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Emergency Response Planning for Providing Drinking Water in Urban Areas after Natural Disasters using Multi Criteria Decision Making Methods

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Introduction

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- **All drinking water and sewerage systems with greater or less degree are damaged during natural disasters such as: earthquakes, floods and droughts (WHO, 1993).**
- **The impacts of a natural disaster can cause:**
- **Contaminate of water,**
- **Break in pipelines,**
- **Damage to structures,**
- **Water shortages,**
- **Collapse of the entire system.**

Introduction

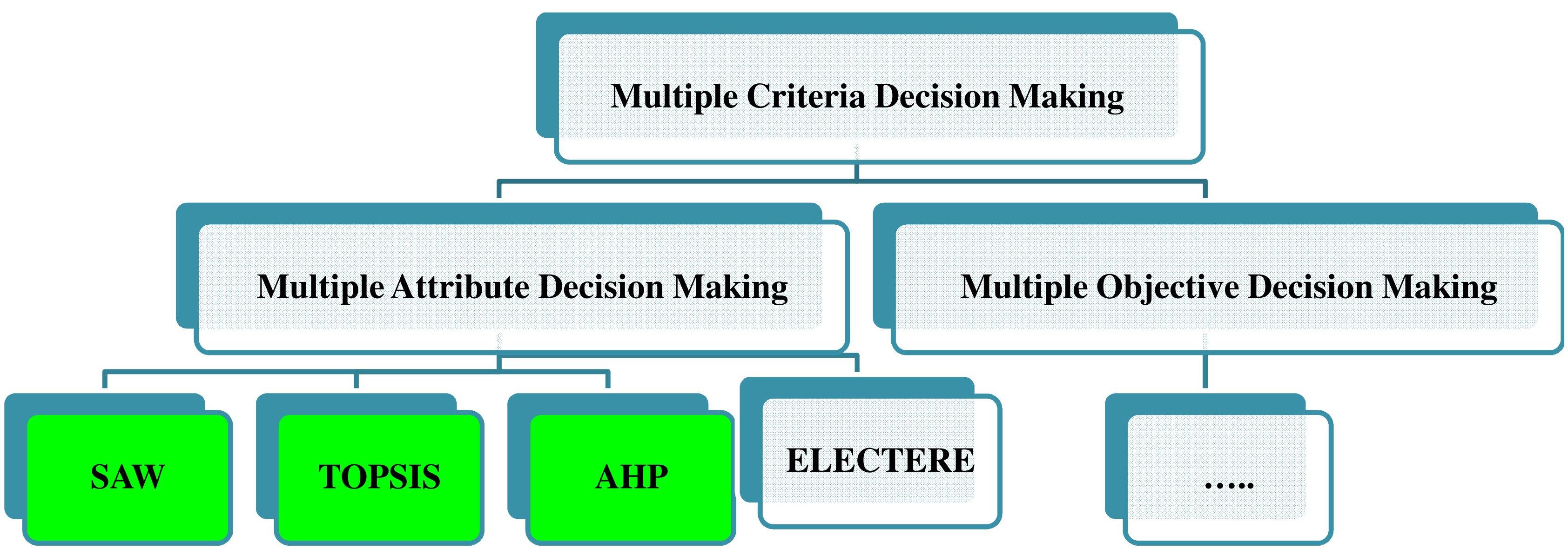
- **Insufficient water and the consumption of contaminated water are usually the first and the main causes of ill health to the affect displaced populations during and after a disaster (WHO, 1998).**

- **Water utilities have a legal responsibility to provide clean and safe drinking water to their customers, even if supplying water under emergency conditions.**

Methodology

Methodology

- **The characteristics of planning for drinking water in emergencies make multi criteria decision making (MCDM) as an attractive approach.**
- **MCDM can be defined as a grouping of techniques for evaluating decision options against multiple criteria measured in different units (Voogd, 1983).**



Methodology

Methodology

- The emergency response plan should identify agencies or private companies that could provide water in the occurrence of a major event.
- In developing an emergency response planning (ERP) for water supplies following steps are important:
- A) Estimating amount of water quantity and quality ,
- B) Exploring options (alternatives) for providing/increasing water supply,
- C) Ranking available alternatives based on the selected criteria by using MCDM tools,
- D) Developing guidelines for applying in disastrous condition for water supply in affected areas.

Methodology

Water quantity and quality in emergencies

- The first priority in emergencies is to provide an adequate quantity of water to the affected population, even if its quality is poor.

- In disastrous condition, a minimum of 15 liters per person per day should be provided as soon as possible (The Sphere Project, 2004).

Way of consumption	Total consumption (liters/person/day)
Personal consumption	15-20
Sanitation	40-60
Cooking	20-30

Water quantity and quality in emergencies

- **Conventional bacteriological standards may be difficult to achieve in the immediate post-disaster period.**

- **The WHO guideline stated that zero E. coli per 100ml of water should be the goal and achievable even in emergencies (WHO, 1993).**

Bacteriological guidelines for drinking water in disastrous conditions (Chalinder, 1994).

Water quality	E. coli/100ml
Reasonable	0-10
Polluted = Must chlorinate	10-100
Very polluted	100-1000
Grossly polluted	1000<

Options for providing/increasing water supply in emergencies

- **potential sources for alternate water supplies include three types of approach (Chalinder, 1994):**

- **A. Transporting water from existing sources to the population via piped systems or tankers,**

- **B. Increasing the output/quality of existing sources by increasing pump and piping capacity, borehole/well deepening or treating surface water resources, using portable water treatment systems,**

- **C. Creating new sources by drilling new boreholes or digging new wells.**

Methodology

Options for providing/increasing water supply in emergencies

- **1- Pocket water**

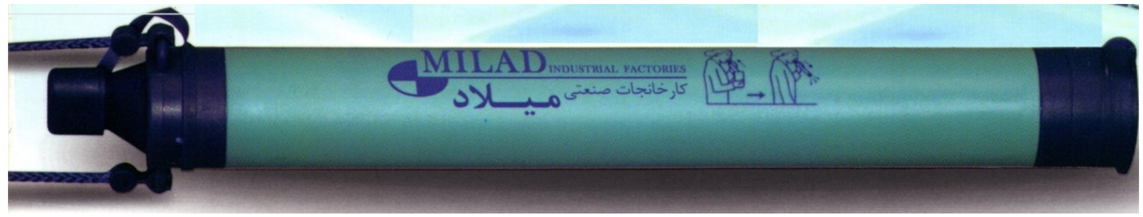
2- Water tankers (Picture from Bam Earthquake in Iran, post-disaster, 40000 people died during this disaster, In 2003)

Options for providing/increasing water supply in emergencies

Methodology

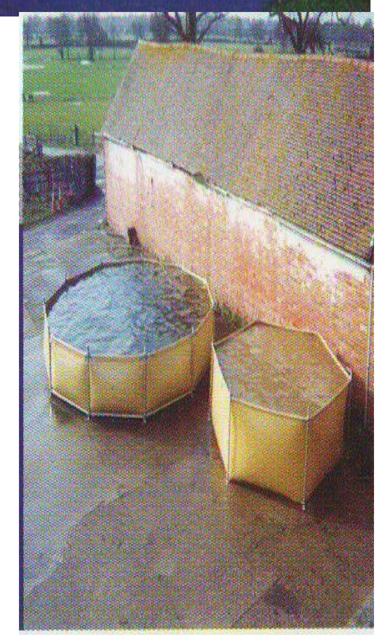
➢3- Portable water treatment system

Life Straw



Options for providing/increasing water supply in emergencies

- 4- Emergency tanks

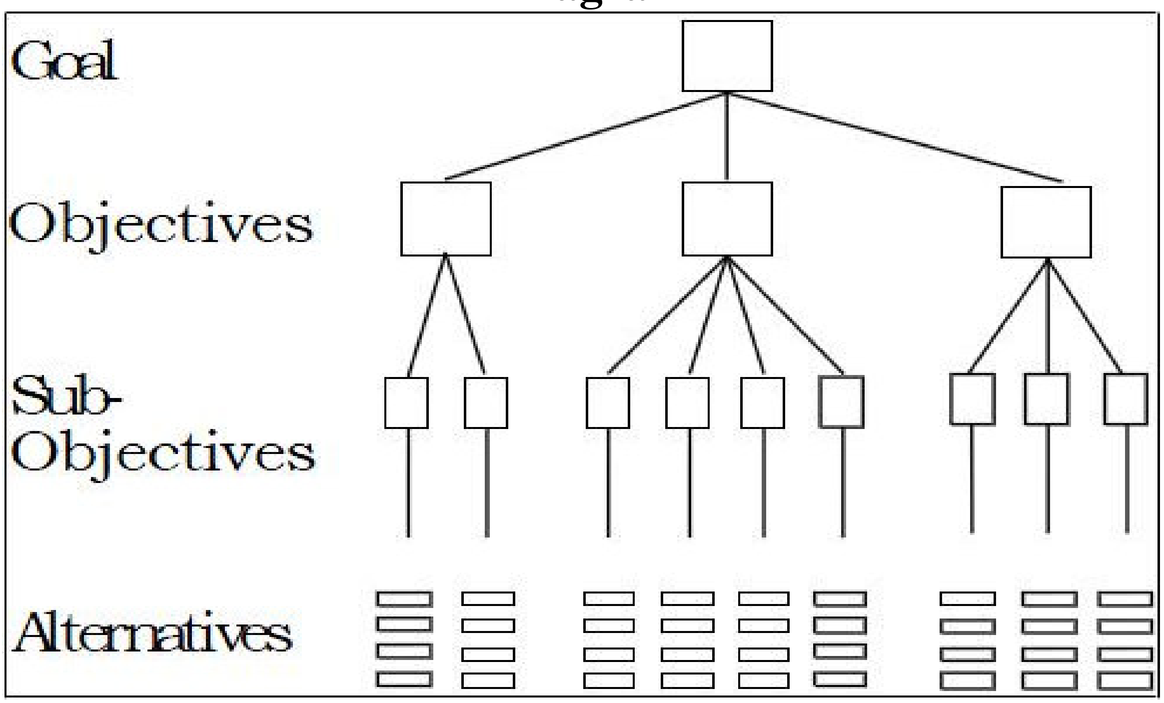


Analytical Hierarchy Process (AHP)

- **In AHP, you can use verbal judgments in order to pair wise comparisons.**

- **The nine point's verbal scale for these judgments is used (Saaty and Vargas, 1994).**

Decision Hierarchy Diagram



Case Study (Pardis City, Iran)

- Pardis City in Iran is one of the satellite towns of Tehran metropolis, located 25 kilometers in the northeast of Tehran.
- This city is highly vulnerable to natural disaster specially, earthquake and flood.

Population	50000
Capacity of the water reservoirs storage	26000 cubic meters
Daily consumption	220 liter/ day per person
Water Resources	6 drinking water wells
Total length of water distribution system (m)	57222
Water Requirement in Pardis (lit/s)	950

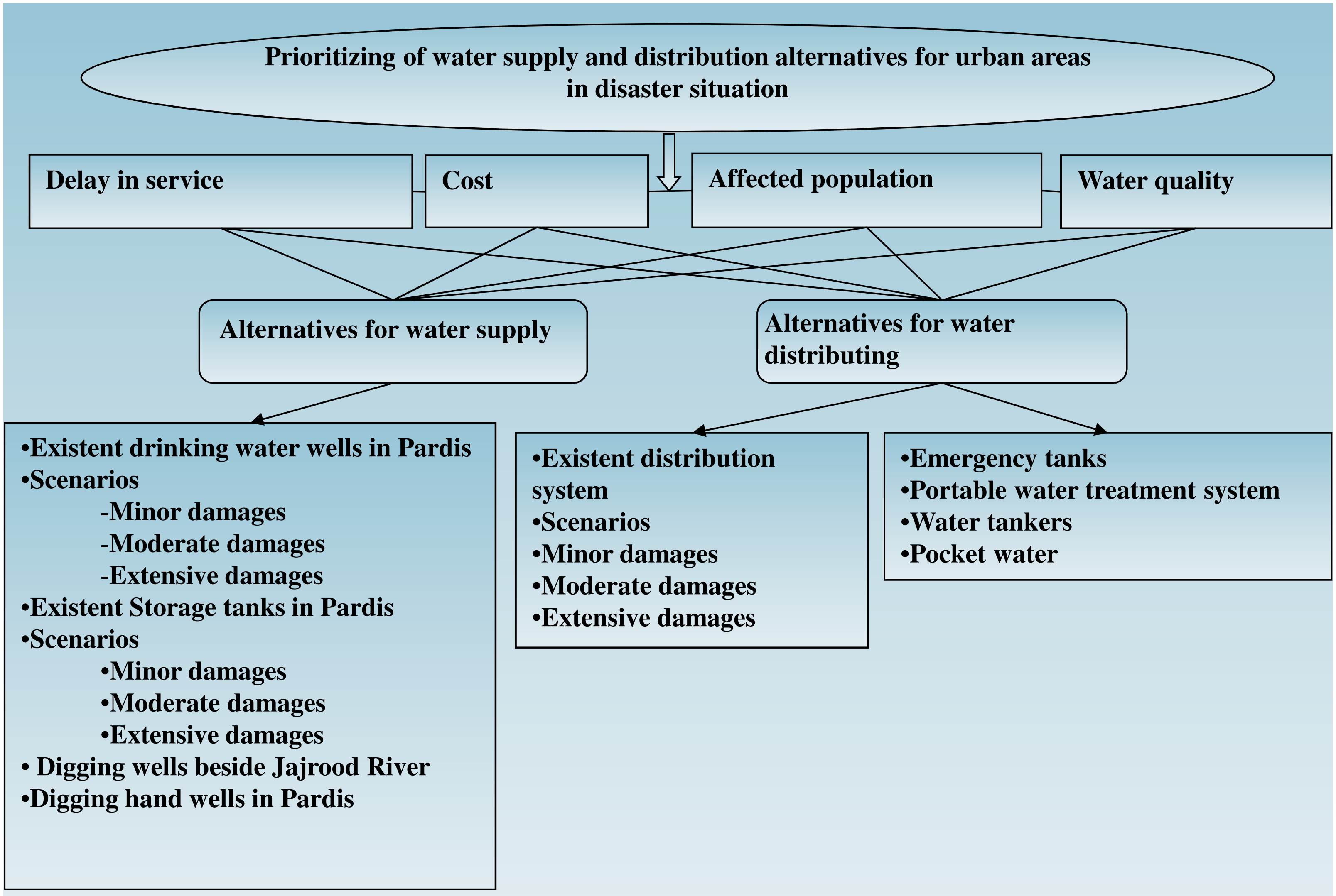
Loss scenarios

- Four hypothetical loss scenarios for water supply and distribution system are supposed separately.

Number of Scenarios	Loss Scenarios	Percent of damage in system	Percent of water system operation	Capacity of drinking water system (lit/s)	Volume of storage tanks	Well discharge (lit/s)
1	Minor damage	10%	90%	855	23400	20.7
2	Moderate damage	30%	70%	665	18200	16.1
3	Extensive damage	50%	50%	475	13000	11.5
4	Total damages	0	0	0	0	0

Criteria and Alternatives

Hierarchy chart in ranking of water distribution and supply alternatives in disasters situation for Pardis City



Pair wise comparison

- 29 experts from universities and organizations with different specialty were surveyed in gathering experts' opinions with questionnaires.
- Criteria and alternatives important weights are calculated by Expert Choice software.

Criteria	Delay in service	Cost	Affected population	Water quality
Important weights	0.157	0.061	0.346	0.436

Final important weights for water distribution alternatives

Loss scenario / Alternatives	Minor damages	Moderate damages	Extensive damages	Complete damages
Emergency tanks	0.113	0.124	0.147	0.127
Portable water treatment system	0.230	0.273	0.357	0.392
Water tankers	[illegible]	[illegible]	0.183	0.172
Pocket water	0.257	0.268	[illegible]	[illegible]
Existing distribution system	0.276	0.181	0.034	-

Final important weights for water supply alternatives

Loss scenario / Alternatives	Minor damages	Moderate damages	Extensive damages	Complete damages
Existent drinking water wells	0.258	0.186	0.118	-
Existent Storage tanks	0.346	0.290	0.224	-
Digging wells	0.200	0.274	0.346	0.730
Digging hand wells	0.196	0.250	0.312	0.270

CONCLUSIONS

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- **This paper discusses about outranking drinking water resources alternatives in order to plan for management in disastrous conditions.**

- **Potential for water supply and water ration have been prioritized in the planning for affected area by identifying the best alternative of water resources among available options.**

- **Here, water quality, cost, number of people, delay in services have been selected as default criteria for prioritizing the alternatives by using Multi Criteria Decision Making (MCDM) in different supposed loss scenarios.**

CONCLUSIONS

- Four different hypothetic scenarios were defined and for each of the scenarios different options and criteria were evaluated by applying AHP which is one of the well-known MCDM methods.

- Four alternatives for water allocation and four alternatives for supplying drinking water have been considered. These options are defined in regards to Pardis City in the vicinity of Tehran metropolitan in Iran.

- In this city, bottled water, tanker and emergency tanks, mobile water treatment and also the existent water system were ranked for water ration alternatives.

- Using existent wells and storage tanks, well drilling, and hand well drilling were chosen for water supply alternatives.

CONCLUSIONS

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- Recently, specially developing countries, are vulnerable to natural hazards.
- Emergency Response Planning (ERP) is an important task to reduce the amount of damages and MCDM methods are useful tools in this planning.
- In disastrous condition, finding available water resources and methods for distributing water between affected people can be planned based on the current study.
- In Iran, some equipments for water supply in emergencies like bottled water, tanker and emergency tanks, mobile water treatment have been produced and used in emergencies. In other developing countries, these equipment should be designed based on the available water resources.

Thank you for your attention