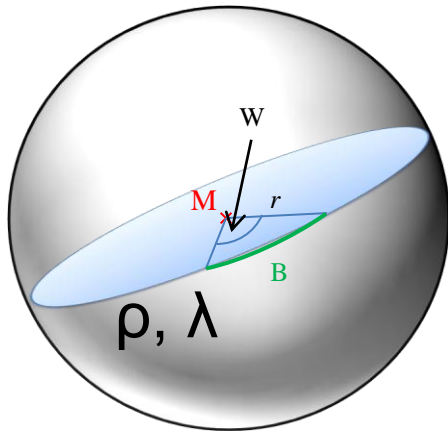


Kit	Weight [kg]	Quantity of people for each kit	Weight/ Person [kg]
Domestic	24	5	4.800
Sanitation	329	5	65.800
Health	998	30,000	0.033
Tent	55	5	11.000
Shelter	20	5	4.000
Water	7,000	10,000	0.700
		sum [kg]	86.333

2. Location model

i	popular name	main countries affected	date	type of hazard	main city affected	latitude ρ			longitude λ			People affected	Transport weight [t]
						[°]	[min]	[dez.]	[°]	[min]	[dez.]		
1	Haiti earthquake	Haiti	2010-01-12	Earthquake	Port-au-Prince	18	32	18.53	-72	-20	-72.33	3,400,000	293,533
2	Sichuan Earthquake	China	2008-05-12	Earthquake	Chengdu	30	40	30.67	104	4	104.07	45,976,596	3,969,310
3	Cyclon Nargis	Myanmar	2008-05-02	Tropical cyclone	Yangon	16	47	16.78	96	9	96.15	2,420,000	208,927
4	Java Earthquake	Indonesia	2006-05-27	Earthquake	Yogyakarta	-7	-48	-7.80	110	22	110.37	3,177,923	274,360
5	Kashmir Earthquake	Pakistan	2005-10-08	Earthquake	Muzaffarabad	31	21	31.35	73	28	73.47	5,128,000	442,717
6	Hurricane Katrina	United States	2005-08-29	Tropical cyclone	New Orleans	29	57	29.95	-90	-5	-90.08	500,000	43,167
7	Mumbai Floods	India	2005-07-26	Flood	Mumbai	18	58	18.97	72	50	72.83	20,000,055	1,726,670
8	South Asian Tsunami	Indonesia, etc.	2005-12-24	Tsunami	Banda Aceh	5	33	5.55	95	19	95.32	2,321,700	200,440
9	Bam Earthquake	Iran	2005-12-23	Earthquake	Bam	29	6	29.10	58	21	58.35	267,628	23,105
10	Dresden Floods	Germany	2005-08-11	Flood	Dresden	51	3	51.05	13	44	13.73	330,108	28,499
11	Gujurat Earthquake	India	2001-01-26	Earthquake	Bhuj	23	15	23.25	69	40	69.67	6,321,812	545,783

2. Location model



- Equation shows the relation between the apex angle W in radian, the radius of the ball and the geo-coordinates of the points $\{\rho, \lambda; \rho_i, \lambda_i\}$ defining W :

$$B = r \cos^{-1}(\cos \varphi \cos \varphi_i \cos(\lambda - \lambda_i) + \sin \varphi \sin \varphi_i)$$

Set of parameters:

- average earth radius is $r = 6,371$ km
- set of customers as disasters with geo-coordinates (ρ_i, λ_i) in radian
- demand b_i of each customer as weight of first urgent supplies per capita times number of people affected

- Target function:**

$$\min \sum_{i=1}^n b_i \cos^{-1}(\cos \varphi \cos \varphi_i \cos(\lambda - \lambda_i) + \sin \varphi \sin \varphi_i) \cdot 6371$$

Derivatives to ρ and λ :

$$\frac{dF}{d\varphi} := \sum_{i=1}^n - \frac{6371b_i(\sin \varphi_i \cos \varphi - \cos \varphi_i \sin \varphi \cos(\lambda - \lambda_i))}{\sqrt{1 - (\cos \varphi_i \cos \varphi \cos(\lambda - \lambda_i) + \sin \varphi \sin \varphi_i)^2}} = 0$$

$$\frac{dF}{d\lambda} := \sum_{i=1}^n - \frac{6371b_i \cos \varphi \cos \varphi_i \sin(\lambda - \lambda_i)}{\sqrt{1 - (\cos \varphi_i \cos \varphi \cos(\lambda - \lambda_i) + \sin \varphi \sin \varphi_i)^2}} = 0$$

'Miehle'-algorithm:

$$\varphi^1 = \cos^{-1} \frac{\sum_{i=1}^n (-6371b_i \cos \varphi_i \sin \varphi^0 \cos(\lambda^0 - \lambda_i) / \sqrt{1 - (\cos \varphi_i \cos \varphi^0 \cos(\lambda^0 - \lambda_i) + \sin \varphi^0 \sin \varphi_i)^2})}{\sum_{i=1}^n (-6371b_i \sin \varphi^0 / \sqrt{1 - (\cos \varphi_i \cos \varphi^0 \cos(\lambda^0 - \lambda_i) + \sin \varphi^0 \sin \varphi_i)^2})}$$

$$\lambda^1 = \cos^{-1} \frac{\sum_{i=1}^n (-6371b_i \cos \varphi^0 \cos \varphi_i \sin \lambda^0 \cos \lambda_i / \sqrt{1 - (\cos \varphi_i \cos \varphi^0 \cos(\lambda^0 - \lambda_i) + \sin \varphi^0 \sin \varphi_i)^2})}{\sum_{i=1}^n (-6371b_i \cos \varphi^0 \cos \varphi_i \sin \lambda_i / \sqrt{1 - (\cos \varphi_i \cos \varphi^0 \cos(\lambda^0 - \lambda_i) + \sin \varphi^0 \sin \varphi_i)^2})}$$

- Iteration calculation
- Iteration boundary with $\varepsilon < 0.1$ and start coordinates $(-1.28333^\circ; 36.816667^\circ)$
 - 1. result: achieving ε after 16th iteration with coordinates $(31.0265^\circ; 103.7466^\circ)$
 - 2. result: set of data without the earthquake of Sichuan, achieved ε $(29.6760^\circ; 73.3332^\circ)$ after 11th iteration
 - 3. result: set of data by considering main parameter such as distance and a crucial parameter such as weight, achieved ε $(50.2006^\circ; 74.6191^\circ)$ after 7th iteration



Optimal facility is in Kazakhstan

3. Comparison of humanitarian response depot setup



IFRC 3 response depot decentralized system

World Food Programme (WFP) 5 response depot, leadtime of 24 hours latest 48 hours

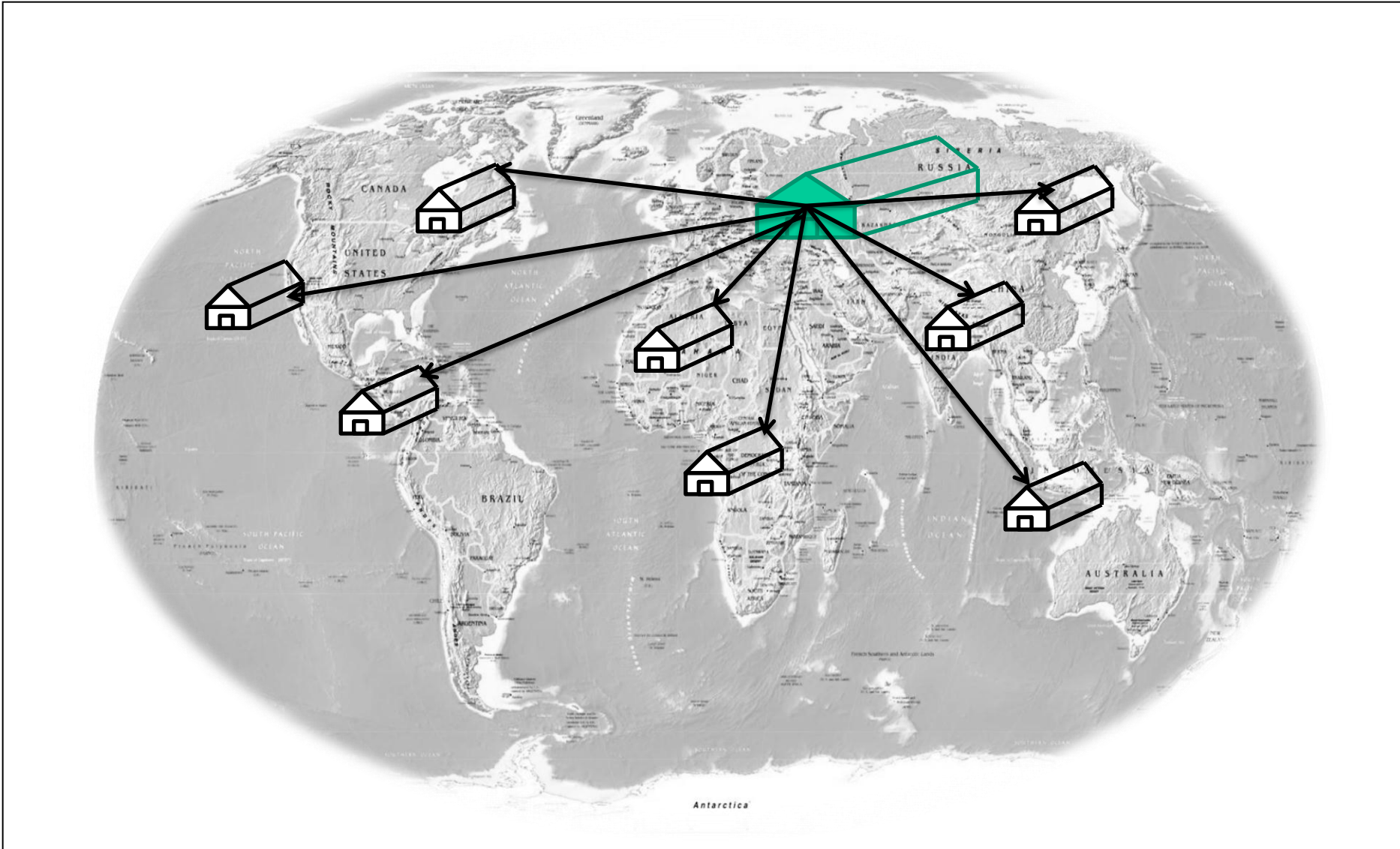


3. Comparison of humanitarian response depot setup

- Reduction of logistics costs by using a centralized response depot
- Quickly delivery of humanitarian aid supply
- Mitigation of reaction time
- Prompting and improving the coordination of relief items

Organization	Number of depot	Overall distance [km]	Overall transport performance [tkm]
Model	1	58,320	29,611,766,349
IFRC	3	21,845	19,584,886,662
WFP	5	17,946	18,690,466,711

5. Future development



5. Future development

- One central depot to assure the preparedness in case of disaster
- Improving, promoting and organization of efficiency and effectiveness in humanitarian logistics
- Reduction of complexity, increase of service quality, security and lead times
- Establishment of HUB and spoke system in humanitarian logistics by considering traffic and logistics infrastructure
- Building an efficient humanitarian logistics network
- Increase performance measurement in humanitarian logistics

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Thank you for your attention!

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