DOCTORAL THESIS PRESENTATION

Department of Civil and Environmental Engineering

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

PhD. Candidate

Seyed Mohammad Amin Hosseini

Tacloban city, Leyte province, Philippines-12/25/2013 - Source: AFP/ Ted Aljibe

Thesis Directors

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PhD. Oriol Pons

Doctoral Program in

Construction Engineering

Barcelona, September 2016

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BARCELONATECH

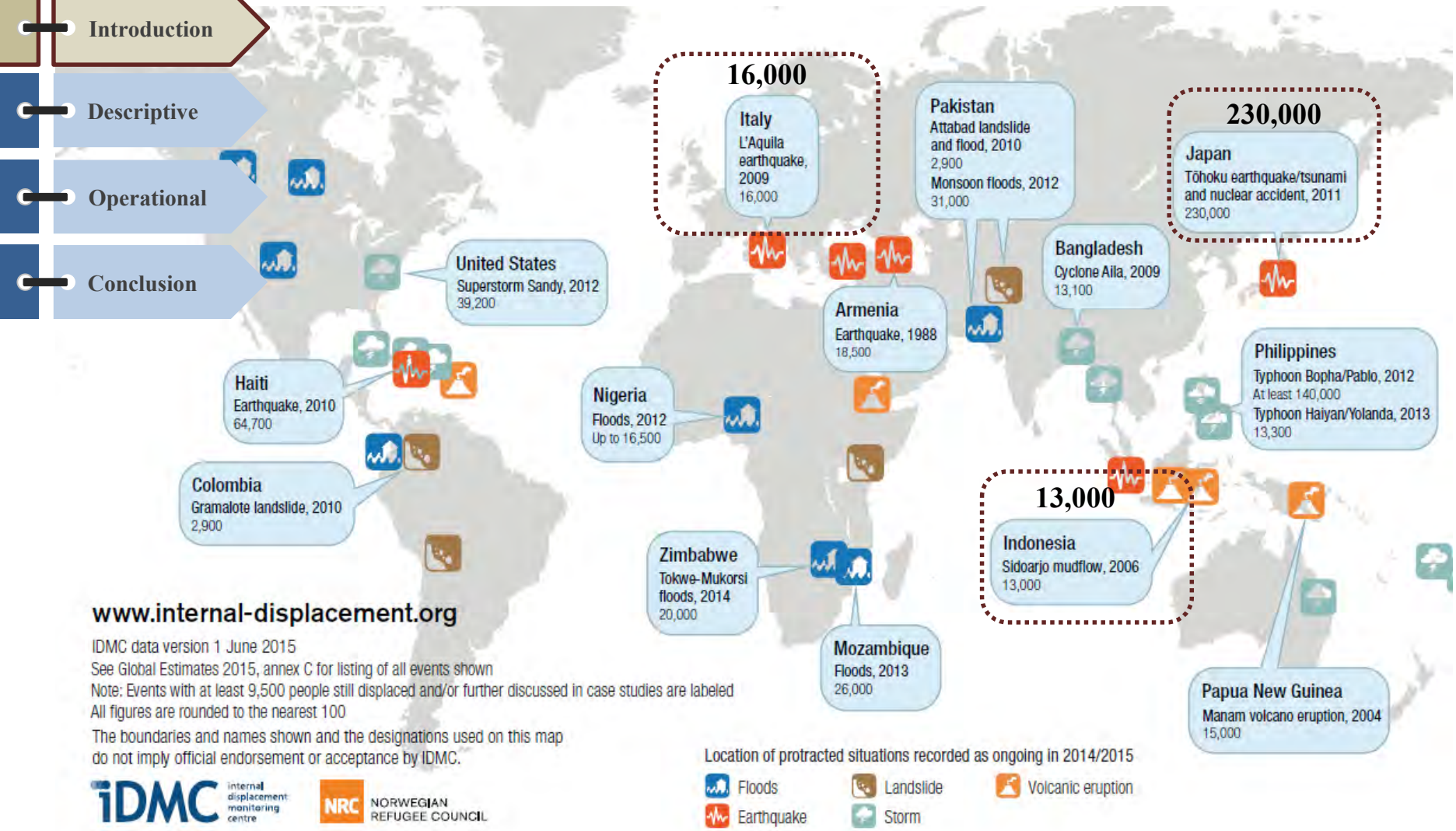
Architects mostly work for privileged people, people who have money and power, Power and money are invisible, so people hire us to visualize their power and money by making monumental architecture. I love to make monuments, too, but I thought perhaps we can use our experience and knowledge more for the general public, even for those who have lost their houses in natural disasters.

Shigeru Bam

We cannot stop natural disasters but we can arm ourselves with knowledge: so many lives wouldn't have to be lost if there was enough disaster preparedness.

Petra Nemcova

Protracted displacement following disasters worldwide in 2014/2015



Population Exposure to Natural Hazards

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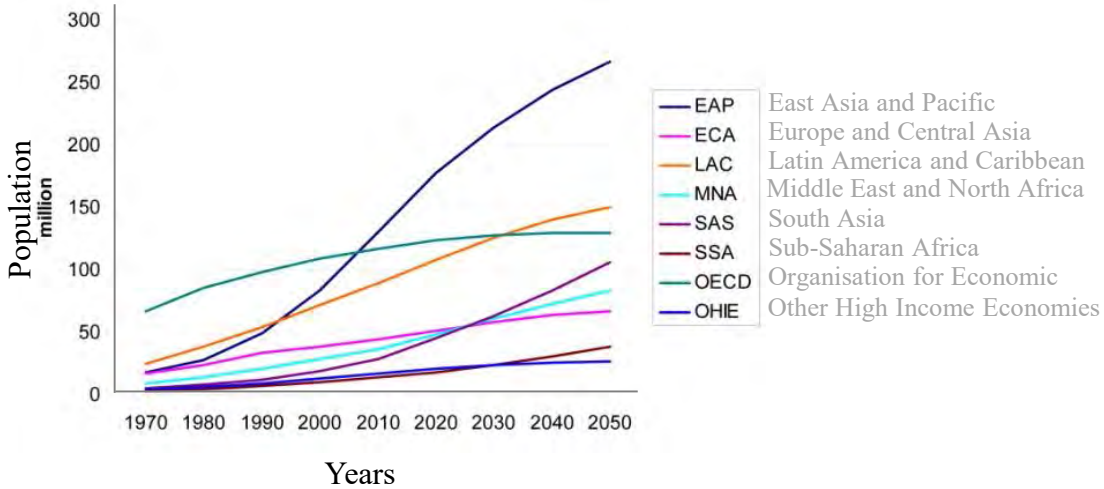
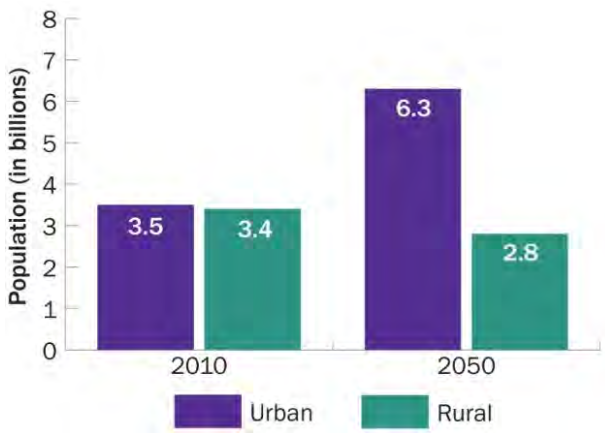
What is an estimation of future displaced population?



Population in large cities exposed to **earthquakes** increases from **370** to **870** million between **2000** and **2050**.

Source: World Bank 2009



Source: Mitchell L. Moss, 2012

Temporary Housing

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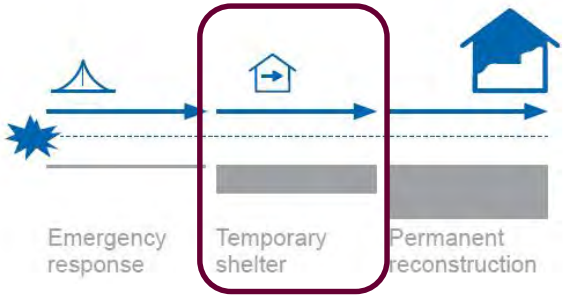
- Introduction
- Descriptive
- Operational
- Conclusion

Post-Disaster Temporary Housing definition



Post-Disaster Temporary Housing Types

Available Accommodations

- Staying with family/friends
- Public facilities
- Rented apartments/accommodations

Object

Not Available (require new construction)

- Newly Constructed Temporary Housing
- Shipping containers or mobile homes

What are the main problems of Post-disaster housing?

Sustainability

- Economic
- Social
- Environmental

Sustainability Problem

Construction Industry → Raw Material Consumption / Energy Consumption / Green Gas Emissions

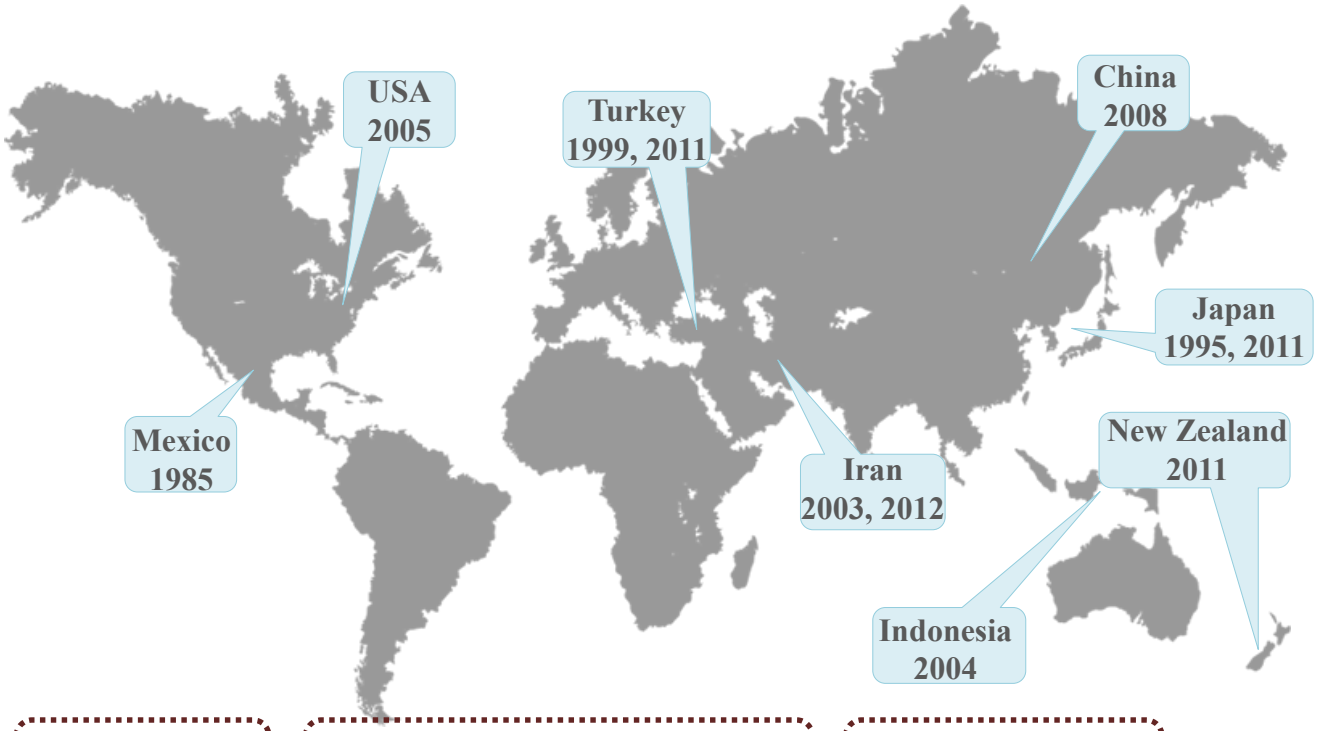
+

Natural Hazard → Short Time / Huge Amount

→ DISASTER

Temporary Housing Characteristics

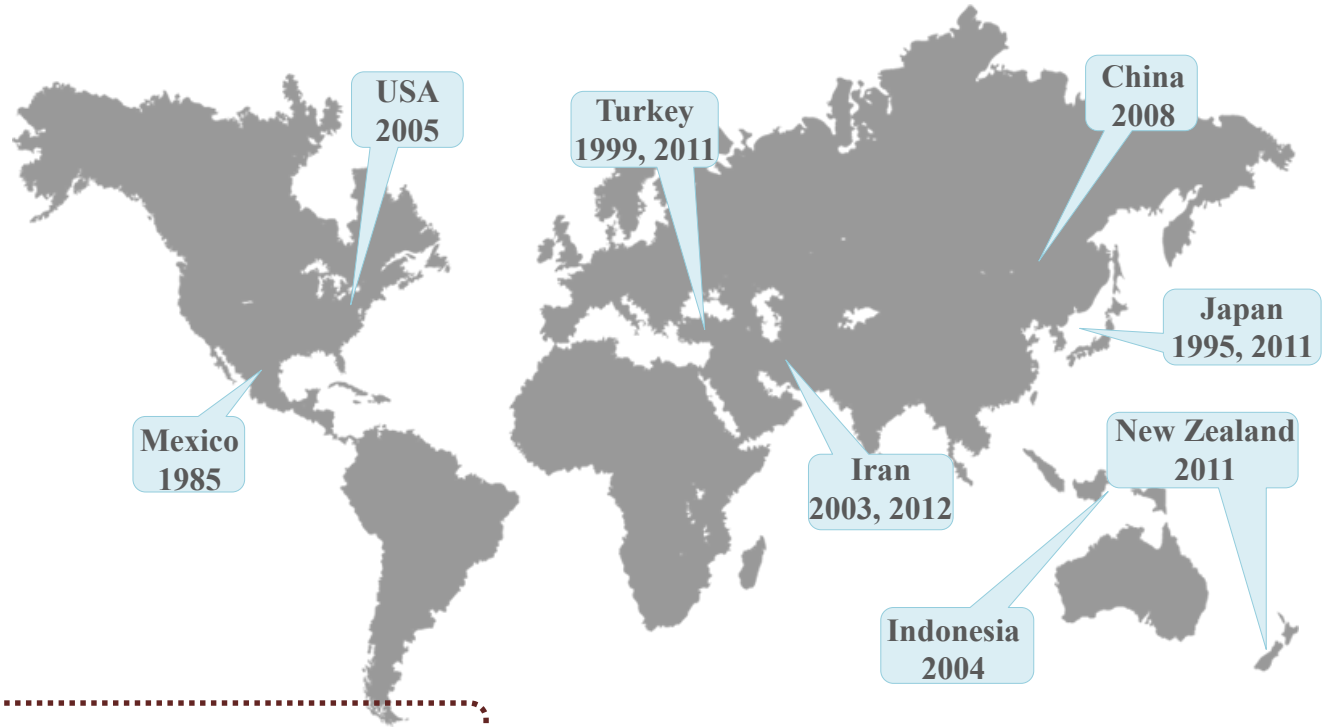
Why were decision-makers forced to choose temporary housing units?



- High Demand
- Displaced Population Pressure
- Climate Condition
- Lack of Other Options
- Avoiding the Mass Exodus of Population

Temporary Housing Characteristics

Why were decision-makers forced to choose temporary housing units?



Natural hazards cannot be eliminated.

Temporary housing is required.

Temporary housing has negative impacts.

→ Temporary Housing Assessment

Objective

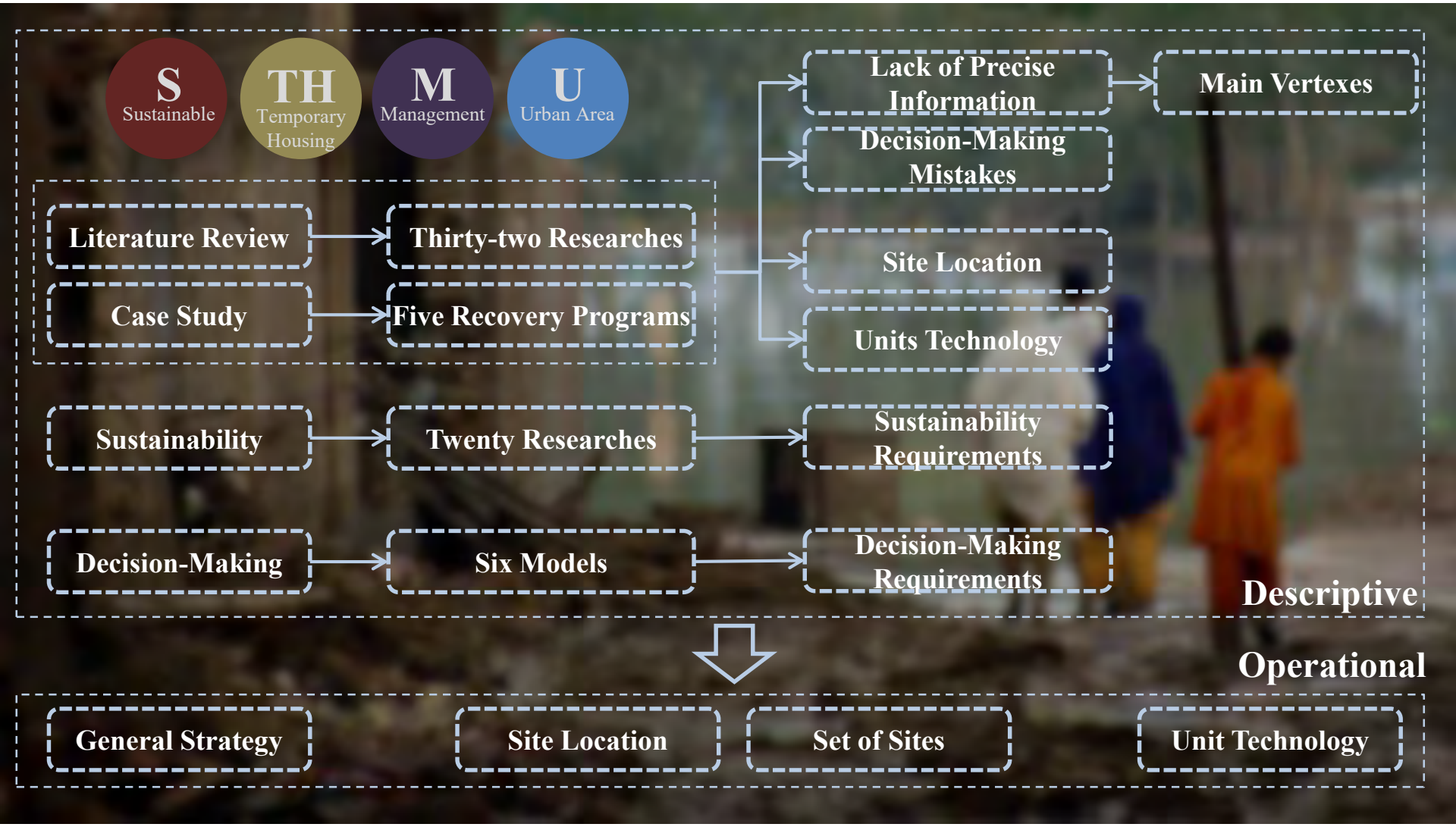
The **main objective** of this research is to **propose a platform for decision-makers for dealing with temporary** housing **in natural hazard-prone urban areas**.

Flexible | **Adaptable** | **Sustainable Solution**

Stakeholders' Preferences

Specific Objective

Model I	Model II	Model III	Model IV
Choosing **the most suitable temporary housing strategy**	Selecting **an optimized site location**	Selecting **the most sustainable area subsets** from various alternatives	Selecting **the most optimal THU alternative** in terms of **sustainability**


S Sustainable
TH Temporary Housing
M Management
U Urban Area
Literature Review
Thirty-two Researches
Case Study
Five Recovery Programs
Sustainability
Twenty Researches
Decision-Making
Six Models
Lack of Precise Information
Main Vertexes
Decision-Making Mistakes
Site Location
Units Technology
Sustainability Requirements
Decision-Making Requirements
Descriptive
Operational
General Strategy
Site Location
Set of Sites
Unit Technology

Methodology

Operational

Designed Models

- AHP
- MIVES
- Knapsack
- Shannon's Entropy
- LCA

Problem Definition & Finding Reasons

Dividing & Organizing Issues

Designing Models

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Descriptive

S Sustainable
TH Temporary Housing
M Management
U Urban Area

Integrated Approach

Integrated Approach

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- Which are the **main requirements** involved in post-disaster accommodation strategies and the constituents?
- Which are the **differences** between implemented post-disaster accommodation **strategies**?

Five Cases

Three Vertexes

Customizable Strategy

Choice Phases

Decision-Making Process Algorithm

Case Study

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Case study	Natural hazard		Post-disaster accommodation	Timing [a]												
	Type	Intensity	Type	week				month					year			
				2	4	6	8	4	6	8	10	12	2	3	4	5
Turkey 1999	Earthquake	Mw=7.4 Mw=7.2	Tent													
			NATH													
			PH [b]													
Iran 2003	Earthquake	Ms=6.5	Tent													
			NATH													
			PH													
Indonesia 2004	Earthquake Tsunami	Mw=9.2	Tent & barrack													
			TH [c]													
			PH													
USA 2005	Hurricane Flood	Category 3 [d]	shelters													
			TH [c]													
			PH													
Italy 2009	Earthquake	Mw=6.3	Winterized tent													
			Semi-/PH													

Turkey-1999

Iran-2003

Indonesia-2004

USA-2005

Italy-2009

Case Study

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- Introduction
- Descriptive
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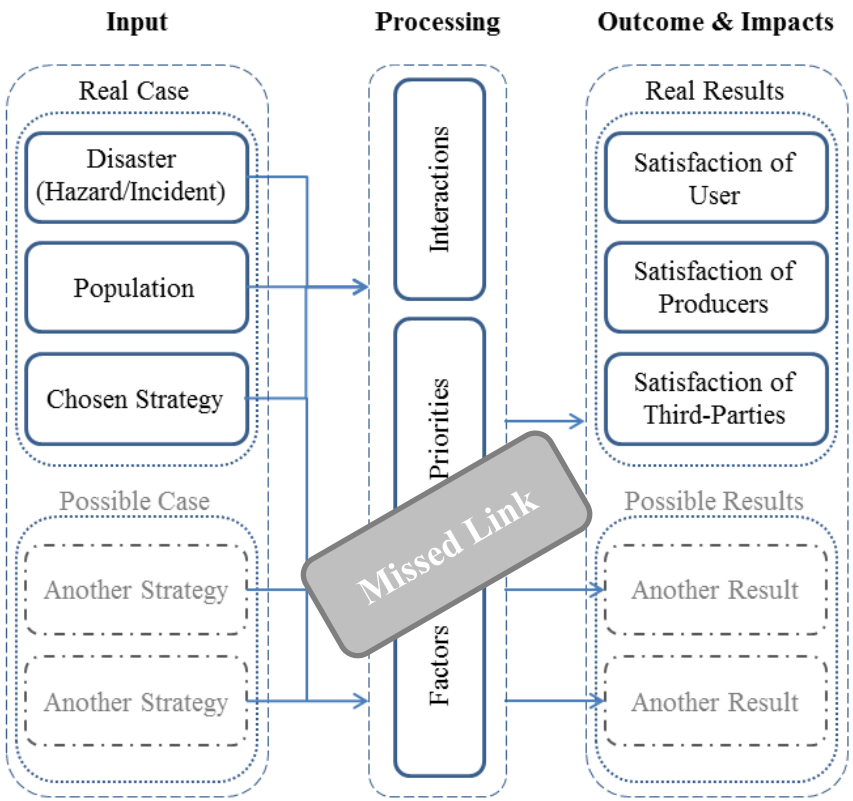
- Conclusion



Turkey-1999

Iran-2003

Indonesia-2004

USA-2005

Italy-2009

Integrated Approach

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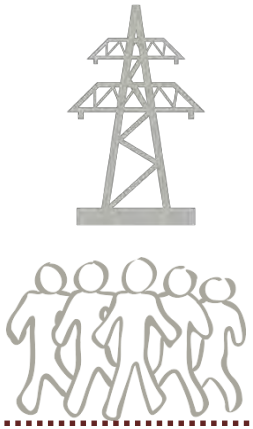
Main Vertexes



+

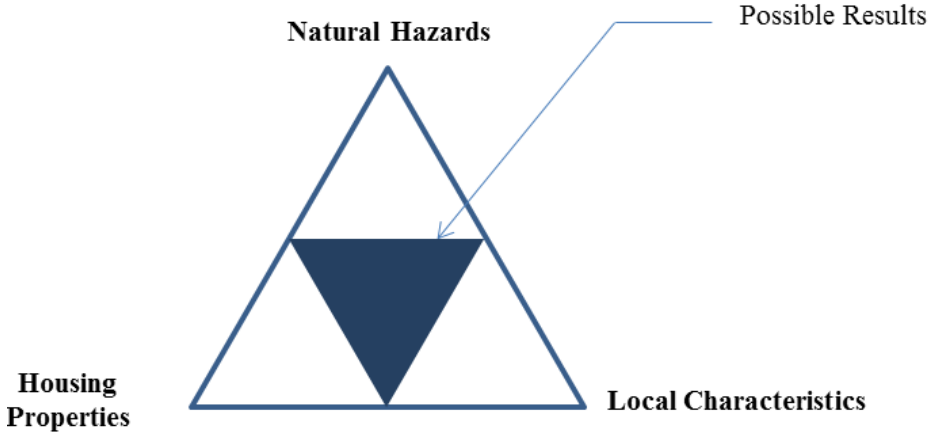
+

Local Characteristics

Post-disaster Housing Properties

Natural Disaster

Findings



The **temporary housing stage cannot be concealed**.

The **elements** can lead to **antithetical effects**.

Choice Phases

Decision-making Algorithm

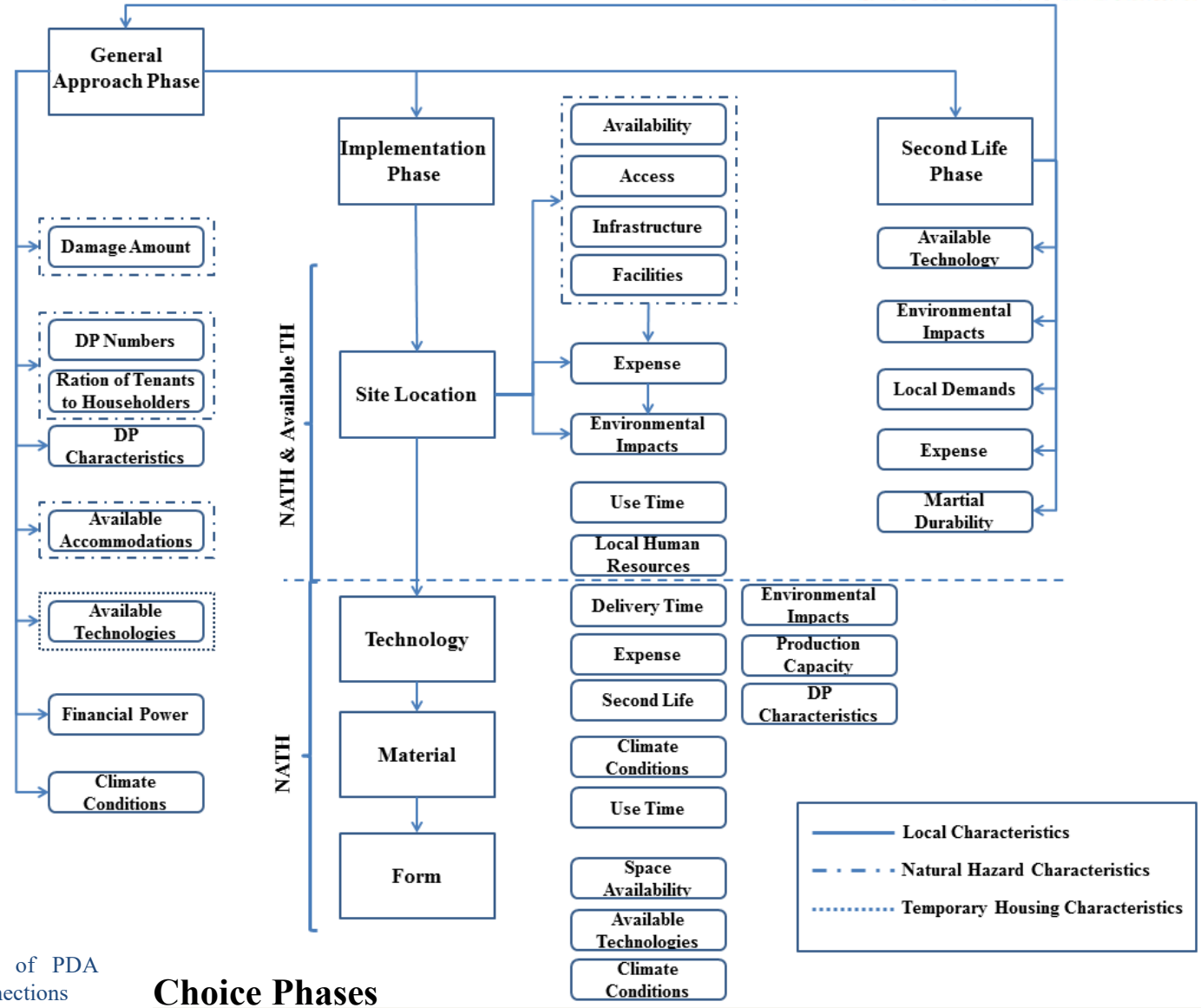


Fig 3.4. The choice phases of PDA including the elements and connections

Choice Phases

Decision-Making Algorithm

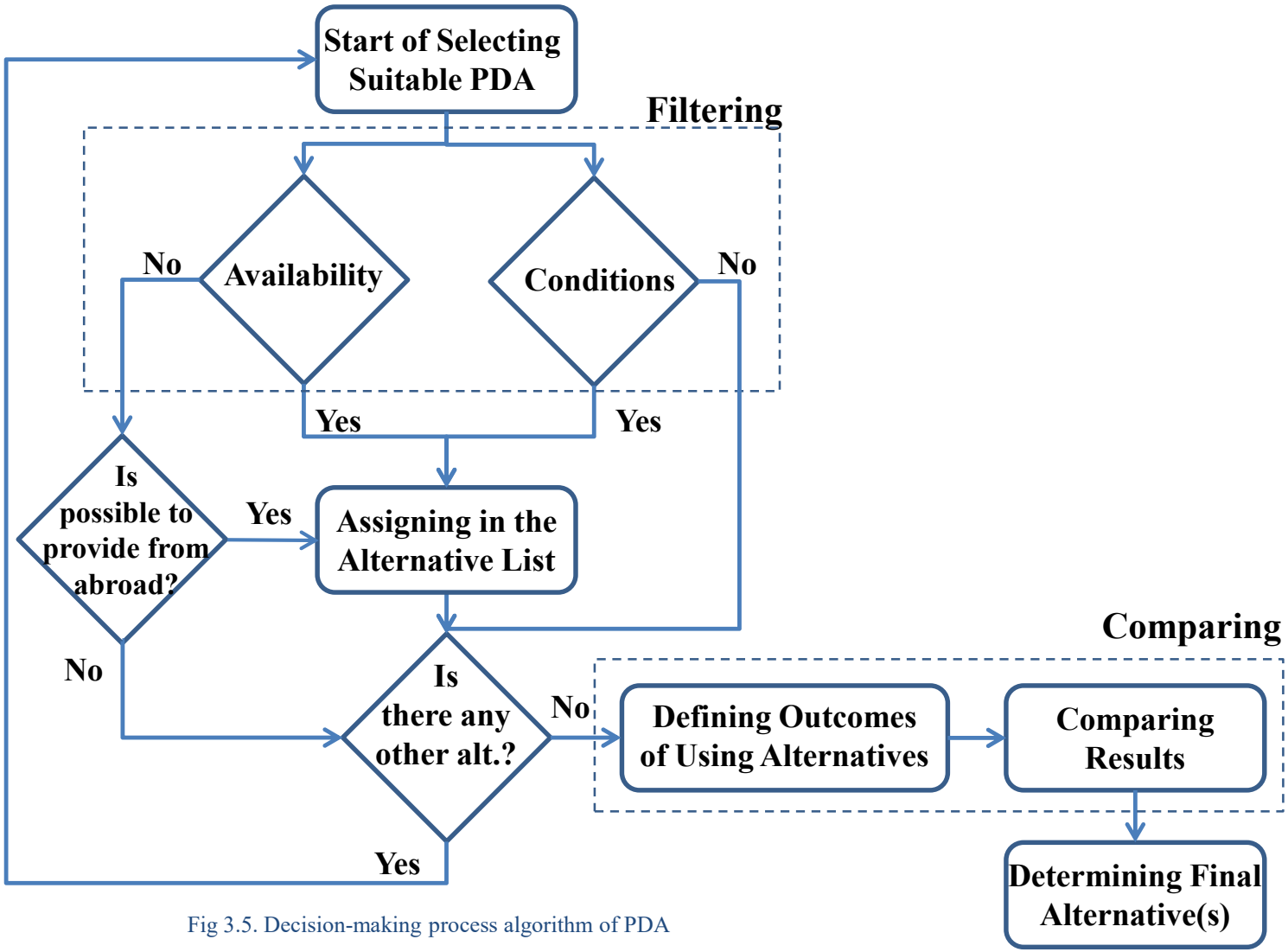


Fig 3.5. Decision-making process algorithm of PDA

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Integrated Approach for Dealing with Post-Disaster Accommodations

Hosseini, S. M. A., Pons, O, Mendoza, C., and de la Fuente, A.,

Journal of Disasters

Wiley Online Library

Disasters UNDER REVIEW

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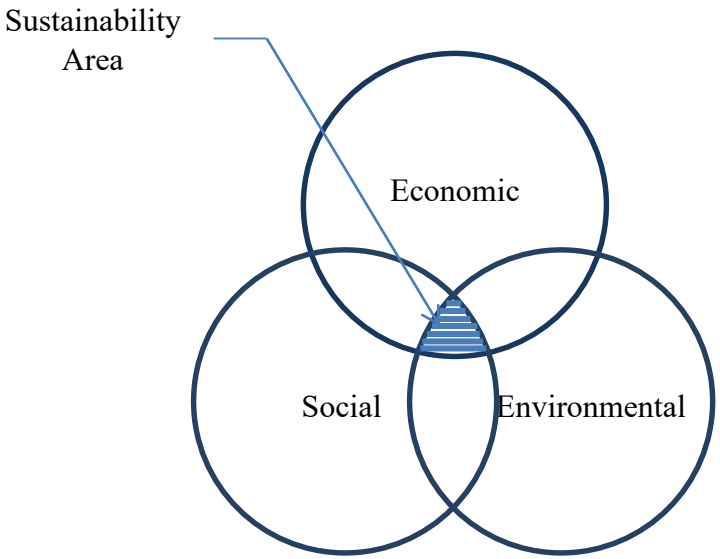
Descriptive

S Sustainable
TH Temporary Housing
M Management
U Urban Area

Sustainability

Sustainability

What is the sustainability of post-disaster housing?



Building Industry

Natural Disaster

Findings

Sustainability index can **vary** for **different areas**.

Complex Problem

Concerns | **Requirements** | **Limitations** and **Impediments**

Potentials

Descriptive

S Sustainable | TH Temporary Housing | M Management | U Urban Area

Decision-Making Models

Decision-Making Model

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- Introduction
- Descriptive
- Operational
- Conclusion

❖ Which are the **main requirements** for the **decision-making process** to deal with post-disaster housing?

❖ Which is the **most suitable method** to assess the **post-disaster housing sustainability** focusing on the aforementioned main requirements?

Previous Studies

Site Selection

Temporary Housing Selection

TOPSIS

AHP

GIS

MADM

Fuzzy

Optimizing

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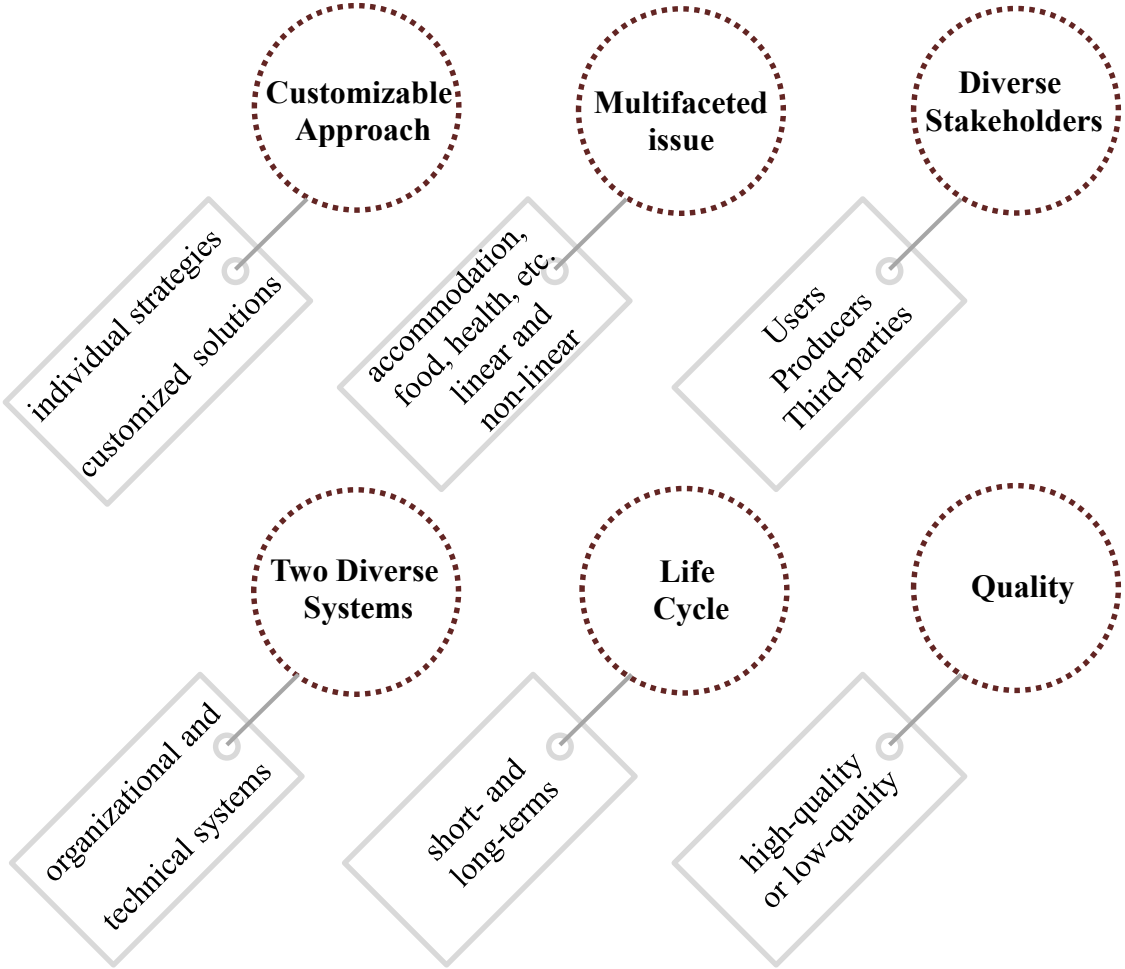
Which are the main requirements for the decision-making process to deal with post-disaster housing?

The characteristics of post-disaster housing decision-making processes



Decision-Making Model

Which is the most suitable method to assess the post-disaster housing sustainability focusing on the aforementioned main requirements?

AHP | TOPSIS | MIVES | ELECTRE
SAW | Fuzzy

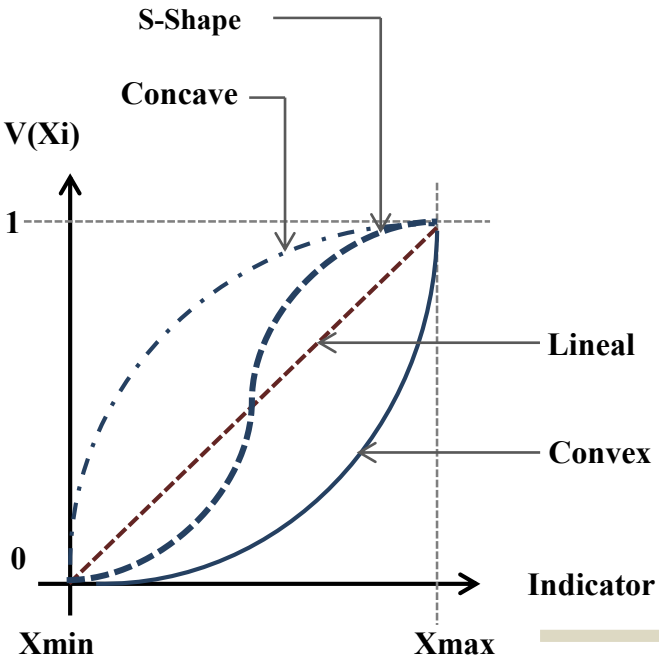
Indicator-Weighting System + Utility Theory

↓

MIVES Method

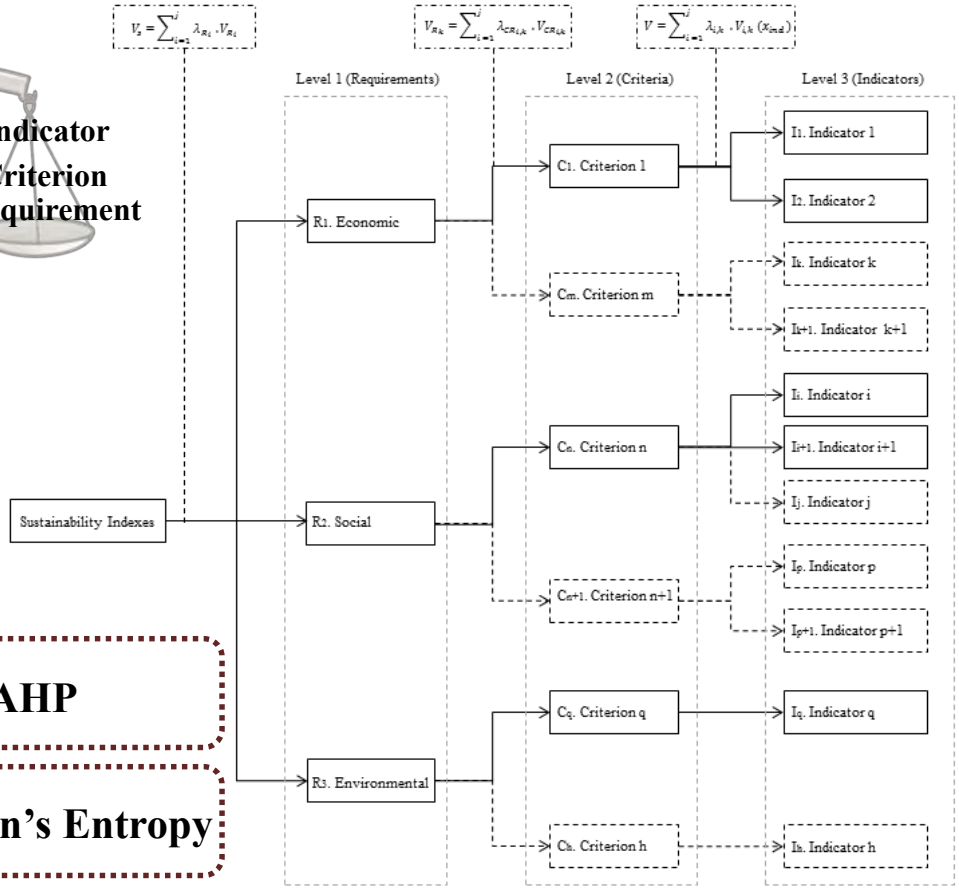
Definition

The integrated value Model for Sustainable Assessment from the Spanish (MIVES) consists of a multi-criteria decision-making method that incorporates the concept of value function.



AHP

Shannon's Entropy



Operational

A Steps Scenario Strategy

A Steps Scenario Strategy

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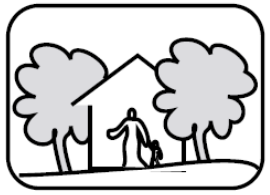
The problems of post-disaster housing can worsen when an **initial chosen strategy** is **changed** by decision-makers in order to select a more suitable one.

Camp
(Grouped)



Yard of Previous Housing
(Dispersed)

Tent

Temporary Housing Unit

A Steps Scenario Strategy

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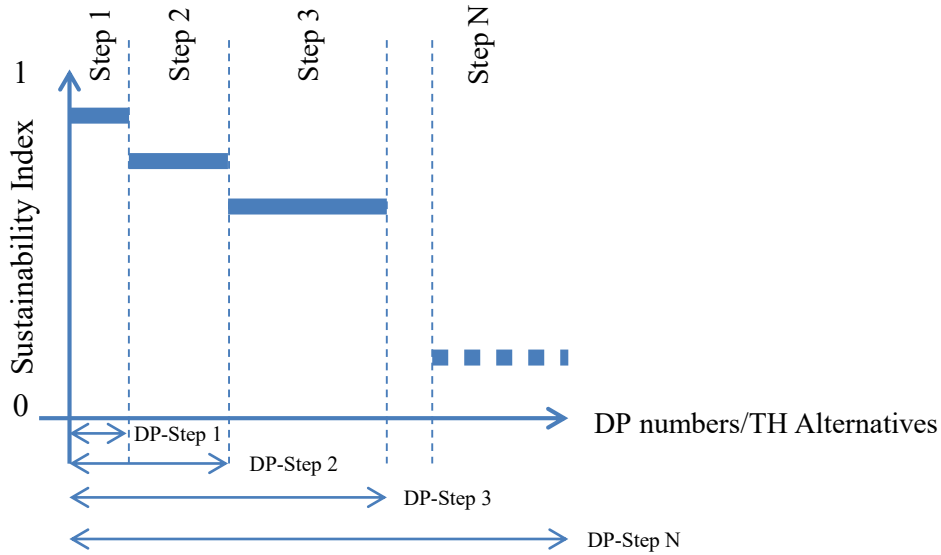
- Introduction
- Descriptive
- Operational
- Conclusion

Step Scenario Strategy



Displaced Population

Alternatives

Host Families

Temporary Housing Units

+ Sustainability Index −

A Steps Scenario Strategy

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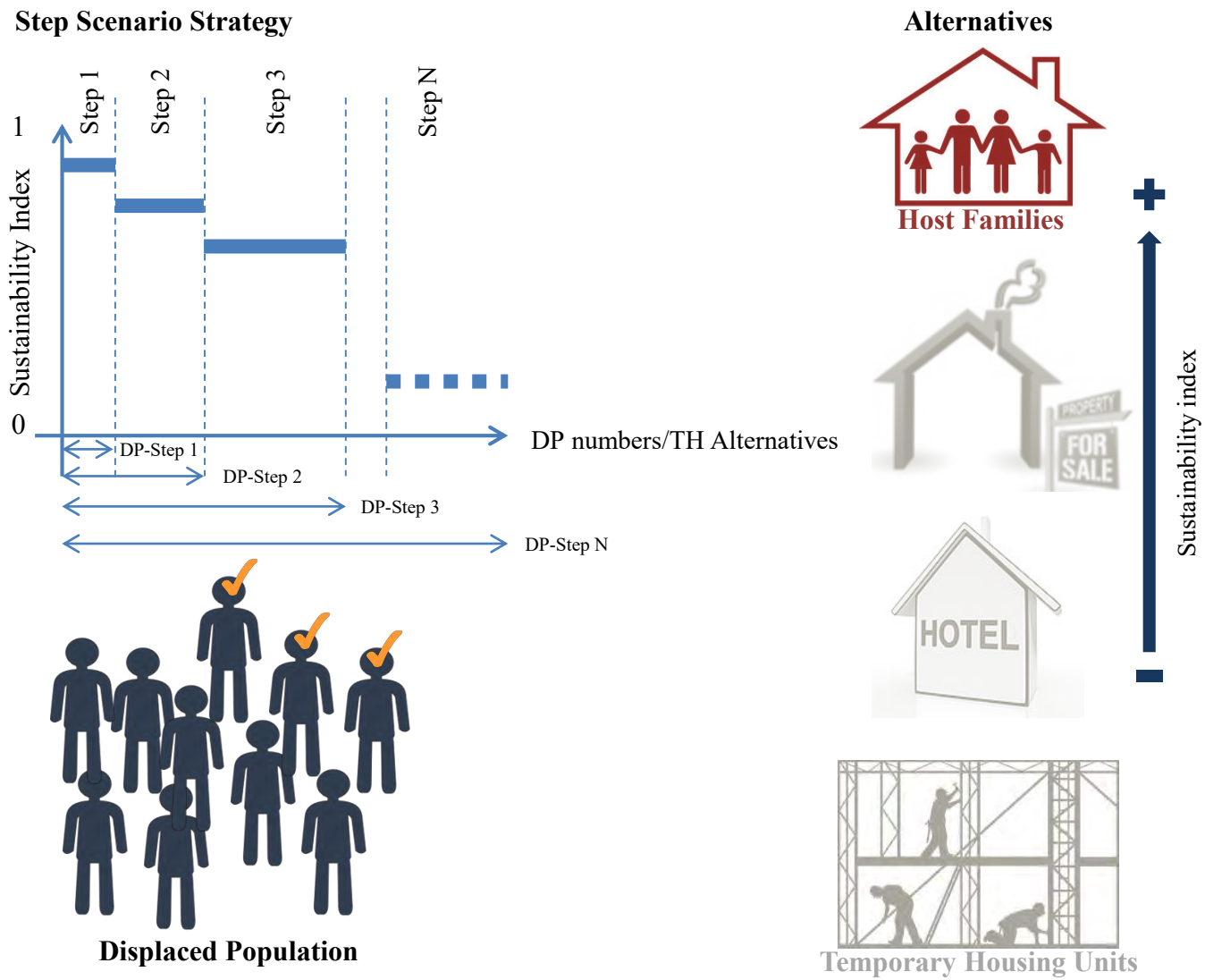

A Steps Scenario Strategy

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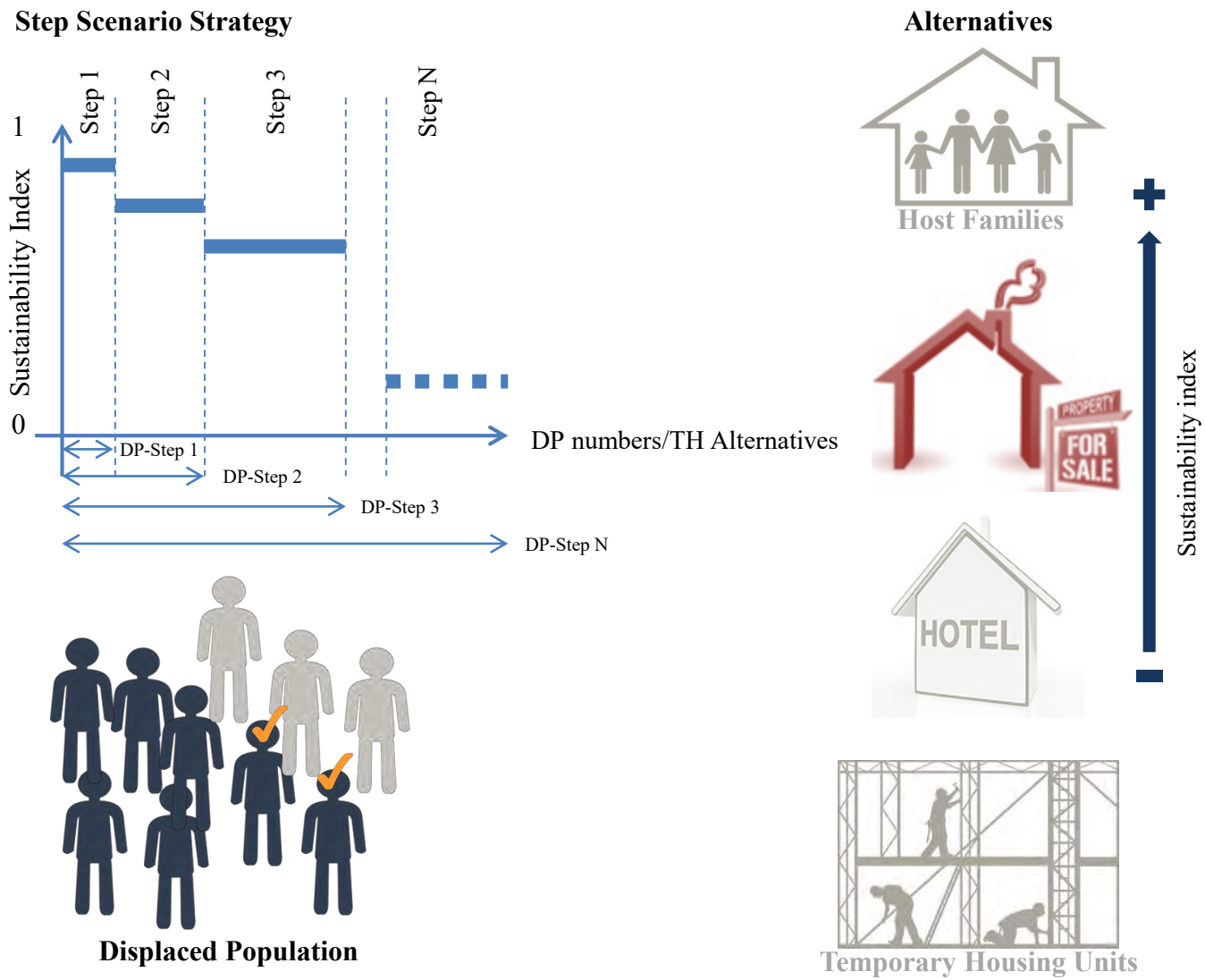

A Steps Scenario Strategy

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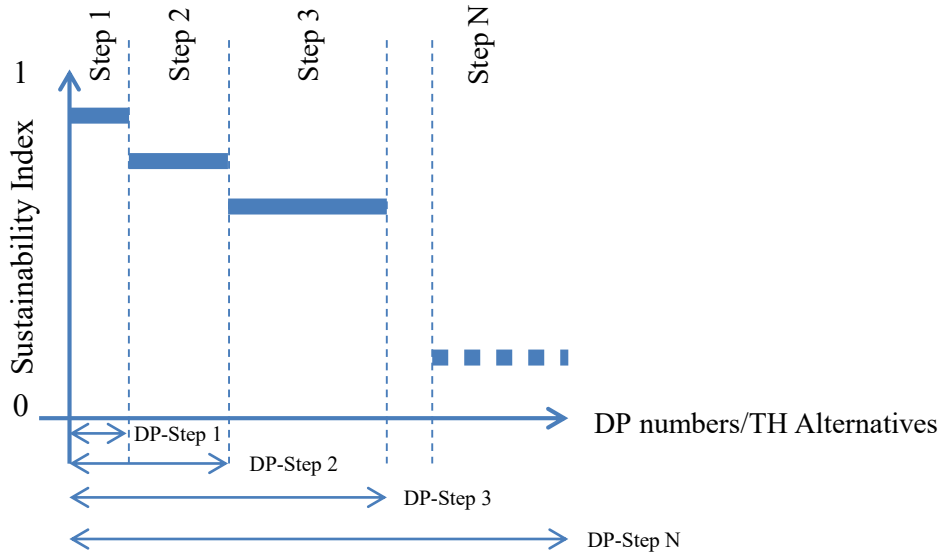
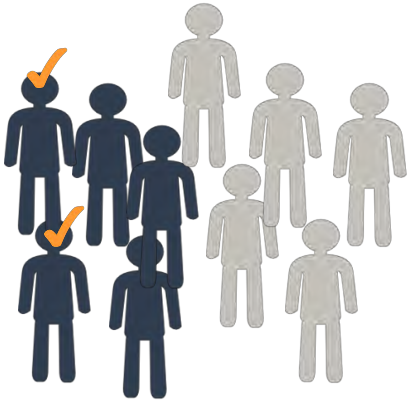
Step Scenario Strategy



Alternatives

+ Sustainability index −



Displaced Population

A Steps Scenario Strategy

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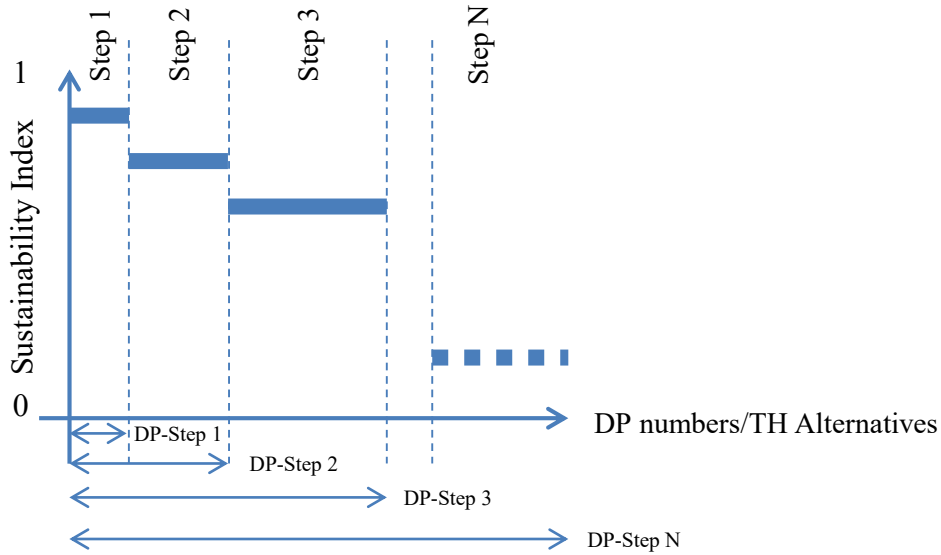
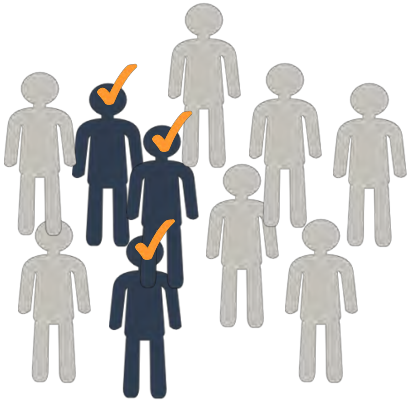
Step Scenario Strategy

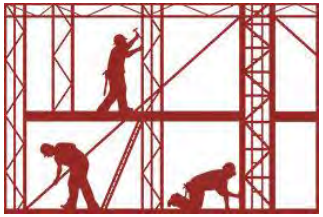


Alternatives

+
Sustainability index
-



Displaced Population



Temporary Housing Units

A Steps Scenario Strategy

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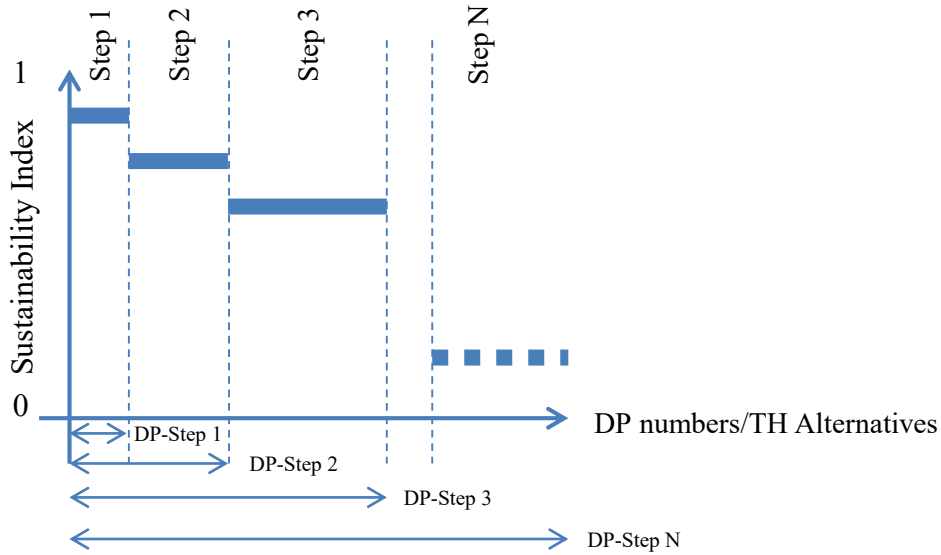
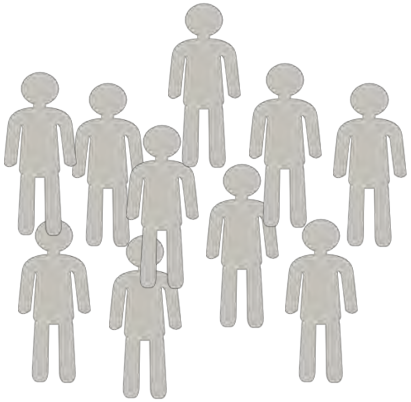
Step Scenario Strategy



Alternatives



Displaced Population

Temporary Housing Units

A Steps Scenario Strategy

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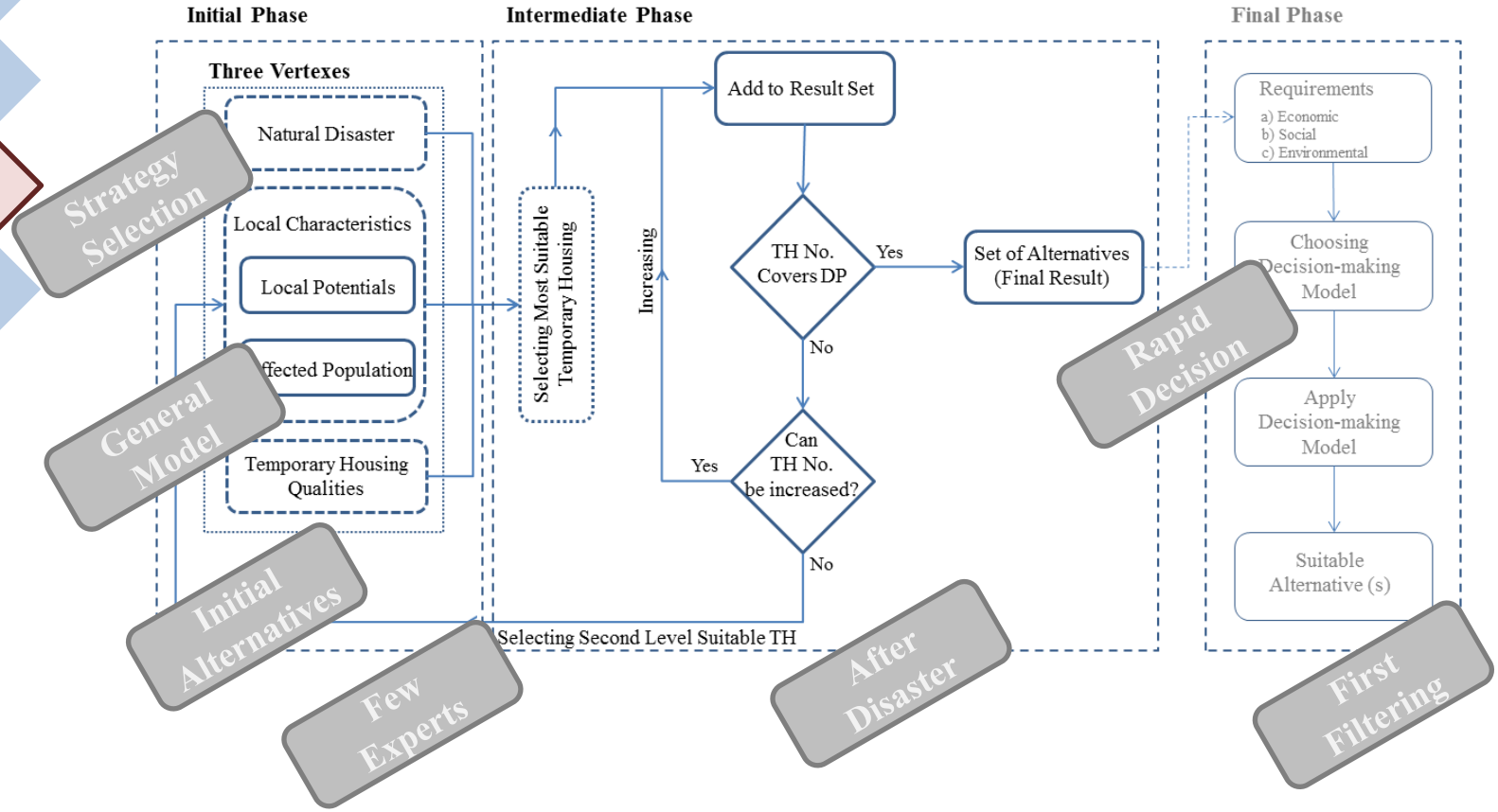
Suggested Model



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Sustainability indexes of temporary housing

Sustainability Concept

Essential Factors

Economic	Social	Environmental
Provision Cost	Health	Pollution
Maintenance Cost	Well-being	Reusability
	Culture	Consumption

A Steps Scenario Strategy

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Analysing

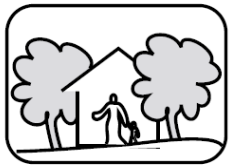
Seminars | **Shannon's Entropy** | **Equal**

Twenty-two Weights Scenarios

Case	Weight / Main Index Indicator	70Ec/15S/15En	50Ec/30S/20En	50Ec/25S/25En	48Ec/30S/22En	48Ec/22S/30En	47Ec/35S/18En	47Ec/18S/35En	45Ec/25S/30En	42Ec/36S/22En	42Ec/22S/36En	38Ec/33S/29En	38Ec/42S/20En	36Ec/42S/22En	35Ec/47S/18En	30Ec/48S/22En	30Ec/45S/25En	25Ec/50S/25En	20Ec/50S/30En	20Ec/30S/50En	15Ec/55S/30En	15Ec/70S/15En	15Ec/15S/70En
Bam	Seminars	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	Equal	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C
	Shannon's Entropy	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	C
Aceh	Seminar	T	T	T	T	T	U	T	T	U	T	U	U	U	U	U	U	U	U	U	U	U	T
	Equal	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	T
	Shannon's Entropy	T	T	T	T	T	T	T	T	T	T	T	U	U	U	U	U	U	U	T	U	U	T

Units 65%

Camp
(C)



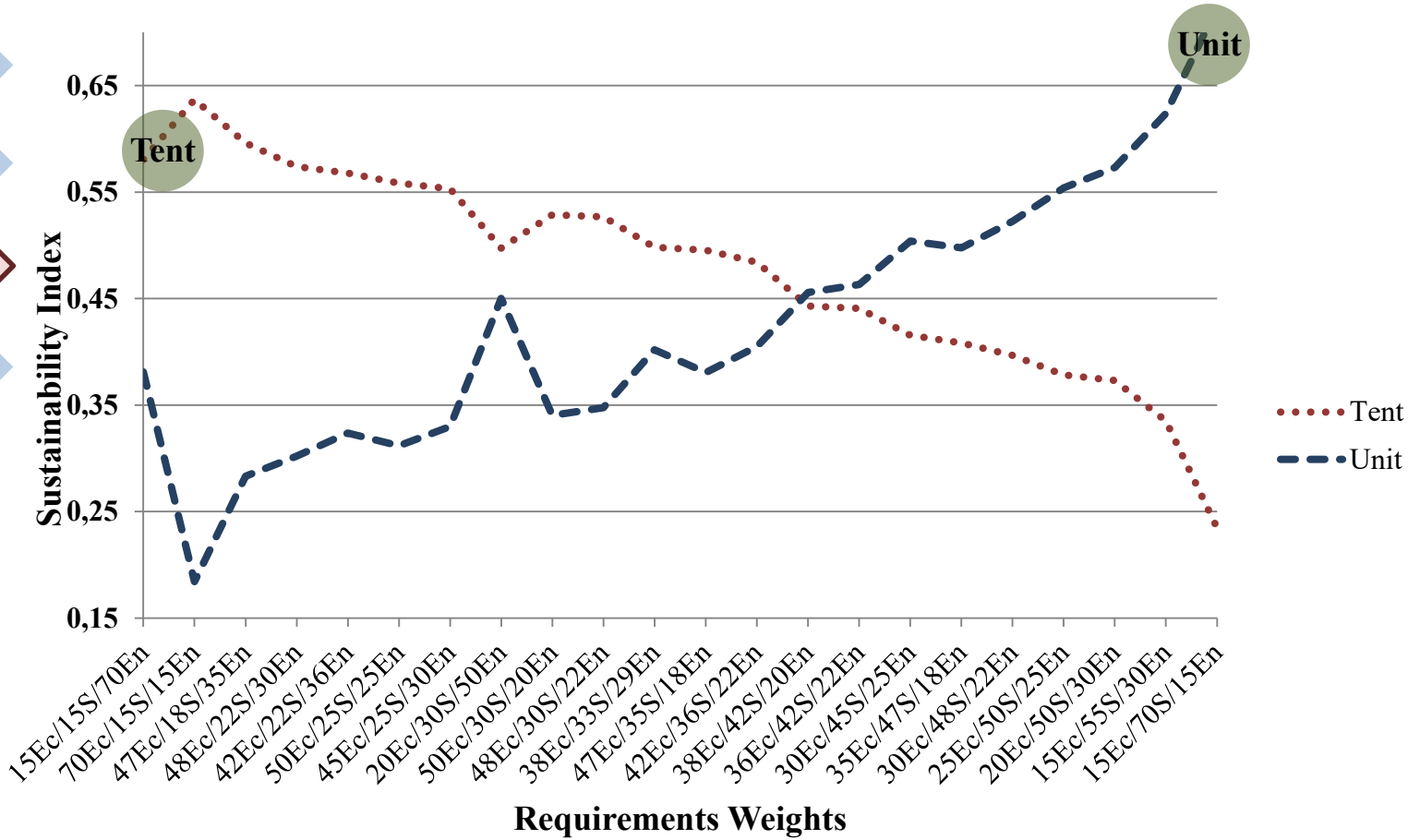
Private Yard
(P)

Tent
(T)

Housing Unit
(U)

(P: private yard of DP´s previous housing; C: camp site; T: tent; U: unit/THU)

A Steps Scenario Strategy



Increasing social weights by the Entropy

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Post-disaster Temporary Housing: A Steps Scenario Strategy for Choosing Sustainable Solutions

Hosseini, S. M. A., Pons, O, Mendoza, C., and de la Fuente, A.,

Journal of Housing and the Built Environment

Springer

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Operational

Site Location Selection I

Site Location Selection

Improper Site Selection

Turkey-Istanbul 1999

Iran-Bam 2003

Italy-L'Aquila 2009

Great Eastern Japan Earthquake 2011

The **objective** of this chapter is to present a **new model** that is capable of selecting an **optimized location** for TH by assessing economic, social, cultural, and environmental aspects.

Site Location Selection

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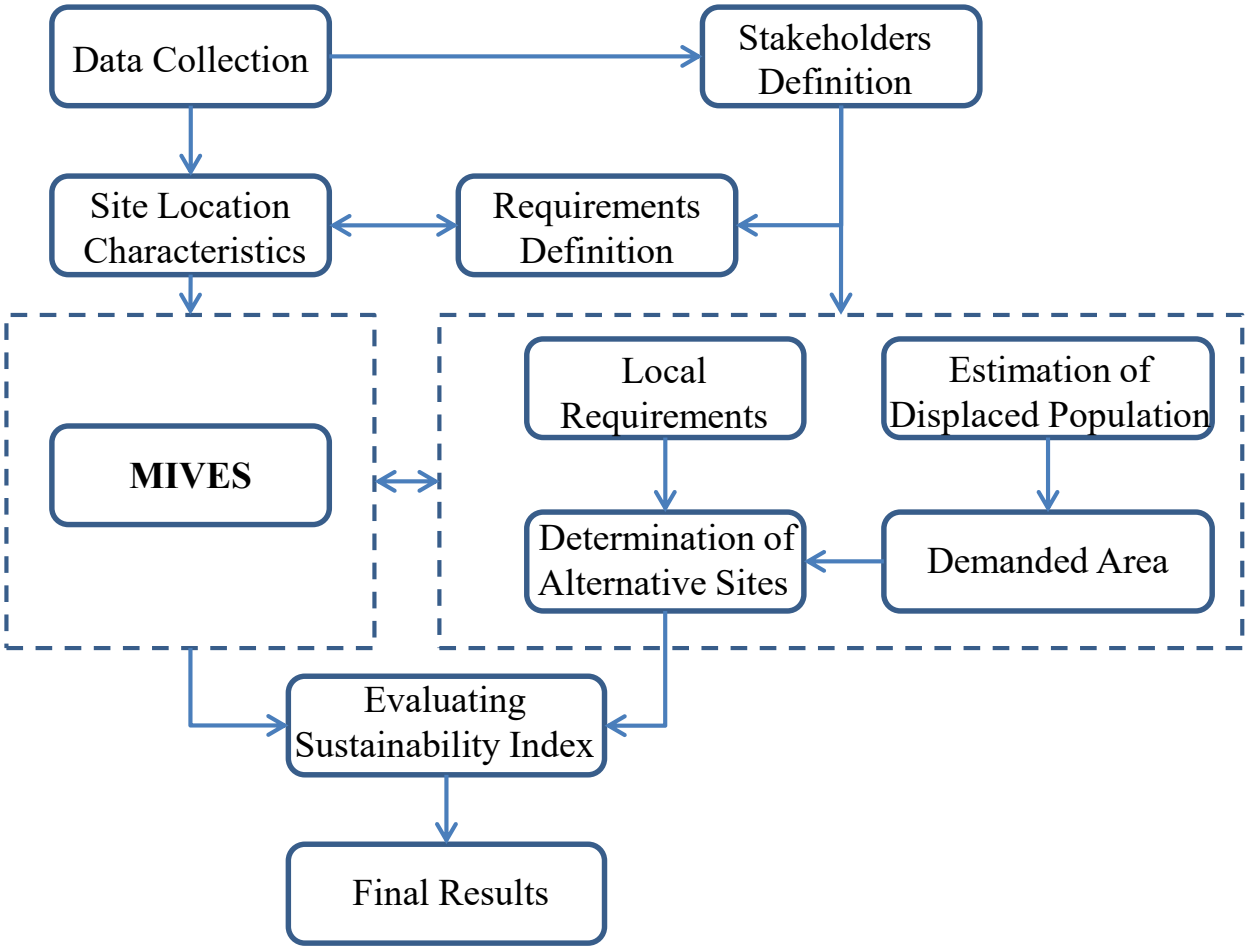
Methodology



Site Location Selection

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- Introduction
- Descriptive
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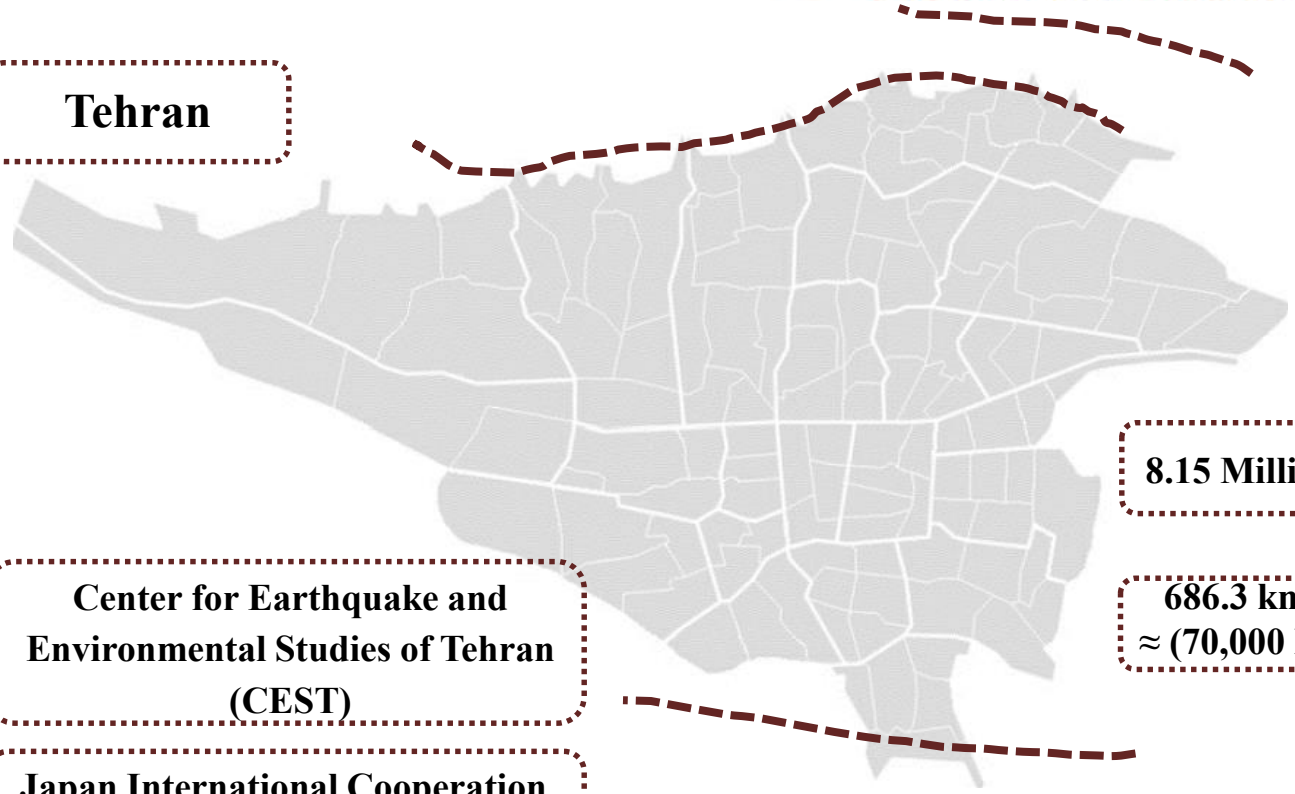
- Conclusion

Tehran



8.15 Million

686.3 km² ≈ (70,000 ha)

Center for Earthquake and Environmental Studies of Tehran (CEST)

Japan International Cooperation Agency (JICA)

18,000 Casualties

610,000 Displaced Population

90,000 Damaged Residential Buildings

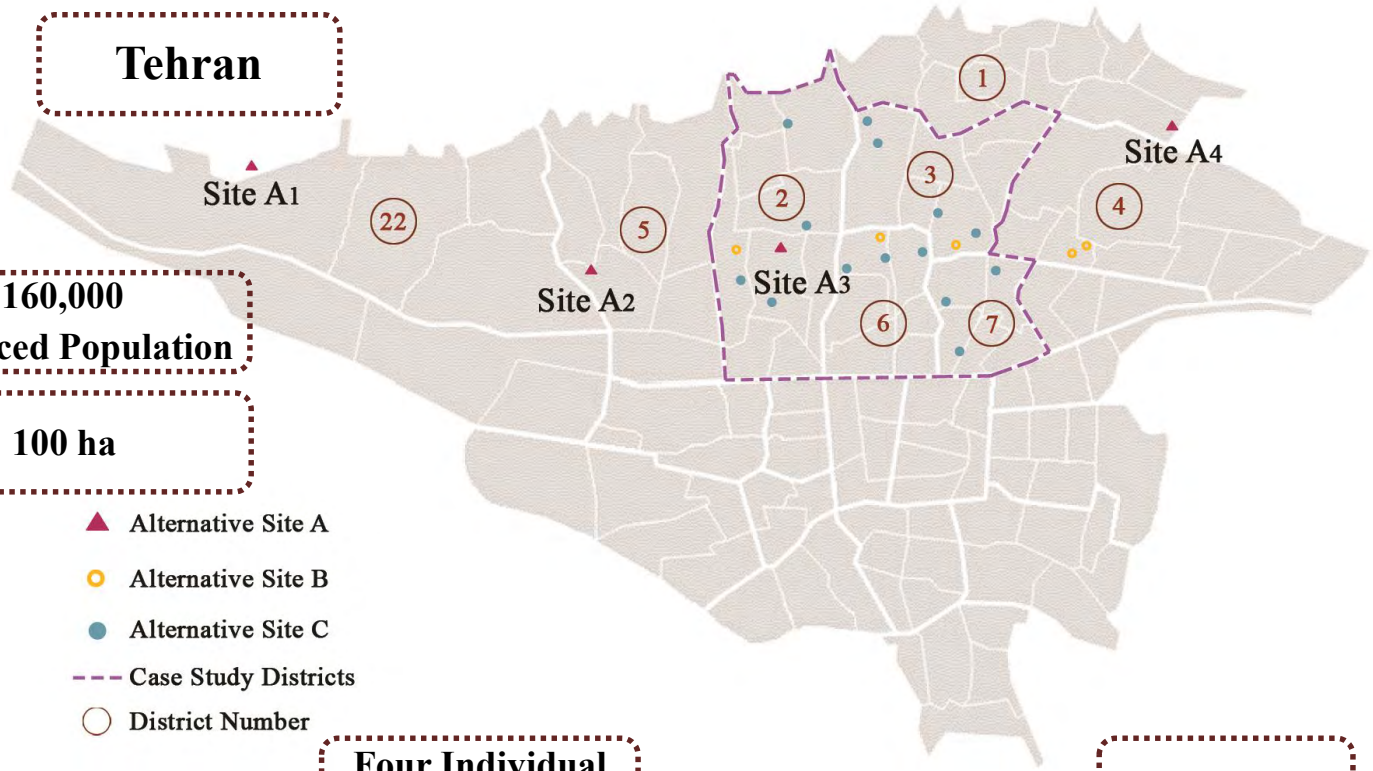
II/I

Site Location Selection

Tehran

160,000 Displaced Population

100 ha



Six Alternatives

Twenty-three Sites

Four Individual Sites → **A1-A4**

Two Alternative Sets
- **Set B** → **B1-B5**
- **Set C** → **C1-C14, B2, B4, and B5**

Site Location Selection

Departament d'Enginyeria de la Construcció
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$$V_S = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}\,(x_{ind})$$

- Sustainability Indexes of Alternatives
  - R1. Economic
    - C1. Invest Capital
      - I1. Land Price
      - I2. Cost of Site Preparation
  - R2. Social
    - C2. User Safety
      - I3. Access
      - I4. Population Covering
      - I5. Distance from Source of Danger
    - C3. Flexibility
      - I6. Property and Land Use Zoning
      - I7. Neighbourhood Acceptability
  - R3. Environmental
    - C4. Land use
      - I8. Landscape Respect
    - C5. Emissions
      - I9. CO2 Emission

II/I

Site Location Selection

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$$V_S = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$

- Sustainability Indexes of Alternatives
  - R1. Economic
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      - I4. Population Covering
      - I5. Distance from Source of Danger
    - C3. Flexibility
      - I6. Property and Land Use Zoning
      - I7. Neighbourhood Acceptability
  - R3. Environmental
    - C4. Land use
      - I8. Landscape Respect
    - C5. Emissions
      - I9. CO2 Emission

DP Access

Emergency Services Access

II/I

Site Location Selection

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$$V_S = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$

- Density
- School
- Sustainability Indexes of Alternatives
- Green Area
- Hospital
- Police
- Fire Stations

- R1. Economic
  - C1. Invest Capital
    - I1. Land Price
    - I2. Cost of Site Preparation
- R2. Social
  - C2. User Safety
    - I3. Access
    - I4. Population Covering
    - I5. Distance from Source of Danger
  - C3. Flexibility
    - I6. Property and Land Use Zoning
    - I7. Neighbourhood Acceptability
- R3. Environmental
  - C4. Land use
    - I8. Landscape Respect
  - C5. Emissions
    - I9. CO2 Emission

II/I

Site Location Selection

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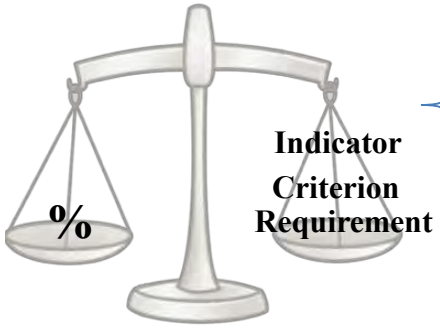
- Introduction
- Descriptive
- Operational
- Conclusion

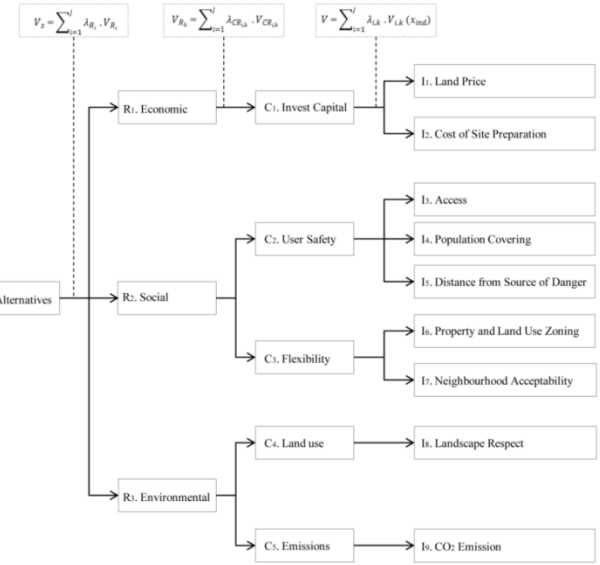


Analysing

- Six Alternatives
- Twenty-three Sites
- Weight Assignment
- Meetings & Seminars
- University Professors & Local Experts

→ Characteristics

↓ Value of Indicator



	Alternative	I	V_{R1}	V_{R2}	V_{R3}	V_{C1}	V_{C2}	V_{C3}	V_{C4}	V_{C5}
1	A_1	0.61	0.59	0.50	0.73	0.59	0.37	1.00	0.50	0.80
2	A_2	0.55	0.47	0.92	0.35	0.47	0.92	0.91	0.50	0.30
6	A_3	0.37	0.18	0.46	0.58	0.18	0.41	0.68	0.50	0.61
3	A_4	0.52	0.28	0.49	0.91	0.28	0.41	0.82	0.75	0.96
5	B	0.43	0.13	0.78	0.60	0.13	0.79	0.75	0.58	0.61
4	C	0.47	0.09	0.93	0.65	0.09	0.99	0.72	0.73	0.62

II/I

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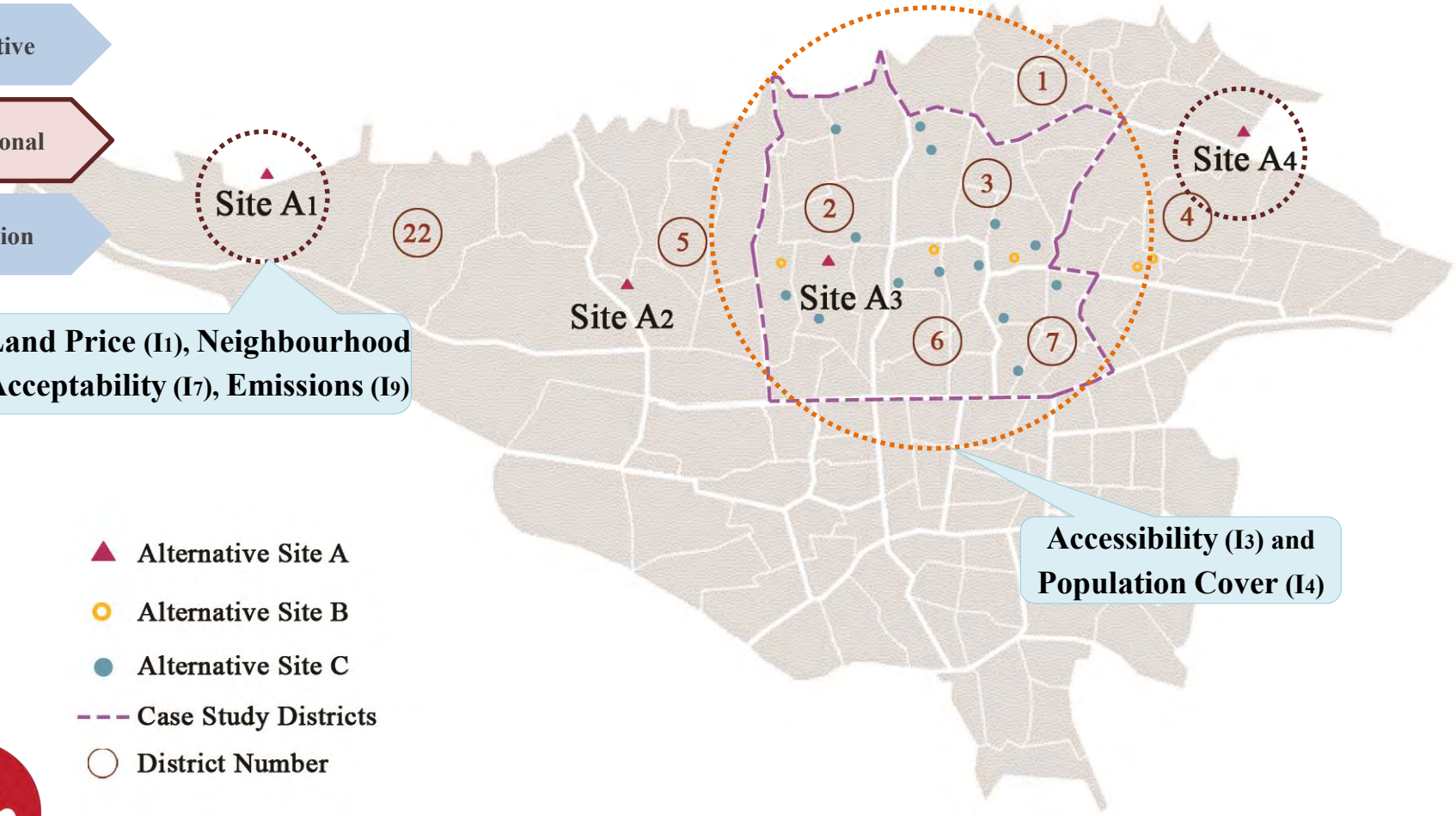
Analysing



II/I

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Analysing

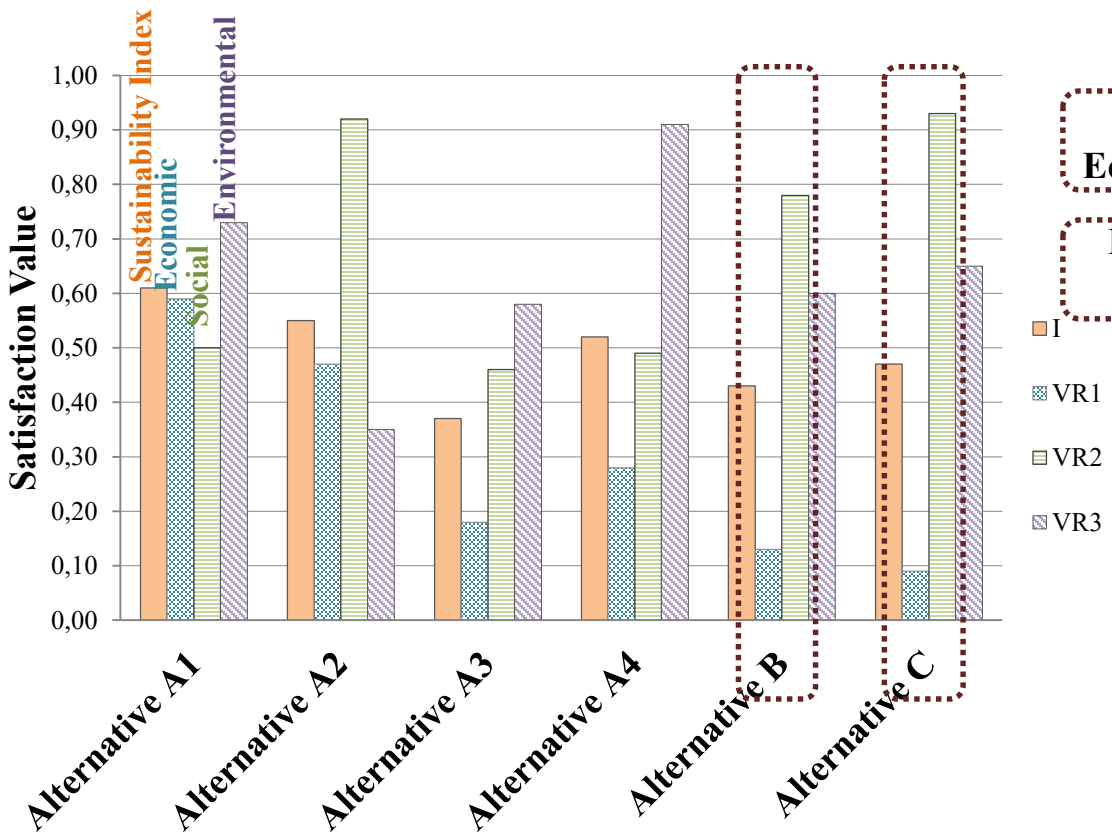

Fig. 7.6. Sustainability index (I) and requirement values for the six alternatives

Alternative sets (B & C)

Minimum Values of Economic Requirements

High Values of Social Requirements

II/I

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Analysing

Sixteen Weights Scenarios

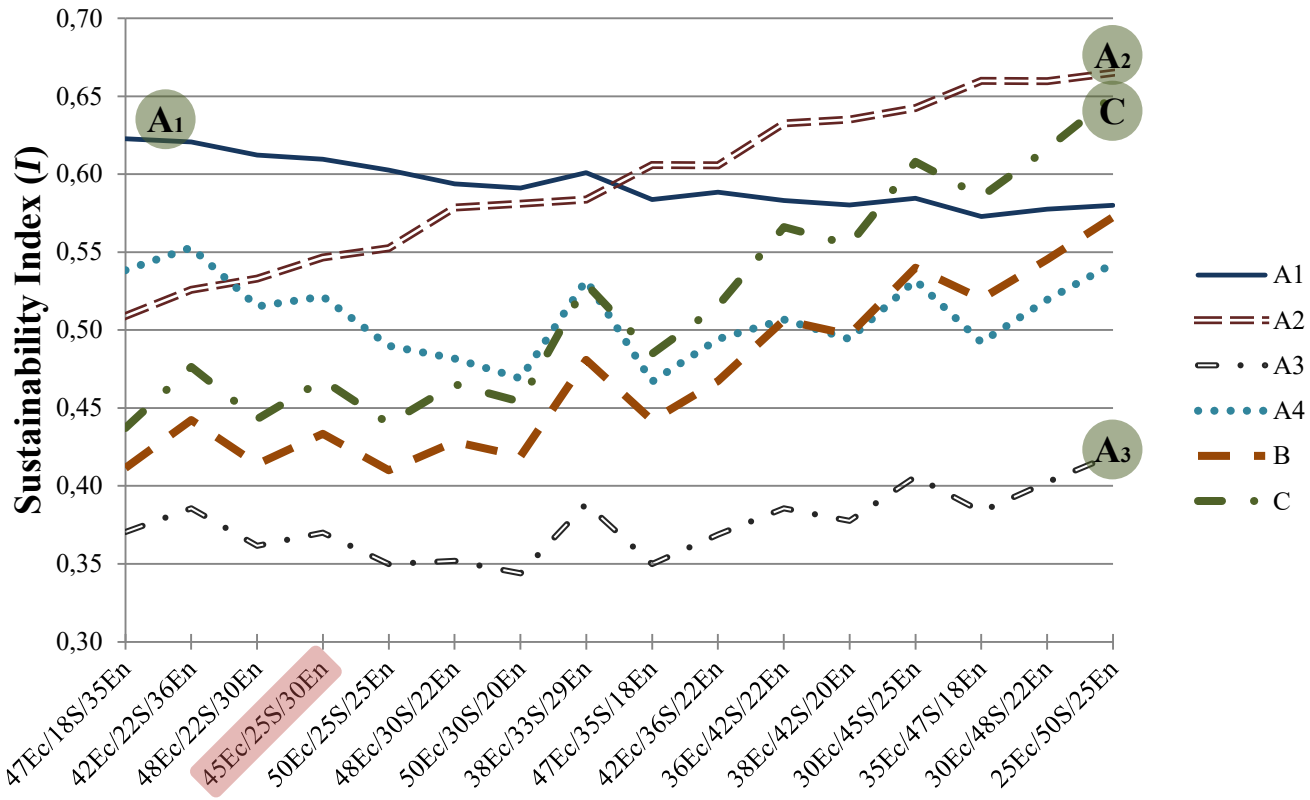

Fig. 7.7. Sustainability indexes of the six alternatives with different requirement weights (economic (Ec), social (S), and environmental (En))

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Analysing

Model Validation

Decision-Making Models

- TOPSIS
- ELECTRE
- SAW

Weight Assignment system

- Shannon's Entropy (SE)
  - (SE/W)
  - (SE/NW)

Ranking \ Method	MIVES (AHP)	MIVES (SE/NW)	TOPSIS (SE/NW)	TOPSIS (SE/W)	ELECTRE (SE/NW)	ELECTRE (SE/W)	SAW (SE/NW)	SAW (SE/W)	Total Results
1	A_1	A_2	A_2	A_1	A_1	A_1	A_1	A_1	A_1
2	A_2	A_1	A_1	C	A_2	A_2	A_4	A_4	A_2
3	A_4	A_4	A_4	A_2	A_4	A_4	A_2	A_2	A_4
4	C	C	A_3	A_4	C	C	C	C	C
5	B	B	B	A_3	B	B	B	B	B
6	A_3	A_3	C	B	A_3	A_3	A_3	A_3	A_3

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Multi-criteria Decision-Making Method for Sustainable Site Location of Post-Disaster Temporary Housing in Urban Areas

Hosseini, S., de la Fuente, A., and Pons, O. (2016). "Multicriteria Decision-Making Method for Sustainable Site Location of Post-Disaster Temporary Housing in Urban Areas." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0001137, 04016036.

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II/I

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Operational

Site Location Selection II

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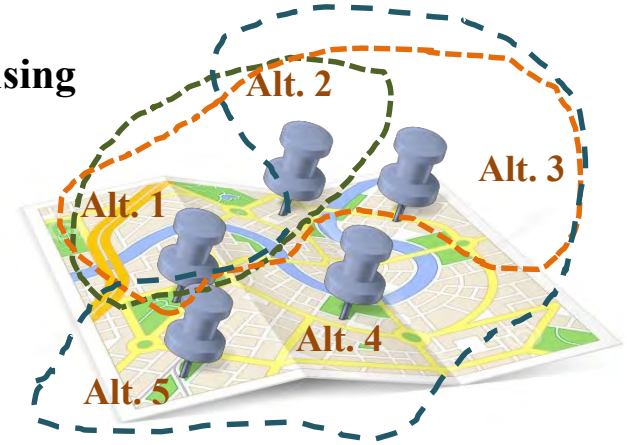
Set of Sites Location for Temporary Housing

Individual Site(s) ✓

Set(s) of Sites ?



$\sum_1^j An = X$ **(Demanded Area)** + **Maximum Sustainability Index**

{ Alt. 1, Alt. 2}

{ Alt. 1, Alt. 3, Alt. 4}

{ Alt. 2, Alt. 3, Alt. 4, Alt.5}

This chapter aims to provide a **platform** to assist decision-makers to determine **most sustainable alternative set(s) of sites** among wide range of **possibilities**.

Set of sites, whose **total area** is **equal** or **close** to the **required area**, with **maximum sustainability index**.

II/II

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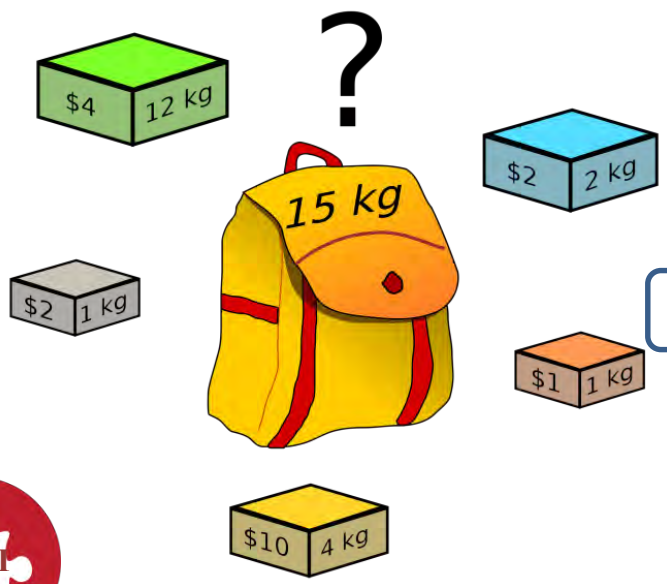
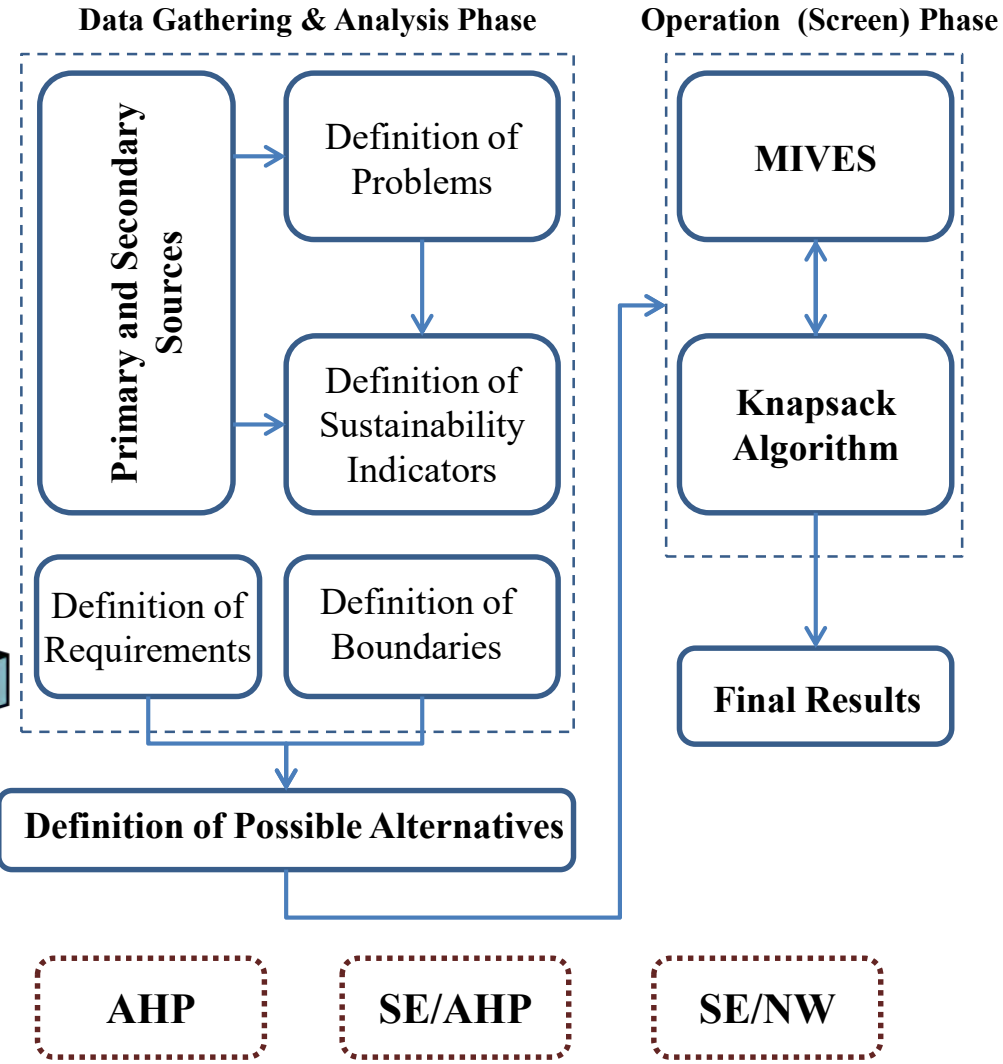
Methodology

MIVES

Knapsack





Site Location Selection

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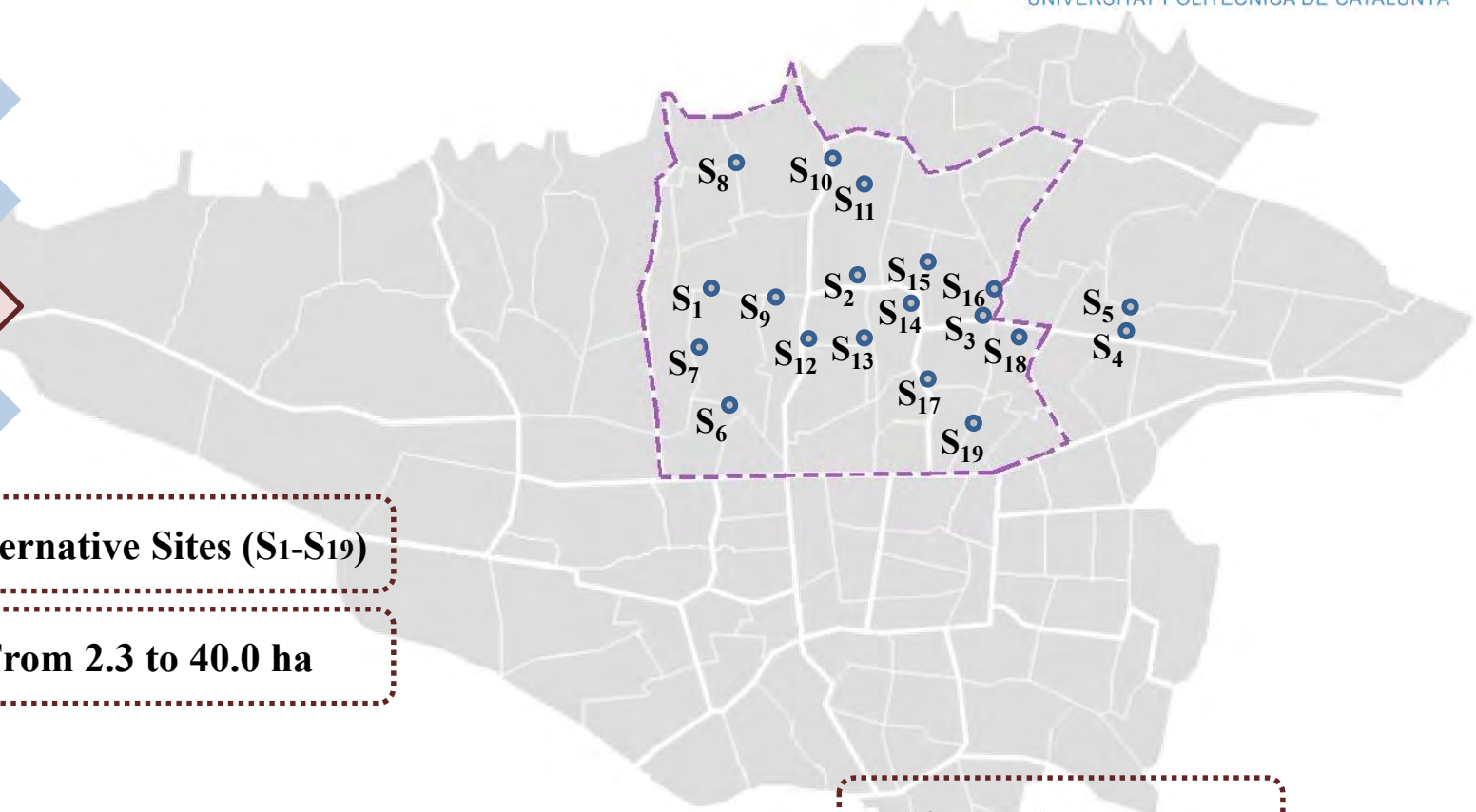

Nineteen Alternative Sites (S_1-S_{19})

Areas : From 2.3 to 40.0 ha

Knapsack

50 ha ≤Area< 55 ha

Sustainability Index

MIVES

II/II

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Results

Weight System	AHP	SE/AHP	SE/NW
	A	B	C
Set	S_2, S_4, S_5, S_6, S_{17}, S_{18}, S_{19}	S_3, S_4	S_2, S_3
SI	0.52	0.60	0.69

Subset	A	B	C	A	B	C	A	B	C
weights	AHP	AHP	AHP	SE/AHP	SE/AHP	SE/AHP	SE/NW	SE/NW	SE/NW
SI	0.52	0.41	0.37	0.56	0.60	0.55	0.49	0.66	0.69

II/II

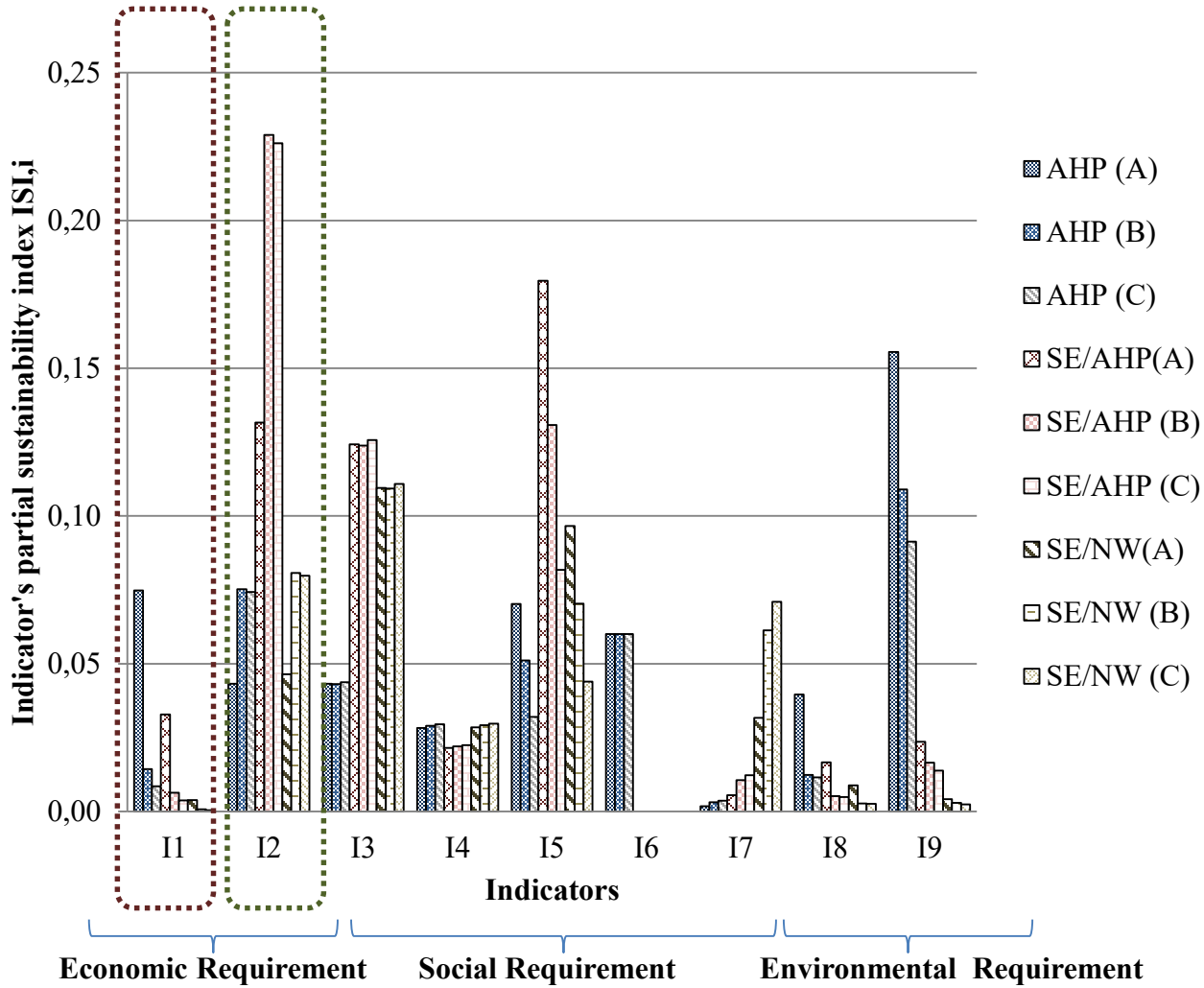

Fig. 8. 3. Partial sustainability indexes of the indicators by considering weights of criteria and requirements based on applying the three methods for the optimal subsets

AHP

SE/AHP

SE/NW

Unreliable

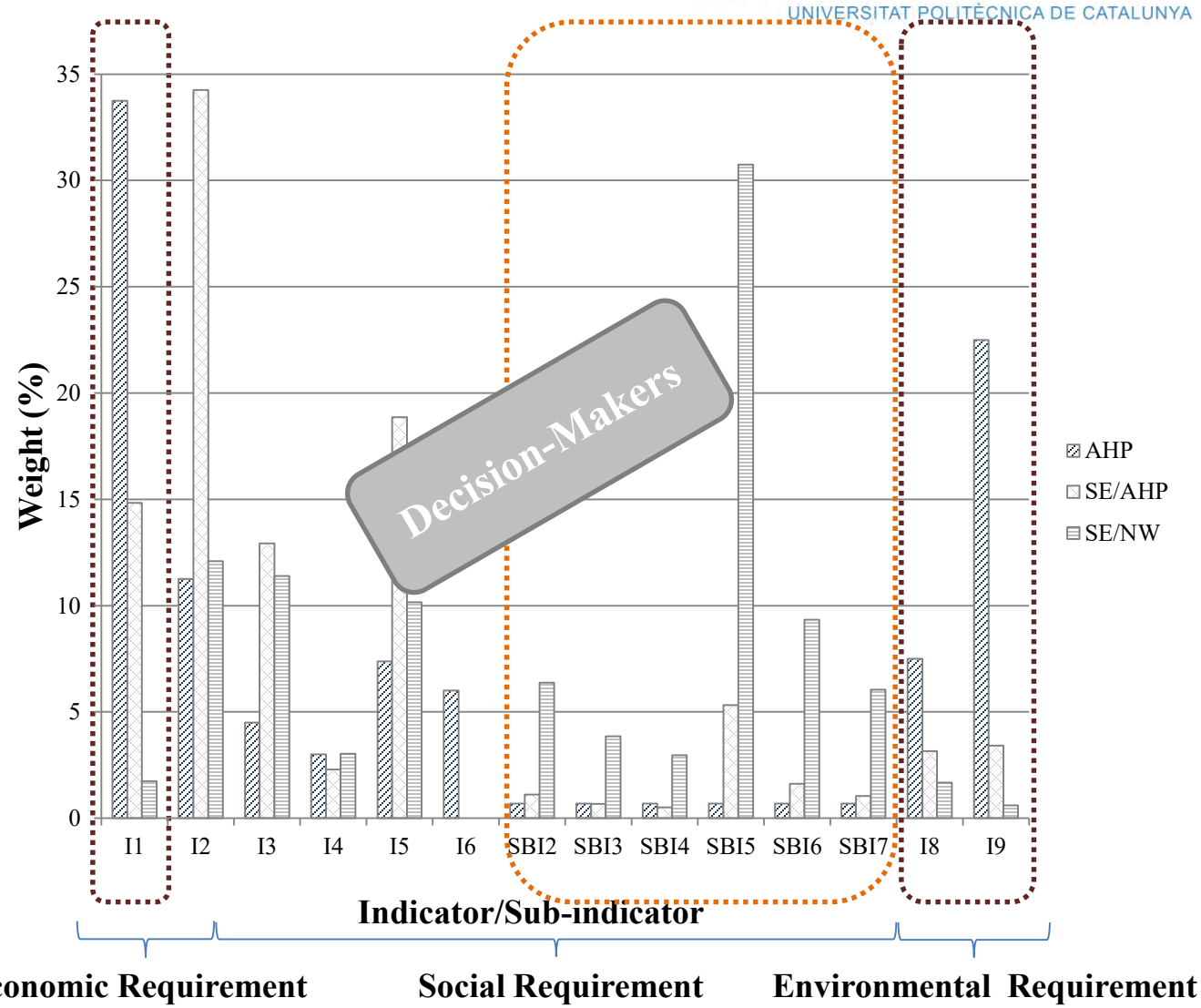

Fig. 8. 5. Assigned weights to the indicators and sub-indicators by the three methods

Sensitivity Analyze

Twenty-eight Requirements' Weighting Distributions → Economic / Social / Environmental → Diverse Sets

AHP

SE/AHP

S_2, S_4, S_5, S_6, S_{17}, S_{18}, S_{19}

S_3, S_4

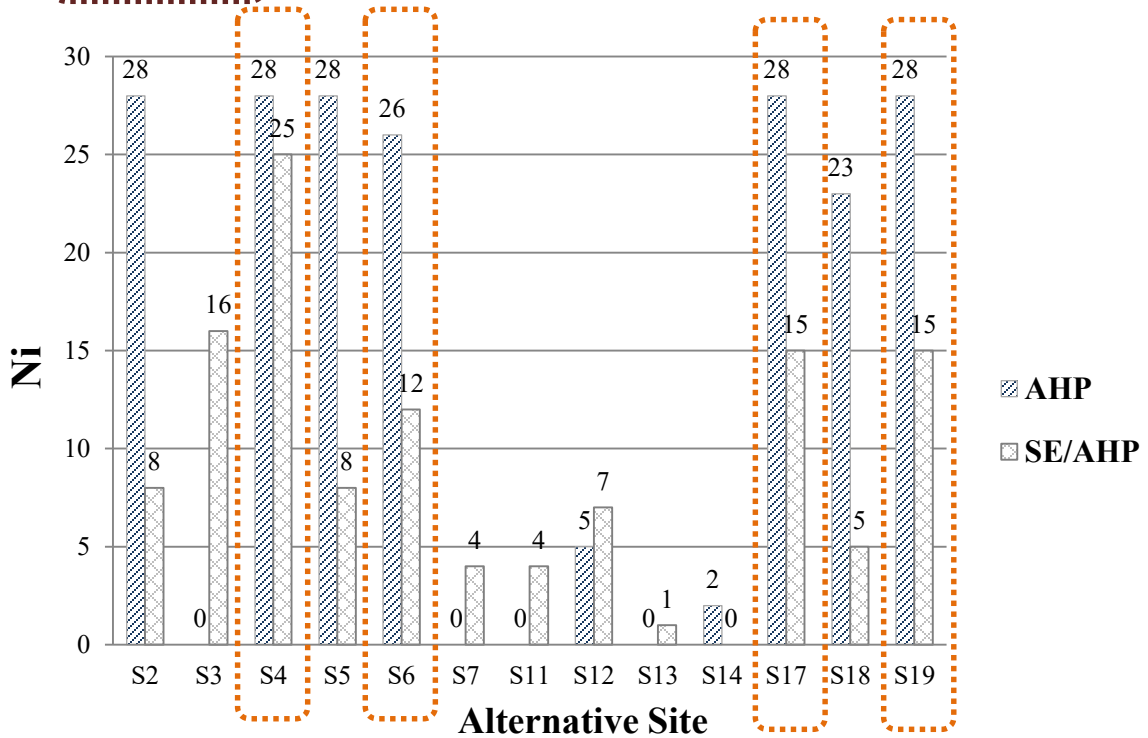

Fig. 8. 6. Frequency of each site (Ni) depending on the weighting technique

Sensitivity Analyze

Twenty-eight Requirements' Weighting Distributions

AHP

SE/AHP

Economic

Social

Environmental

Diverse Sets

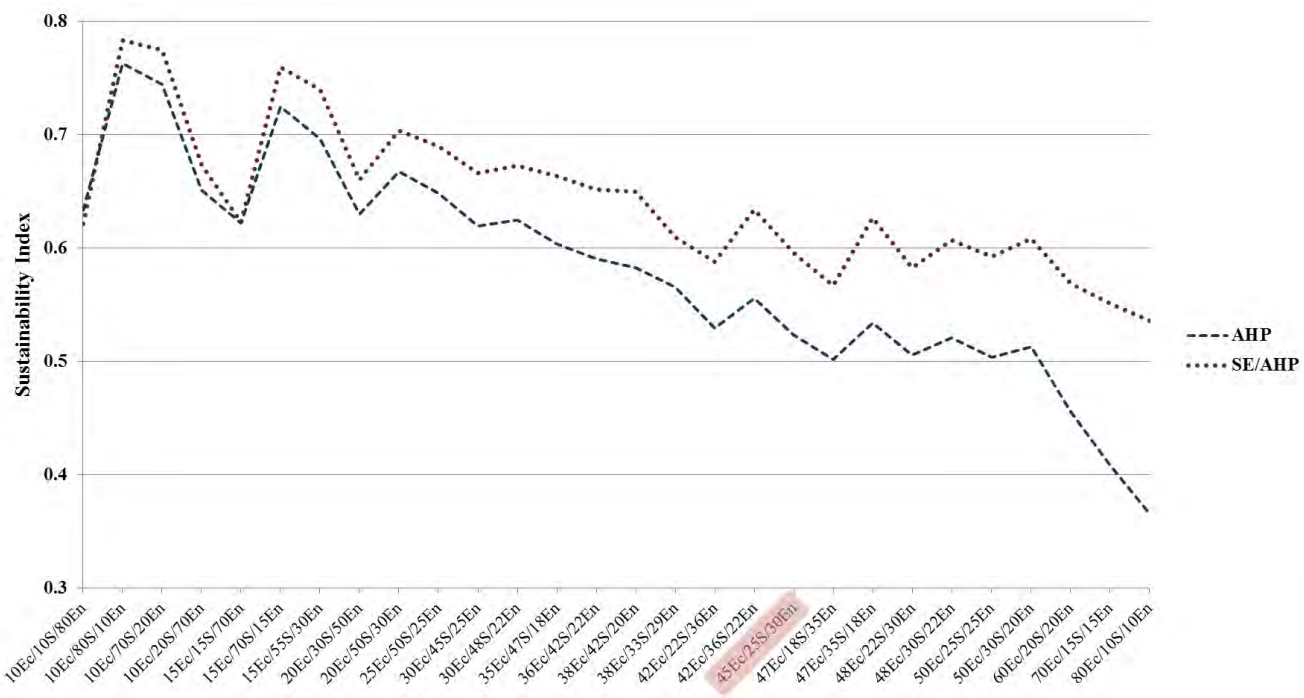

Fig. 8. 7. Sustainability indexes of the chosen subsets by AHP and SE/AHP based on twenty-eight weights scenarios

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UNIVERSITAT POLITÈCNICA DE CATALUNYA

A Combination of Knapsack Algorithm and MIVES for Choosing Optimal Complex of Temporary Housing Sites Location: A Case Study Tehran

Hosseini, S. M. A., Pons, O, and de la Fuente, A.,

Journal of Building and Environment

Departament d'Enginyeria de la Construcció
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Operational

Temporary Housing Units Selection

Housing Units Selection

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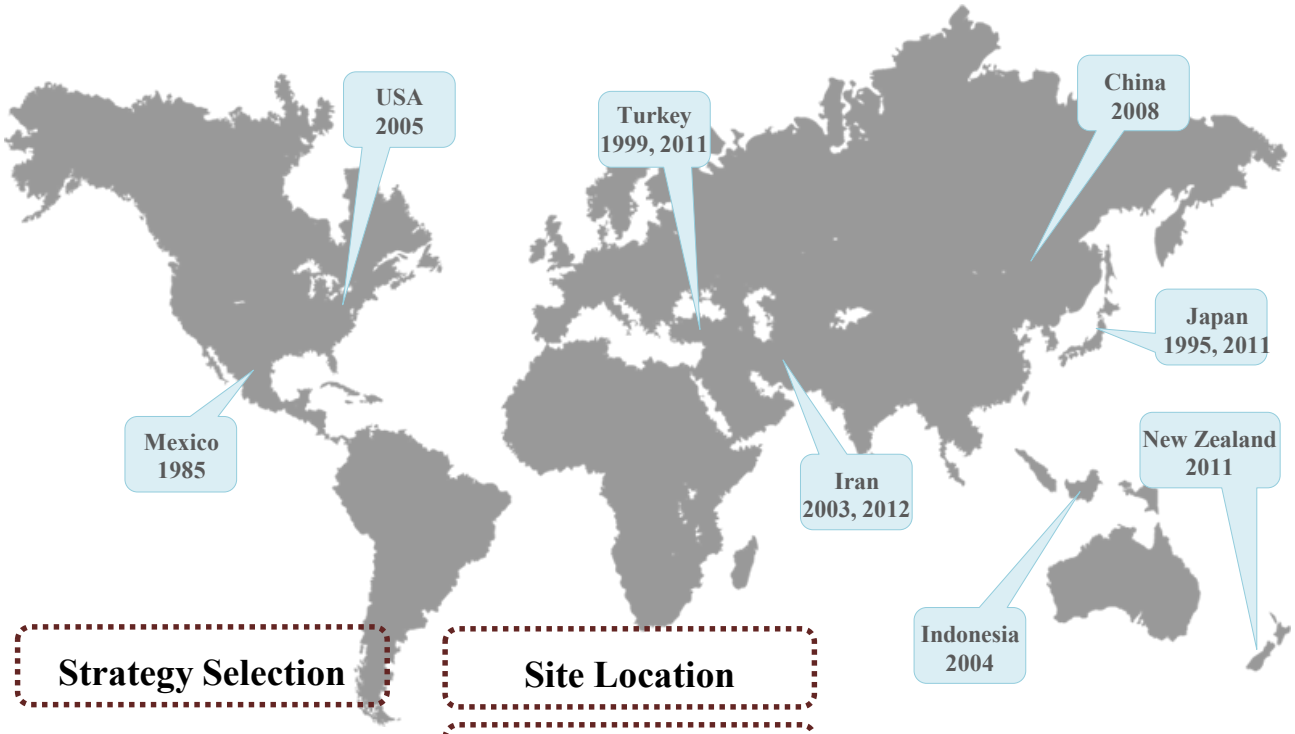

Strategy Selection

Site Location

Housing Units

The **objective** of this chapter is to present a model for selecting the optimized temporary housing unit technology by considering local characteristics and sustainability.

III

Housing Units Selection

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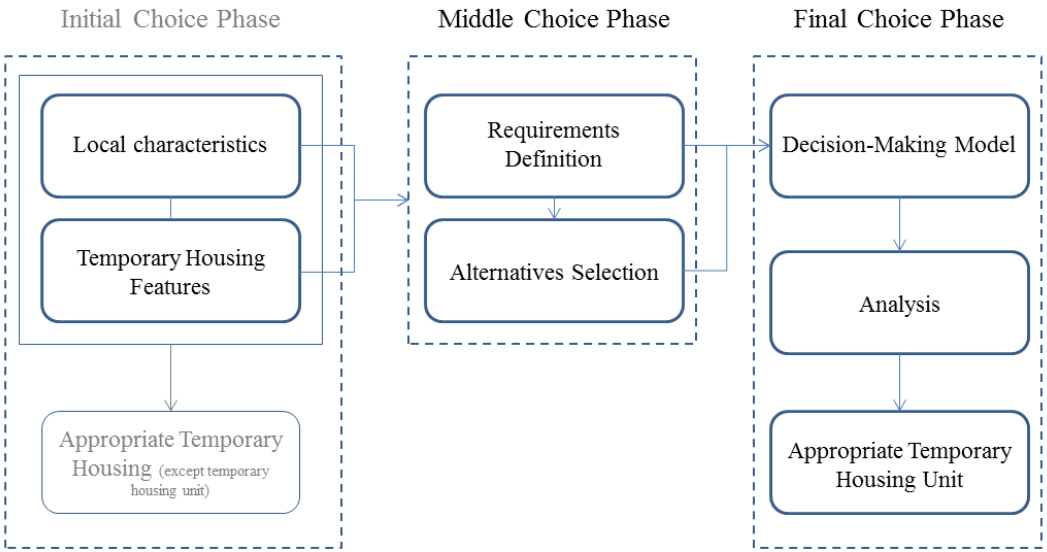
- Introduction
- Descriptive
- Operational
- Conclusion

Methodology

MIVES



Bam Temporary Housing Units

Bam Earthquake 2003 → **75,000 Displaced People**

A total of 35,905 Units

Housing Foundation of Islamic Republic of Iran (HFIR) — **26,900 Units on Private Properties**

Ministry of Defence — **9,005 in 23 Camps**

Housing Units Selection

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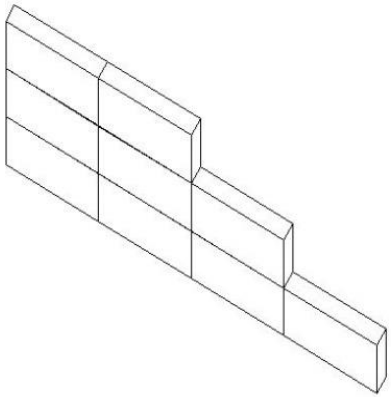
Bam Temporary Housing Units

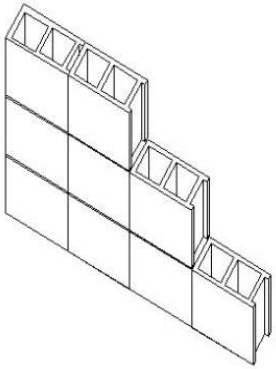
Eight Alternatives

Four Walls

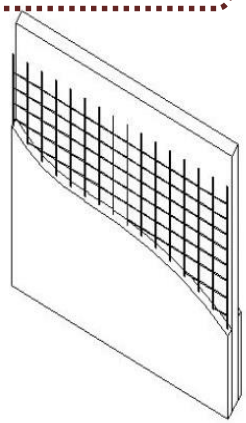
Two Roofs



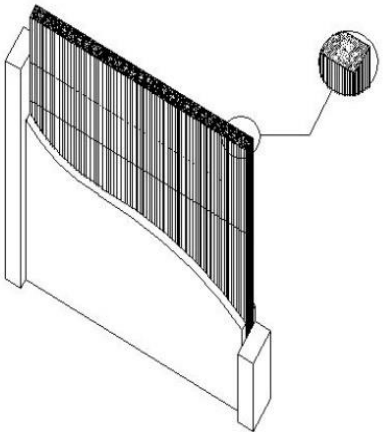
Autoclaved Aerated Concrete Block (AAC Block)



Concrete Masonry Unit (CMU)



3D Sandwich Panel (3D)



Pressed Reeds Panel (PR)

Galvanized Iron Sheets, 2 cm

Corrugated Galvanized Iron, 4 cm

Housing Units Selection

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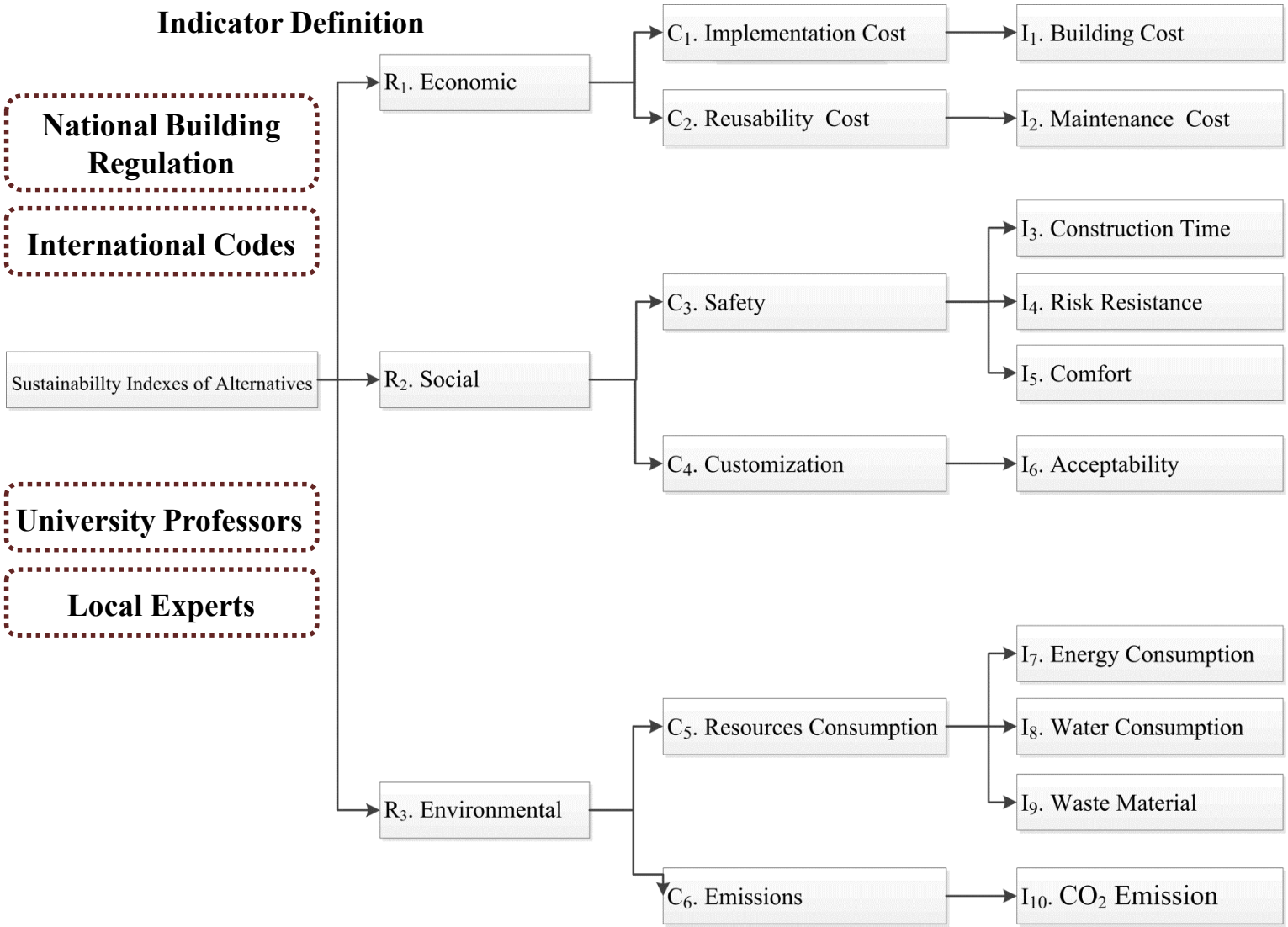
Indicator Definition



Housing Units Selection

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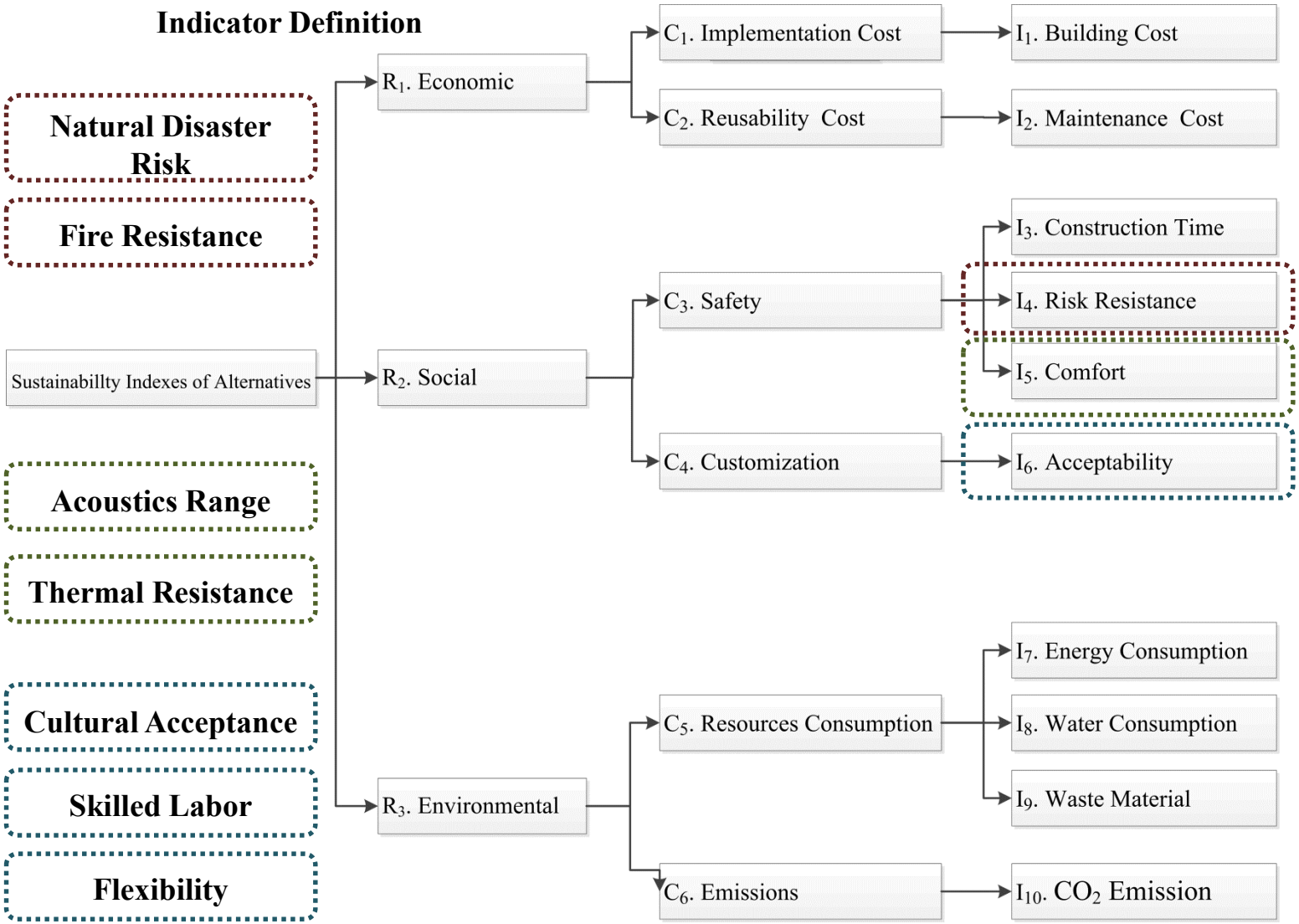
Indicator Definition



Housing Units Selection

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- Introduction
- Descriptive
- Operational
- Conclusion

AHP

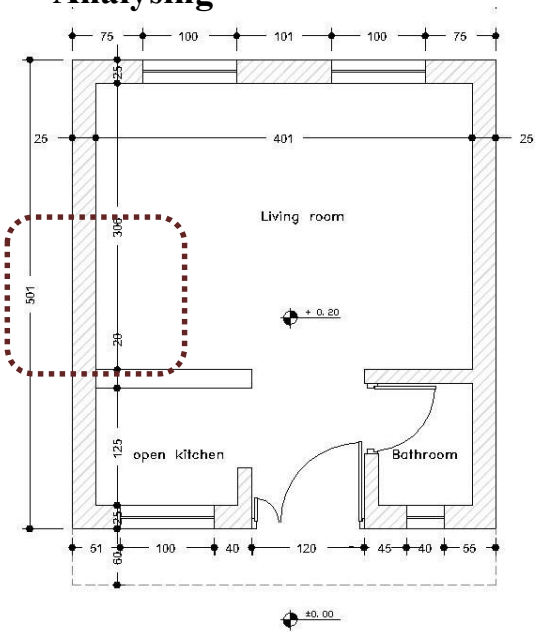
Seminar

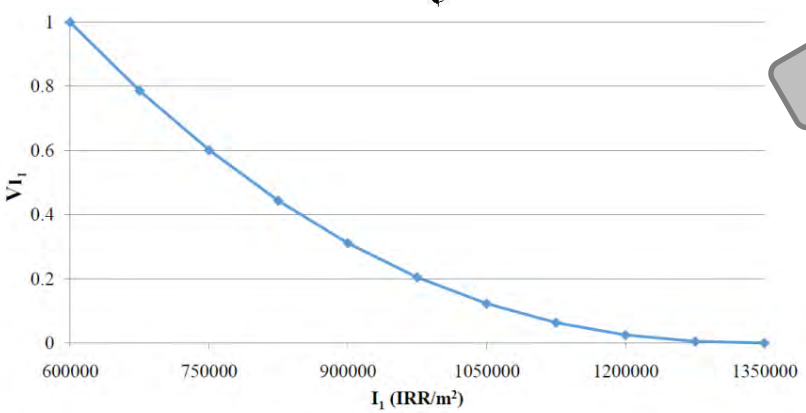
University Professor

HFIR's Expert

III

Analysing





Sustainability Index

Technology Characteristics

Partitions

Mortar

Core

Materials (Components)

Mesh

CO_2 Emissions

Thermal Resistance

Building Cost

Construction Time

Acoustic Range

Parameters

Fire Resistance

Waste

Thermal Resistance

Others

Value of Indicators

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Result

	I	V_{R1}	V_{R2}	V_{R3}	V_{C1}	V_{C2}	V_{C3}	V_{C4}	V_{C5}	V_{C6}
AAC	0.50	0.76	0.39	0.20	0.74	0.87	0.43	0.34	0.25	0.11
CMU	0.53	0.62	0.39	0.49	0.63	0.59	0.29	0.55	0.48	0.51
PR	0.53	0.55	0.19	0.79	0.55	0.52	0.21	0.15	0.74	0.9
3D	0.36	0.28	0.38	0.46	0.32	0.06	0.61	0.02	0.43	0.52

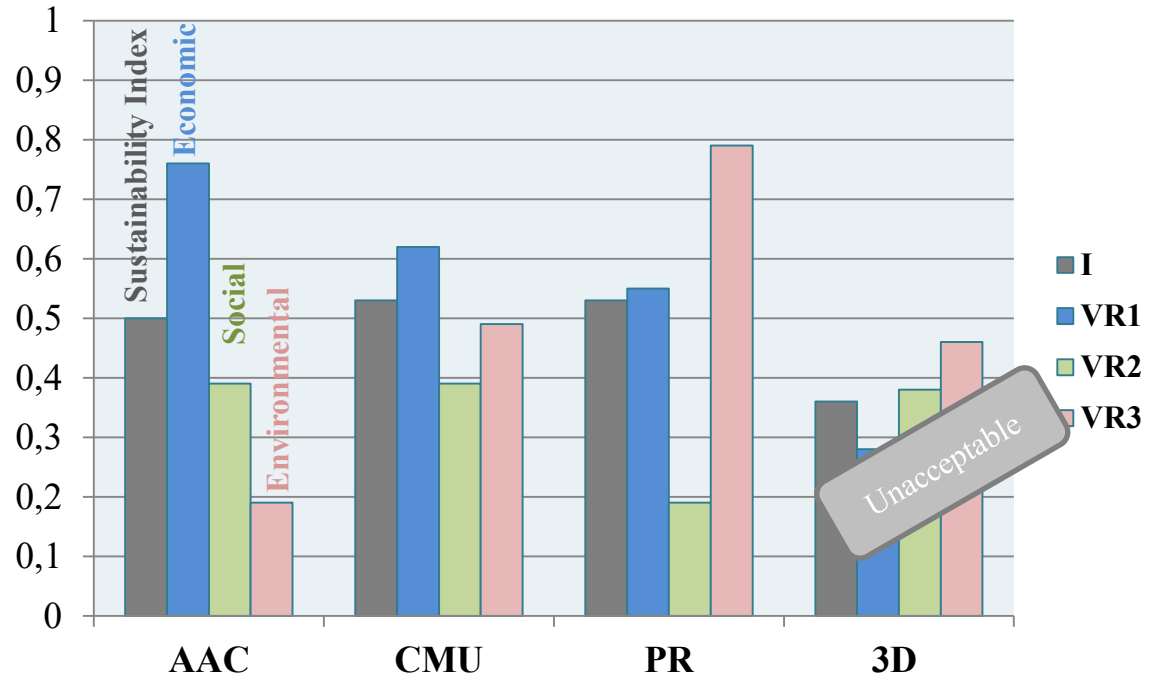

Fig. 9.6. Requirements values for the four alternatives

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Sensitivity Analyze

Environmental Indicator Assessment

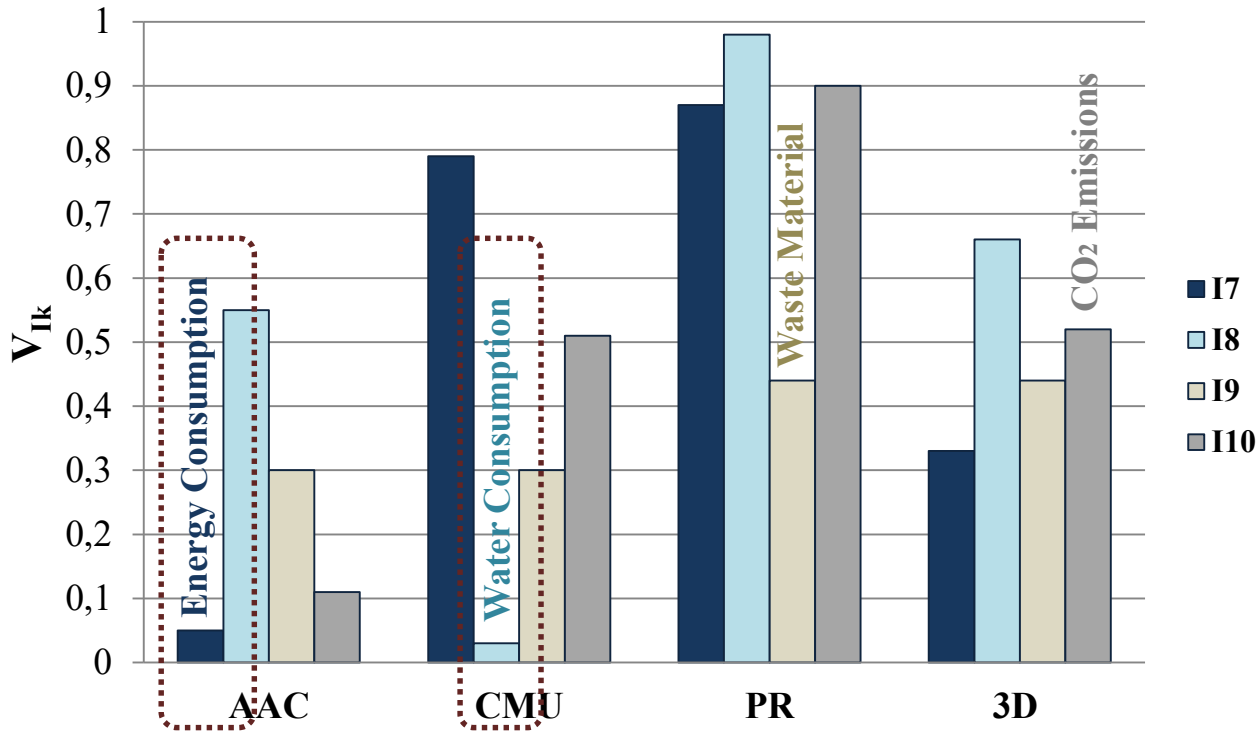

Fig. 9.7. Environmental indicator values for the four alternatives

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Sensitivity Analyze

Environmental Indicator Assessment + CMU PR Sixteen Requirements' Weighting Distributions

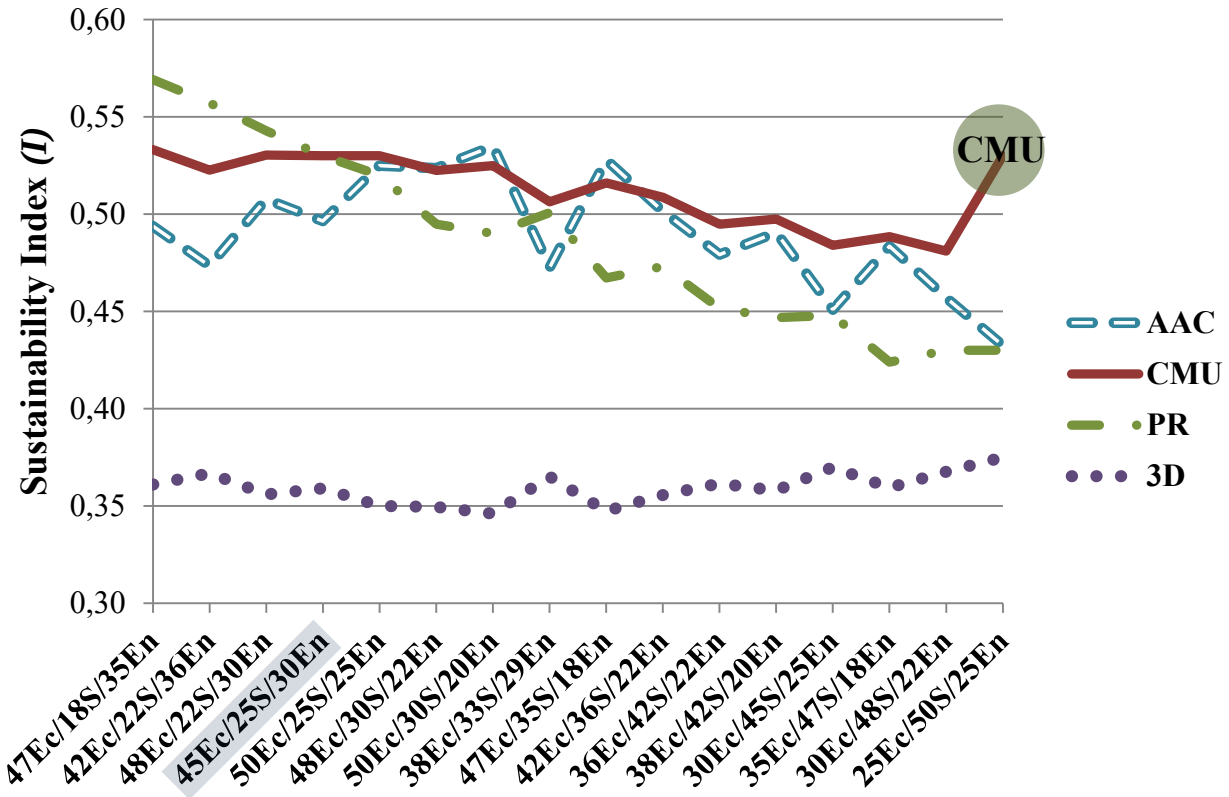

Fig. 9.8. Sustainability indexes of the four technologies with different requirement weights (economic (Ec), social (S), and environmental (En))

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Multi-criteria decision-making method for assessing the sustainability of post-disaster temporary housing units technologies: A case study in Bam, 2003

Hosseini, SM Amin, Albert de la Fuente, and Oriol Pons. "Multi-criteria decision-making method for assessing the sustainability of post-disaster temporary housing units technologies: A case study in Bam, 2003." *Sustainable Cities and Society* 20 (2016): 38-51.

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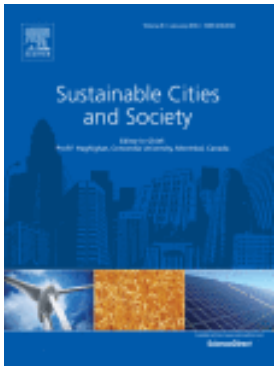
Volume 20, January 2016, Pages 38–51



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Conclusion

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Main Conclusions

General Model

A new conceptual model oriented to select the sustainability of post-disaster temporary housing strategy alternatives

Unit Selection

A new model to assess the sustainability of post-disaster Temporary housing units

Site Selection

A new model to support decision-makers in choosing site locations for post-disaster temporary housing unit

Set Selection

A new model to assist decision-makers in choosing set of site locations for post-disaster temporary housing unit

Designed Models Conclusions

To make a **proper decision** it is required to **detect problems**, define **possible responses**, determine **all characteristics** of responses based on **different conditions** without prejudice.

Sites that had **other functions prior** to selection and already had facilities could achieve **higher sustainability indexes**.

The **assigned weights** by different techniques had **considerable impacts** on choosing **optimal alternatives** for TH. Therefore, it is required to consider **stakeholders concerns** about **priorities** of **indicators** by involving all experts in this process.

However, **some technologies** seems **unsuitable** alternatives for temporary housing units at first glance. These could obtain the **highest sustainability index** due to other parameters.

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Specific Conclusions

A **direct relationship** between **stakeholder's satisfaction** and the **local initial** conditions is **difficult** to be established.

Site location of all post-disaster accommodation types in general has **substantial impacts** on economic, social, and environmental aspects, even more than units technologies.

Some parts of **TH issue**, have been formed based on some **myths** and **prejudices** that need to be assessed with pinpoint accuracy in order to **realize truths**, as some studies have done.

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Future Perspective

Ongoing Research

Combination of **MIVES** and **GIS** to determine **initial stages site locations**.

Combination of **MIVES** and **knapsack** to consider suitable **distribution** of displaced population in **rental units**.

Continuous Research Line

Analysing the **suitability** of **conventional residential buildings** based on the **core-housing concept**

Analysing the **decision-making models**, especially **weight assignment system** to increase **adaptability** of models to this issue.

Analysing the **impacts** of **shape**, **form**, and **area** of temporary housing **units** on **sustainability index**.

Thanks for Your Attentions

Muhammed Muheisen/AP

Barcelona, September 2016

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Annex

Natural Disaster

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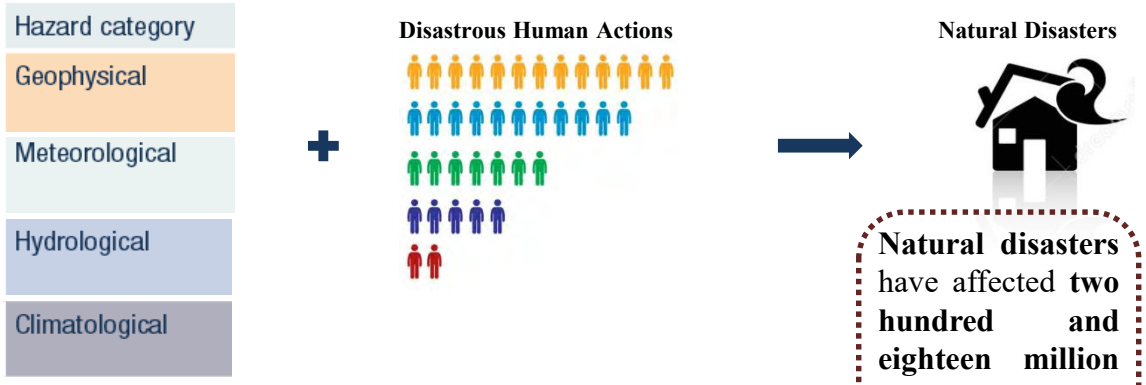
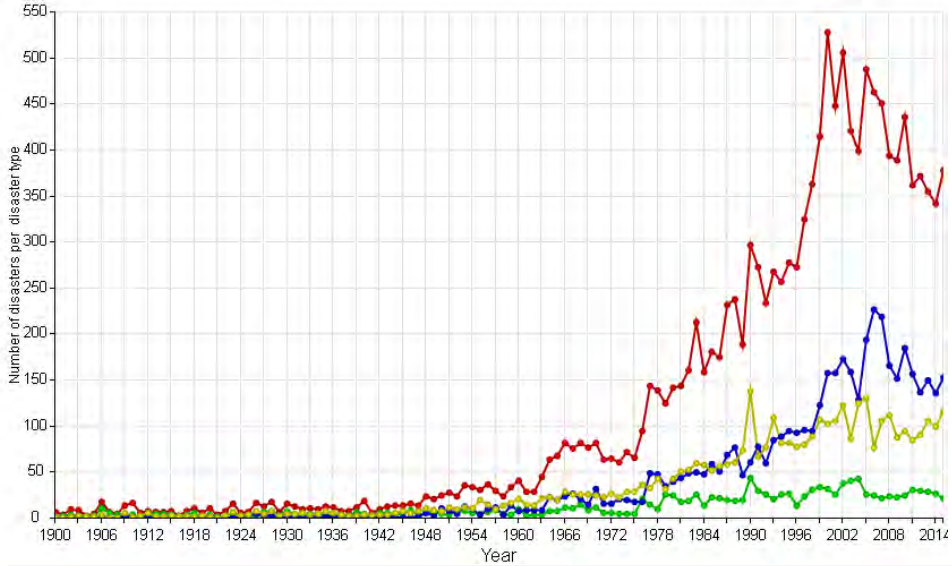
What is a natural disaster?

Natural disasters are caused by a complex combination of natural hazards and disastrous human actions (Blaikie et al. 2014)



Natural disasters have affected **two hundred and eighteen million people** each **year** on average between 1994 and 2013 (The Centre for Research on the Epidemiology of Disasters (CRED) 2015).



Source: EM-DAT

Urban Area Characteristics

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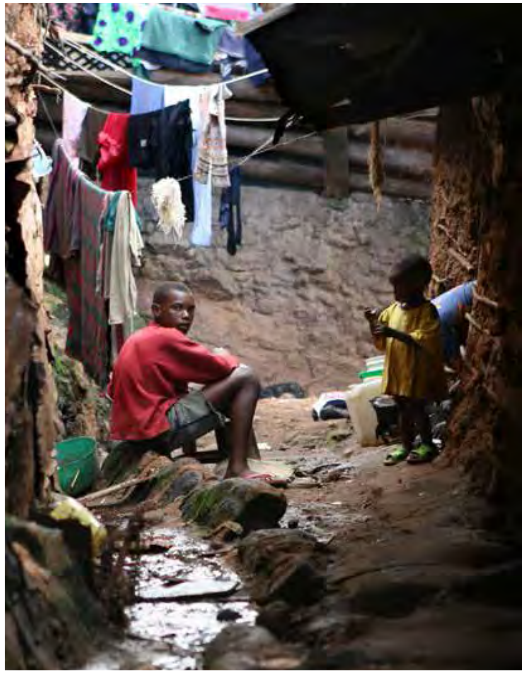
Why is necessary to consider urban and rural areas individually?

- High Density
- Land Scarcity
- Land Price
- Displaced Population Abilities and Requirements
- Slums

There are around **one billion people** living in **slums**, largely in **developing countries** (nearly one-third of all city-dwellers in developing countries) (UNHABITAT).

Lack of statistics

Unsuitable shelters quality



Source: Julius Mwelu / UN-Habitat

Urban slum population at mid-year by region (thousands)

Region	1990	1995	2000	2005	2007	2010	2014
Developing Regions	689,044	748,758	791,679	830,022	845,291	871,939	881,080
Northern Africa	22,045	20,993	16,892	12,534	13,119.1	14,058.3	11,418
Sub-Saharan Africa	93,203	110,559	128,435	152,223	163,788	183,199	200,677
Latin America & the Caribbean	106,054	112,470	116,941	112,149	112,547	112,742	104,847
Eastern Asia	204,539	224,312	238,366	249,884	250,873	249,591	251,593
Southern Asia	180,960	189,931	193,893	195,828	196,336	195,749	190,876
South-eastern Asia	69,567	75,559	79,727	80,254	79,568	84,063	83,528
Western Asia	12,294	14,508	16,957	26,636	28,527	31,974	37,550
Oceania	382	427	468	515	534	563	591

Source: UN-Habitat, Global Urban Observatory Urban Indicators Database 2015

Sustainability Problem

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Construction Industry

- **consumes 24% of the raw material** (Bribia et al. 2009)
- **more than 30%** of all annual range of **green gas emissions** (Sbci UNEP 2009).
- **consumes the 40%** of the **global energy consumed** (Sbci UNEP 2009).

+

Natural Hazard

- **Short Time**
- **Huge Amount**

→ **DISASTER**

Negative Effects

Economic, Social, Environmental

Temporary Housing Characteristics

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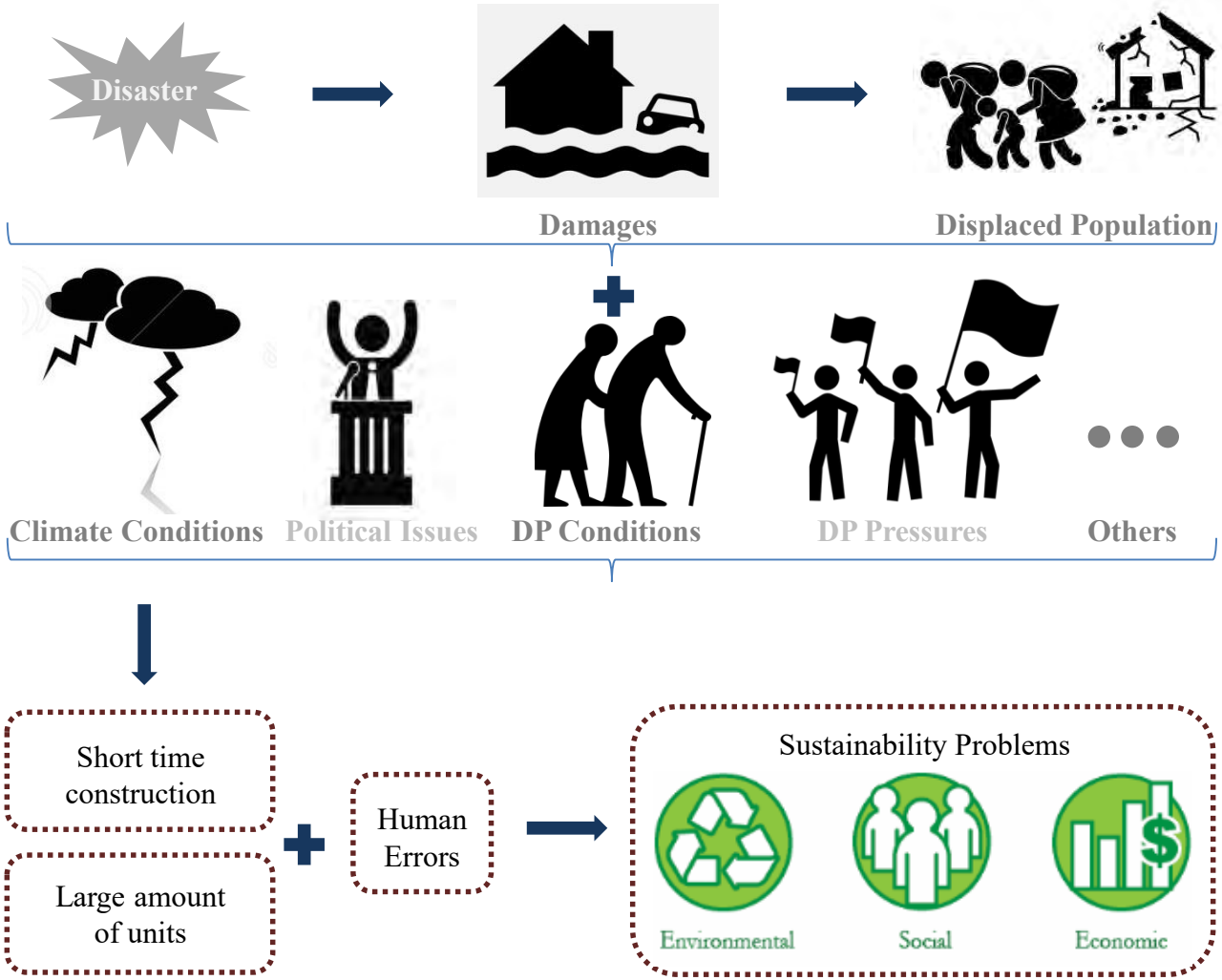
What are main reasons of Post-disaster housing problem?



Temporary Housing Characteristics

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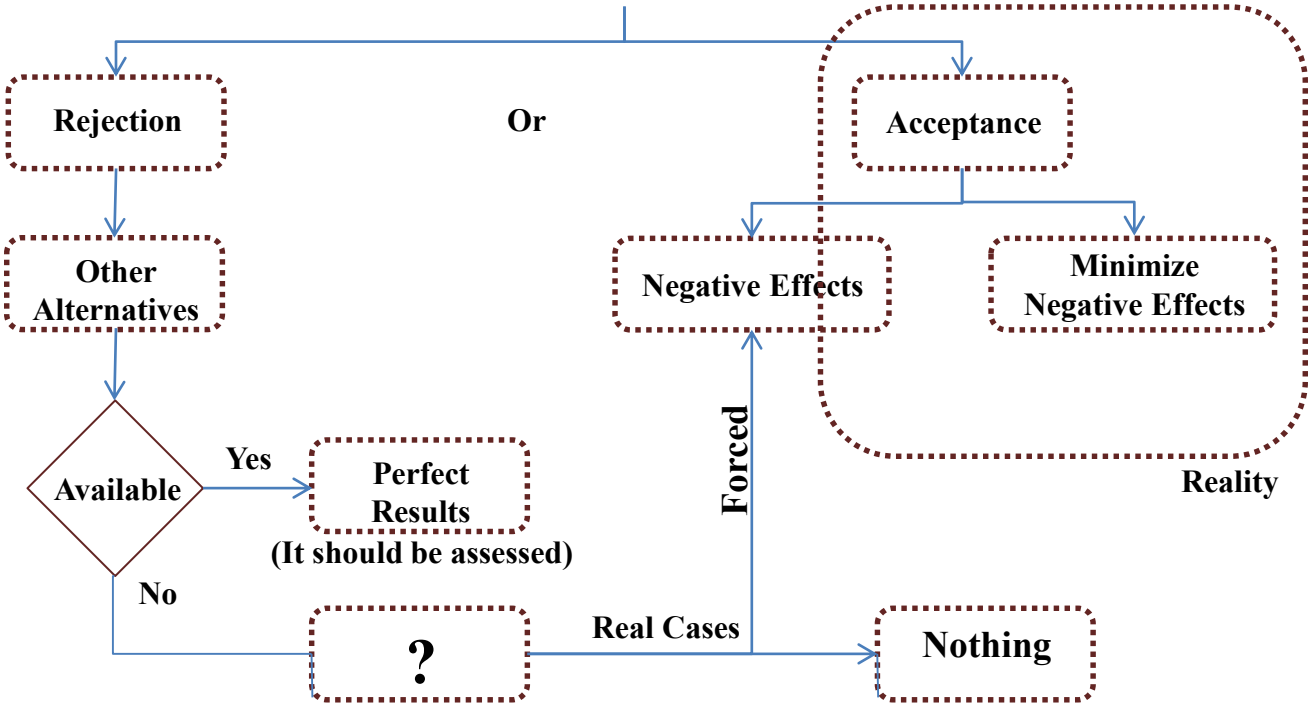
What is the strategy of emergency managers to deal with the mentioned problems?



What happens if displaced population does not receive suitable temporary housing?

Displaced population provide **low-quality shelters** for **themselves** as temporary housing (e.g., the Colombian recovery program after the Armenia earthquake, 1999 (Johnson et al. 2006)).

Source : http://saint-germains-children.org

Literature Review

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Twenty-seven researches have been reviewed to determine requirements of the descriptive section.

This literature review is organized into three categories: (1) temporary housing **generic factors**, (2) **sustainability** aspects, and (3) **decision-making models**

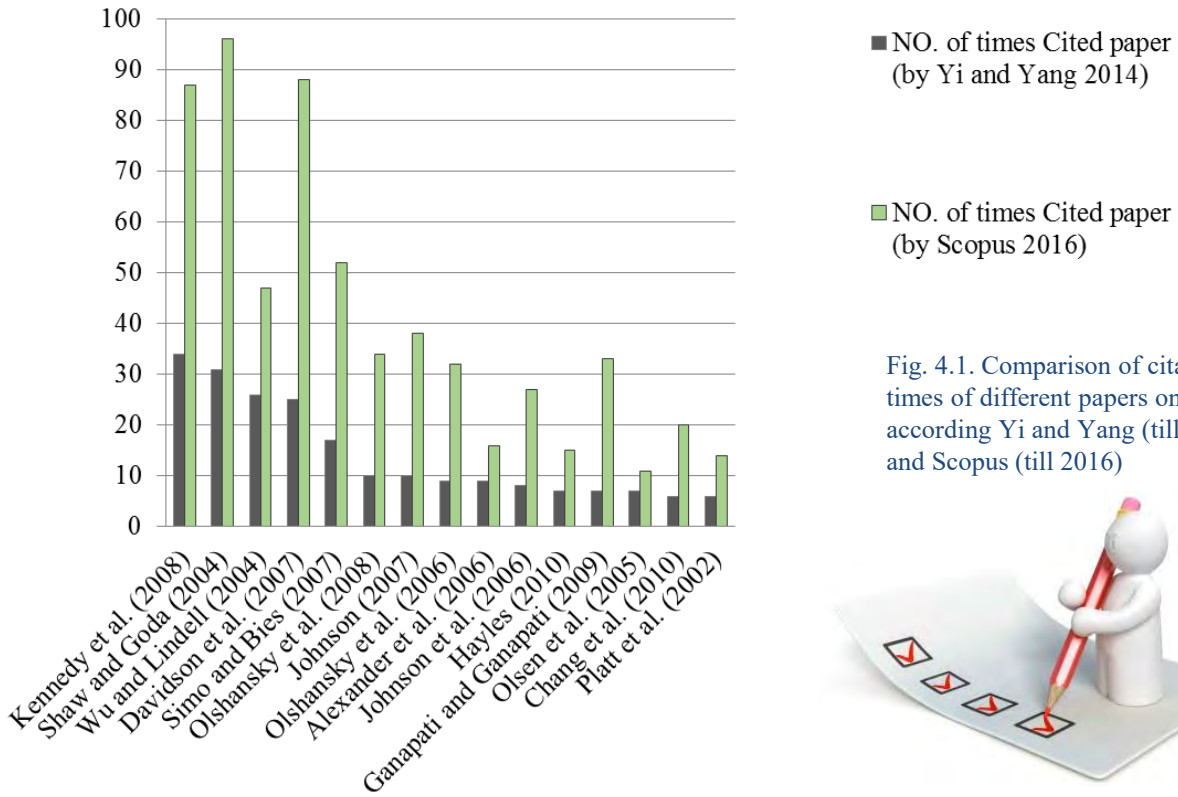

Fig. 4.1. Comparison of citations times of different papers on PDH according Yi and Yang (till 2014) and Scopus (till 2016)

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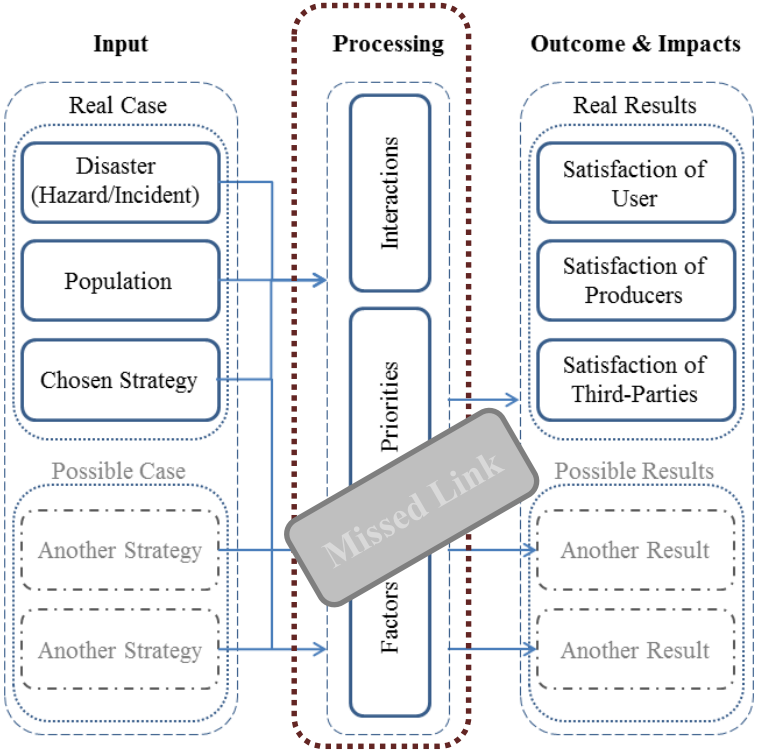
What is a main shortfall in previous relevant studies?

Sustainability — Focus more on **rural** areas not on **urban** areas.

Optimization — Focusing on disaster **management** is higher than **technical** assessment.

The **connection between** a chosen strategy and its outcomes is usually **missed link**.



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- Which are the **main requirements** involved in post-disaster accommodation strategies and the constituents?
- Which are the **differences** between implemented post-disaster accommodation **strategies**?
- What are the **social** and **physical outcomes** of applying each post-disaster accommodation strategy? (**When/Where/How** can each strategy of post-disaster accommodation provision be applied?)

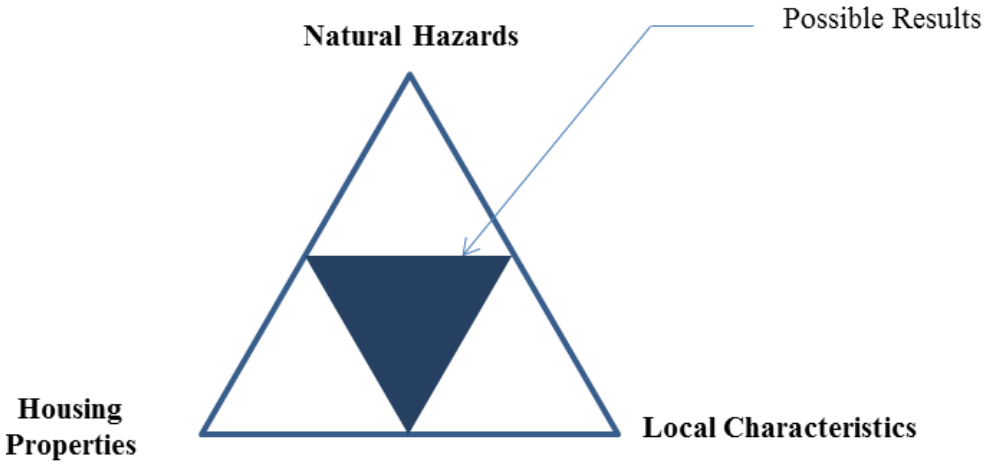

Fig. 3.1. Three main vertexes of post-disaster accommodation

Integrated Approach

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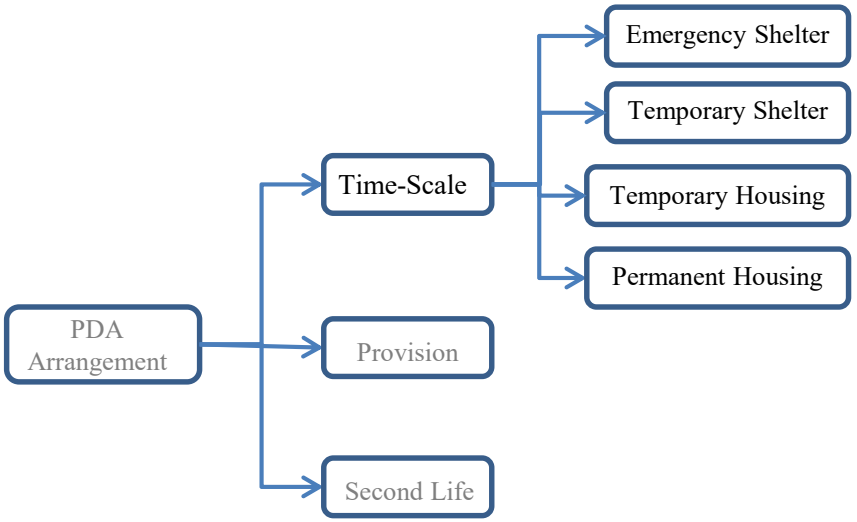
Post-disaster Housing Properties

This section presents post-disaster accommodation arrangement, which includes: the **time-scale**, **provision**, and **second life** of temporary housing.

Time-Scale | **Provision Styles** | **Second Life**

Time-Scale

Some accommodations have the ability to be used for different housing recovery stages, such as: tents or winterized tents, which can be applied for emergency shelter, temporary shelter, and TH phases.



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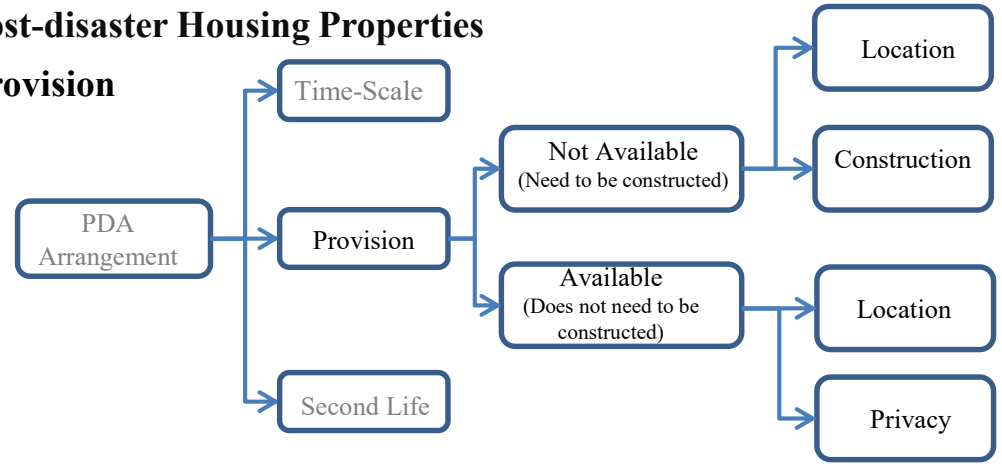
Post-disaster Housing Properties Provision



Site Location

The social problems due to an **unsuitable location** normally happen when the displaced population is forced to move to other areas, because according to (Davis 1978; Johnson 2002), displaced population prefers to live close to the previous properties, communities, and activities (Aquilino 2011; Johnson 2002).

Site selection is a process that involves many steps from planning to construction, consisting of an initial inventory, alternative analysis, assessment, detailed design, and construction procedures and services (Kelly 2010).

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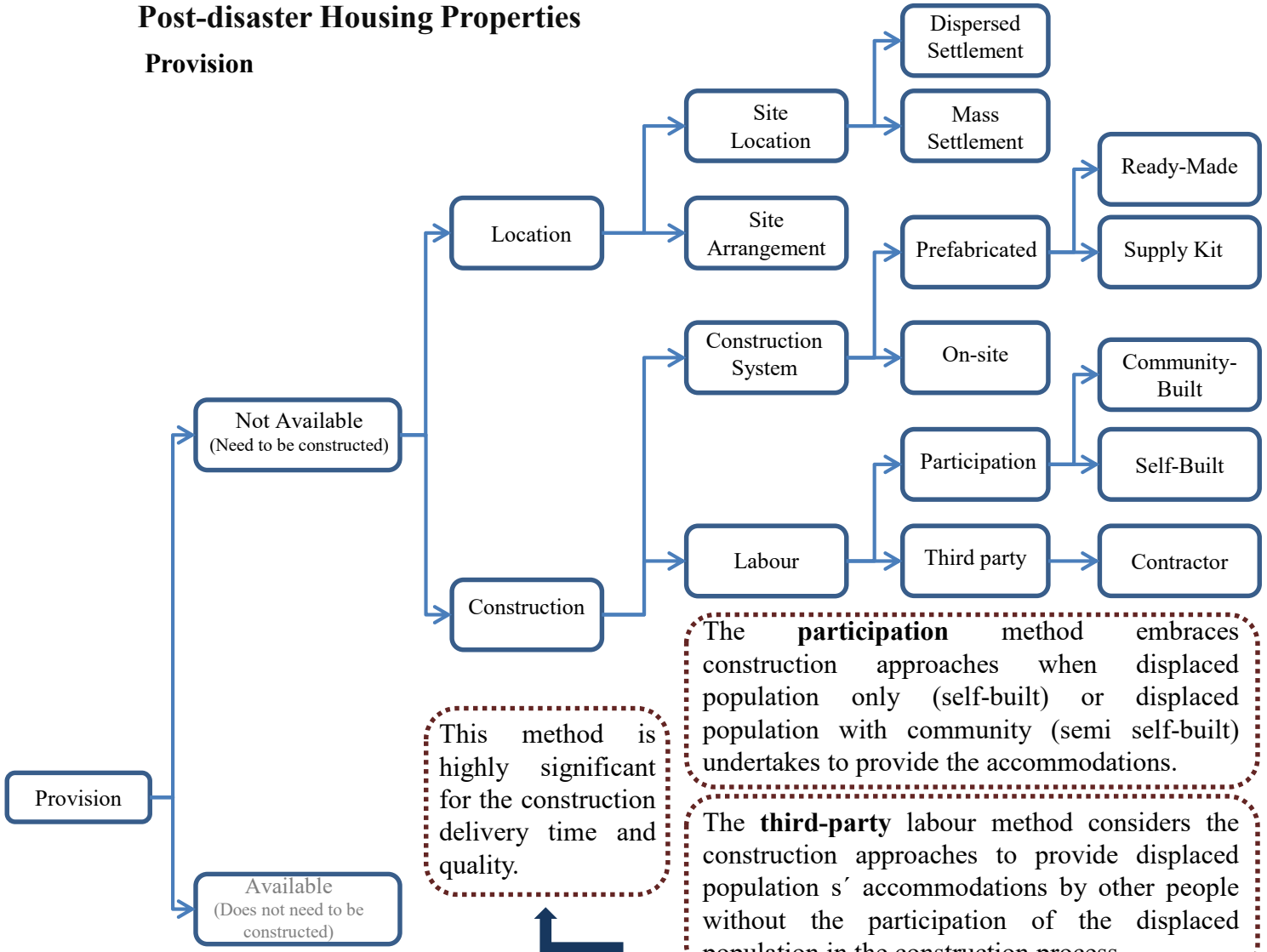
Post-disaster Housing Properties

Provision



This method is highly significant for the construction delivery time and quality.

The **participation** method embraces construction approaches when displaced population only (self-built) or displaced population with community (semi self-built) undertakes to provide the accommodations.

The **third-party** labour method considers the construction approaches to provide displaced population s´ accommodations by other people without the participation of the displaced population in the construction process.

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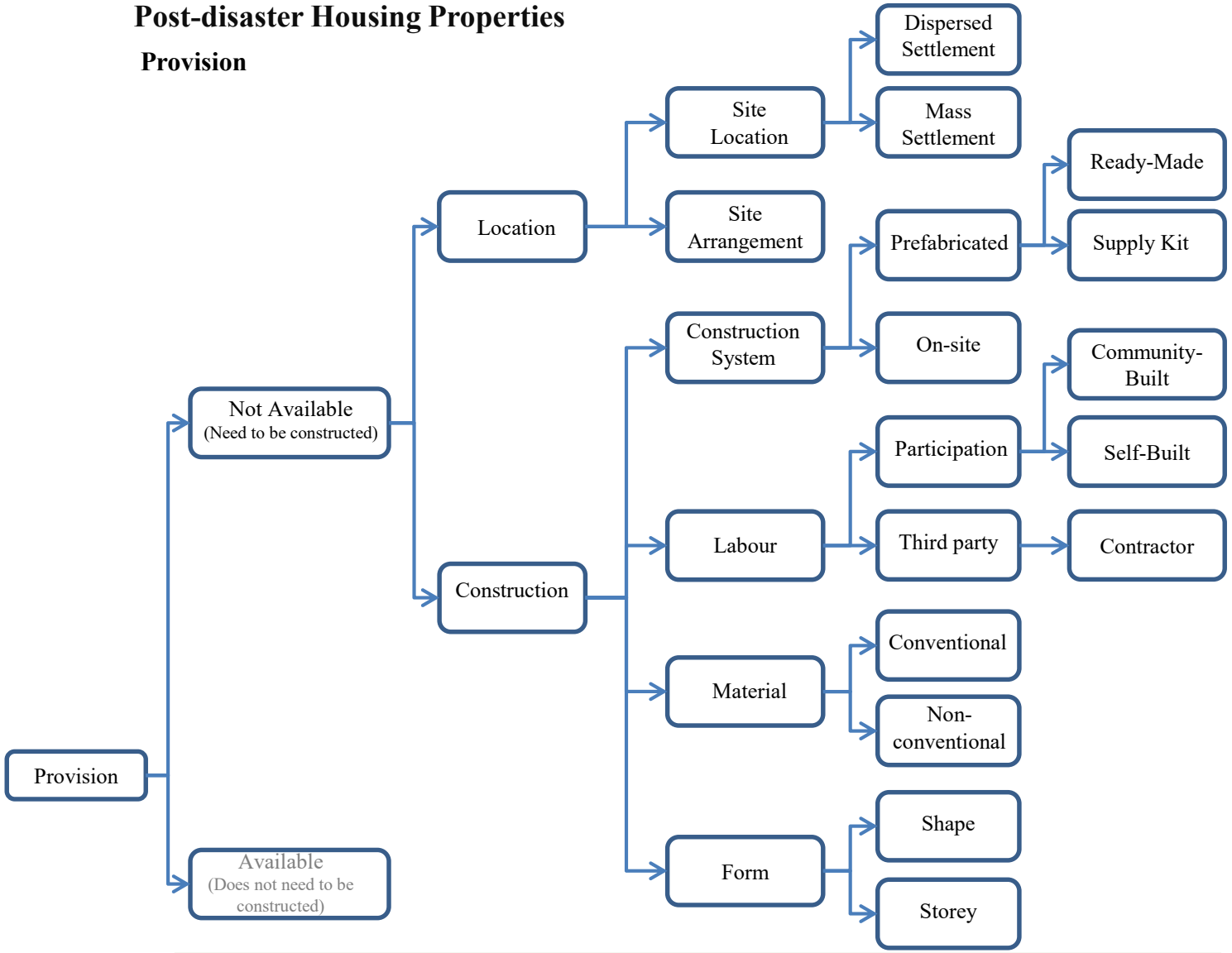
Post-disaster Housing Properties

Provision



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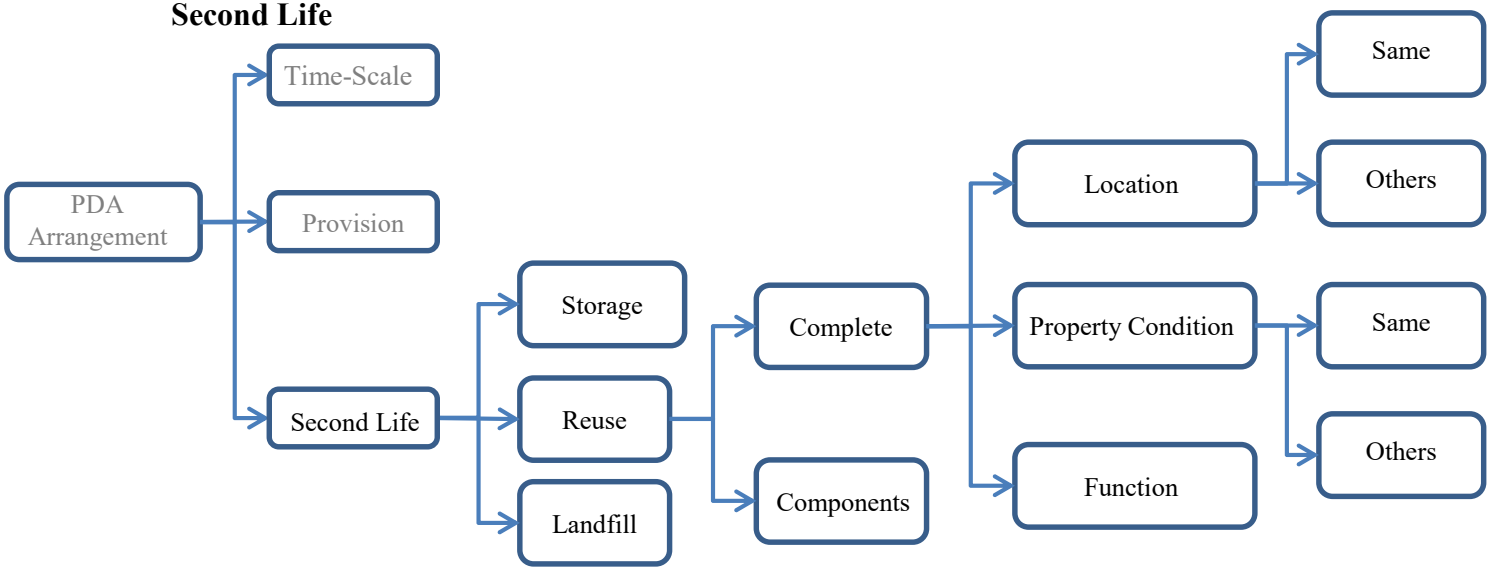
Post-disaster Housing Properties

Second Life



Dining hall formed from four housing Units, Duzce,
Source: Hakan Arslana,, Nilay Cosgun, 2008

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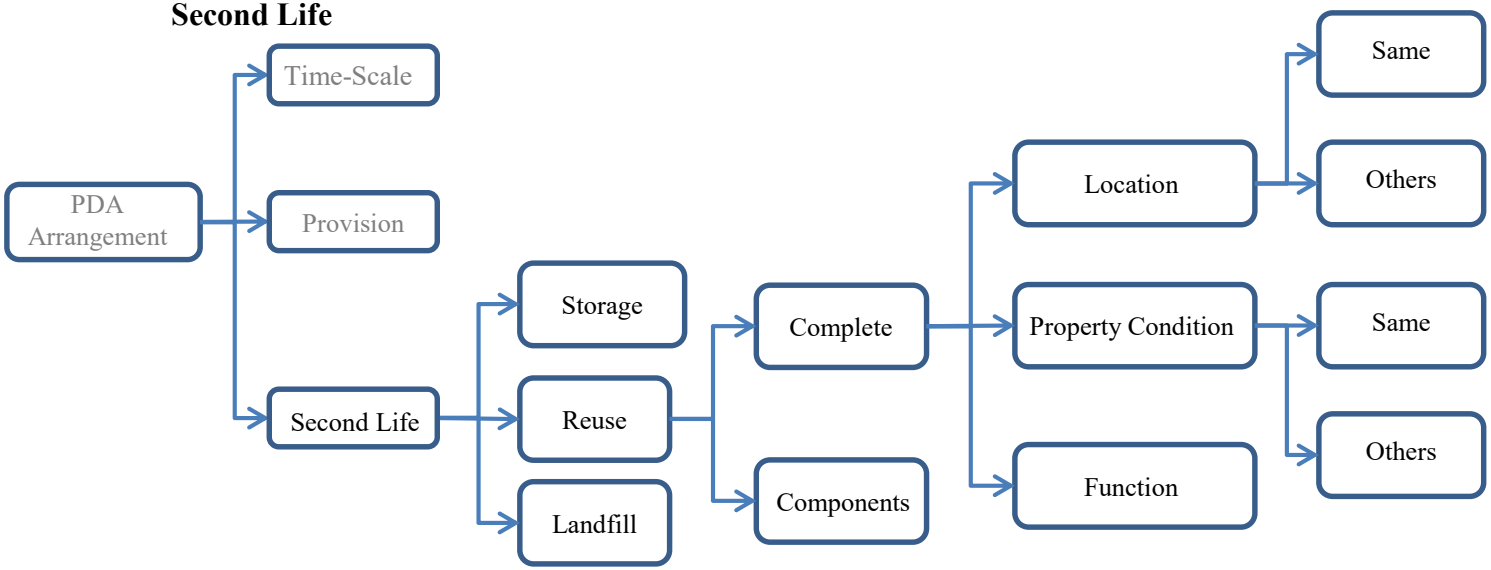
Post-disaster Housing Properties

Second Life



Turkey, 1999, UMCOR,
Cassidy Johnson, 2007

Sustainability

Limitations to achieve sustainability

- Research Limitation
- Operational Barriers
  - Establishing a universal sustainability strategy
  - Characteristics of recovery program

The Requirements of Sustainability

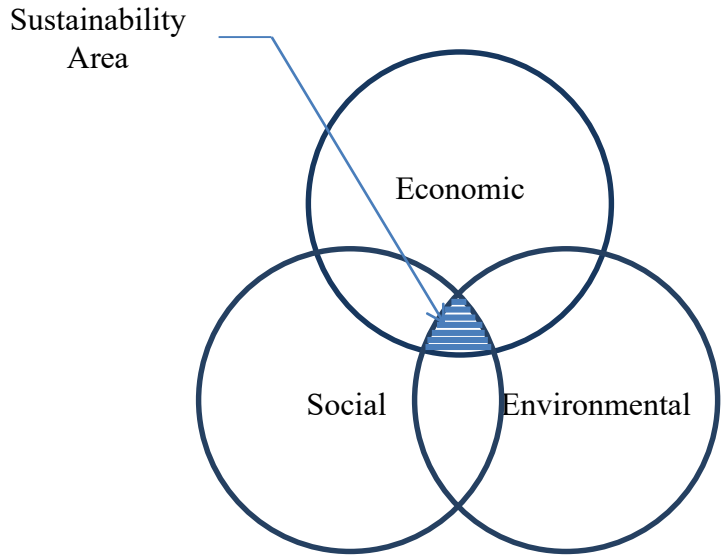


Fig. 4.2. Main requirements of PDH sustainability

Sustainability

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What is the misunderstanding of sustainability?

Indigenous Material and Technologies → **High Sustainability Index**

Not Always

Natural Disaster

Arg-e-Bam, Iran, before (right) and after (left) Bam Earthquake, 2003.

Source : http://www.gettyimages.co.uk

This **complex** had been constructed **approximately 2500 years ago** in Iran (Fallahi A. 2007). Arg-e-Bam is the **largest adobe complex** in the world (Nakamura et al. 2005) and was constructed with clay, mud brick, straw and trunks of palm (Manafpour 2008).

This fact demonstrates that **local technologies** and **materials** are **not only factors** of **sustainability**.

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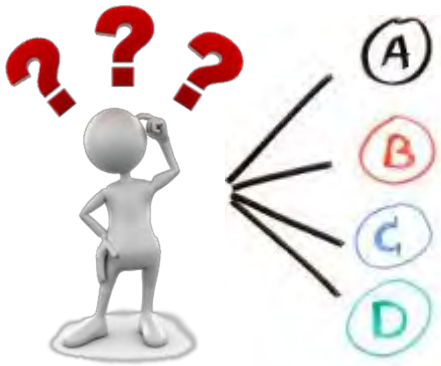
Decision-making Process of Post-disaster Housing Approaches

Choosing suitable options among diverse limited alternatives



For example, choosing a suitable site location of THUs between initial chosen site.

Determining suitable possible alternatives without having initial alternatives

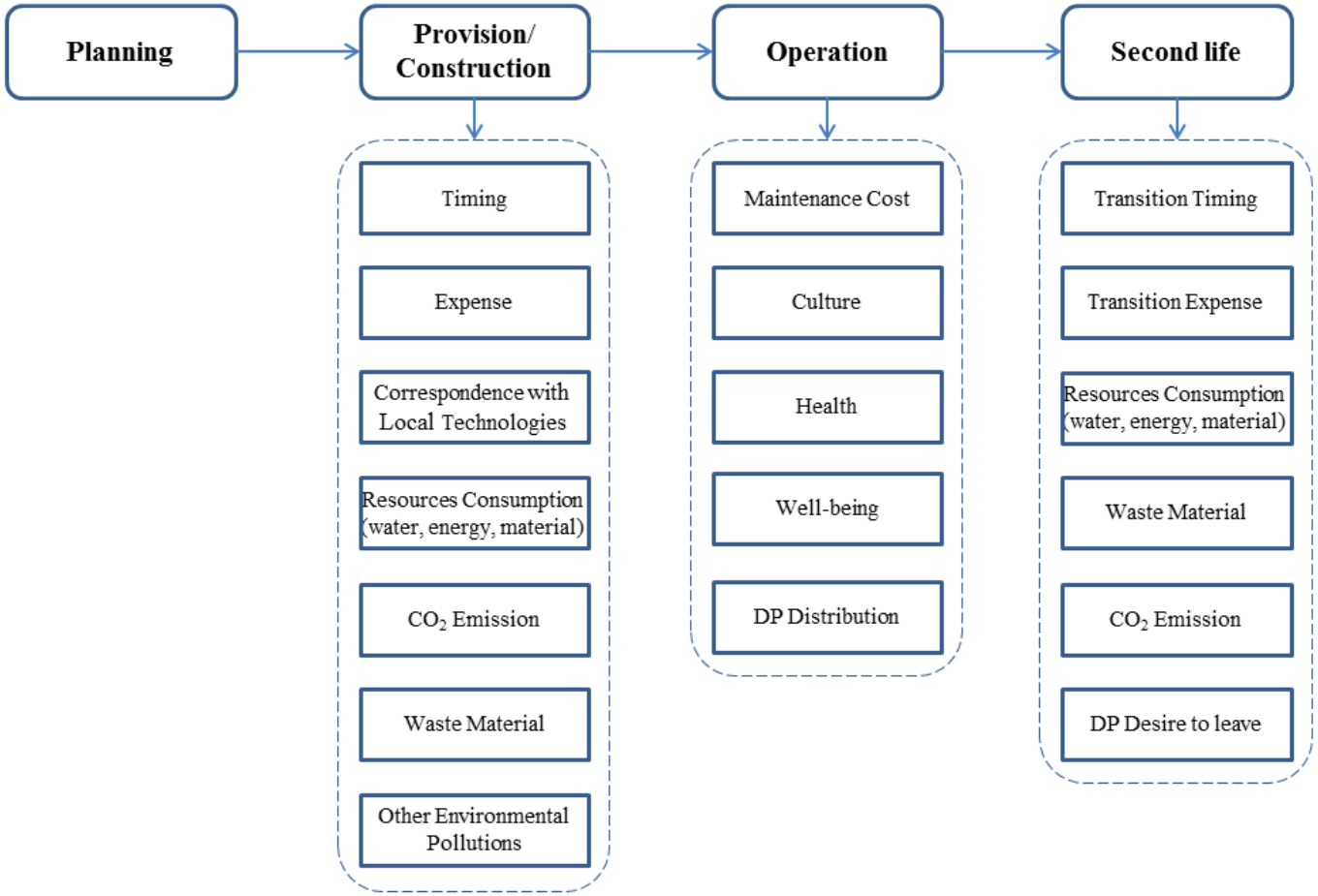
For instance, a model is used for choosing a proper settlement by considering all areas (see (Alparslan et al. 2008)).

A Steps Scenario Strategy

Life cycle phases of temporary housing

A Steps Scenario Strategy

Life cycle phases of temporary housing



Site Location Selection

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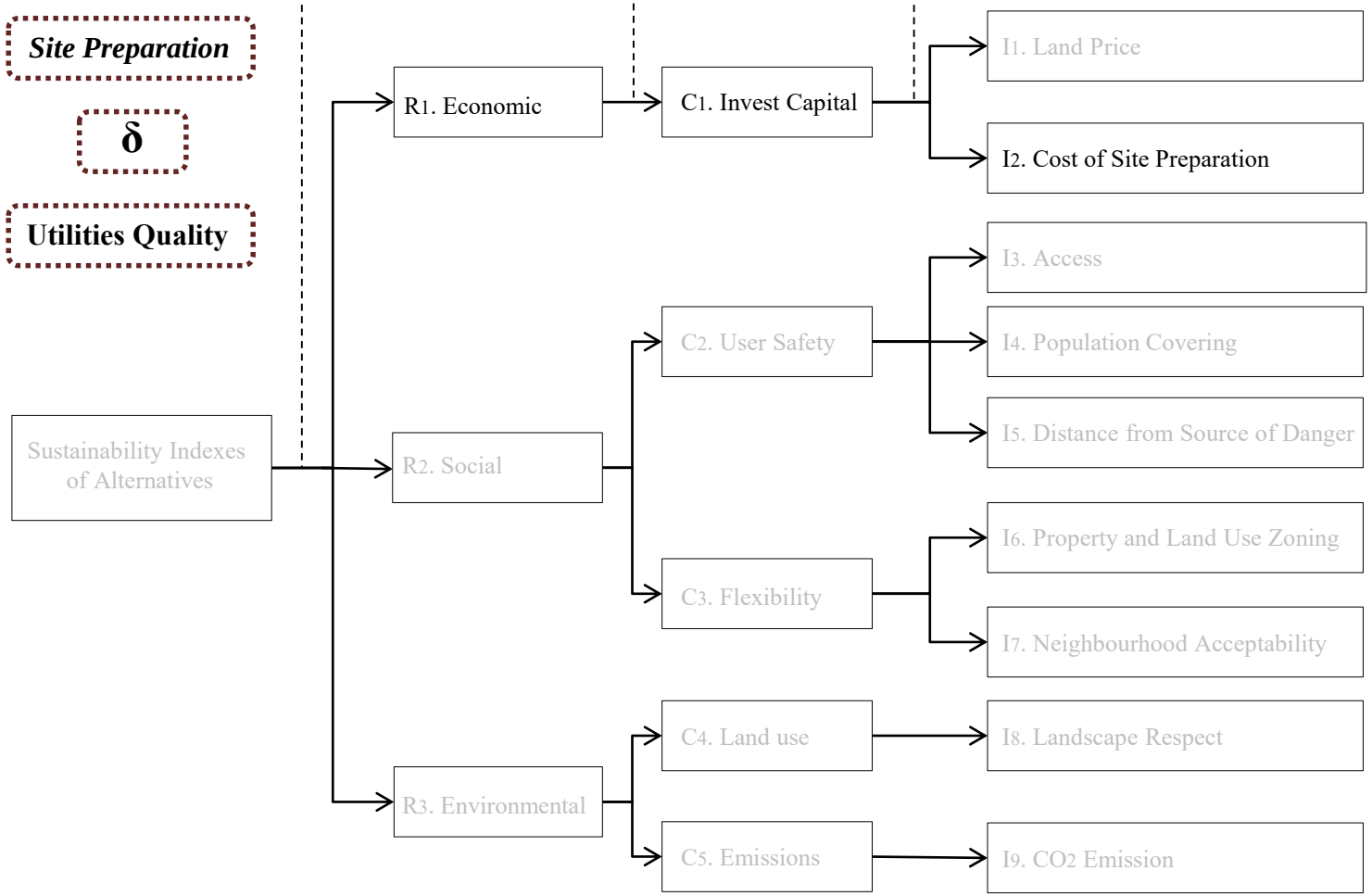
$$V_s = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$



Site Location Selection

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$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$

Population Covering

Maximize Coverage DP

Distribute Sites

Sustainability Indexes of Alternatives

- R1. Economic
  - C1. Invest Capital
    - I1. Land Price
    - I2. Cost of Site Preparation
- R2. Social
  - C2. User Safety
    - I3. Access
    - I4. Population Covering
    - I5. Distance from Source of Danger
  - C3. Flexibility
    - I6. Property and Land Use Zoning
    - I7. Neighbourhood Acceptability
- R3. Environmental
  - C4. Land use
    - I8. Landscape Respect
  - C5. Emissions
    - I9. CO_2 Emission

II/I

Site Location Selection

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$$V_s = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$

Distance from Source of Danger

γ

Danger Level

Sustainability Indexes of Alternatives

- R1. Economic
  - C1. Invest Capital
    - I1. Land Price
    - I2. Cost of Site Preparation
- R2. Social
  - C2. User Safety
    - I3. Access
    - I4. Population Covering
    - I5. Distance from Source of Danger
  - C3. Flexibility
    - I6. Property and Land Use Zoning
    - I7. Neighbourhood Acceptability
- R3. Environmental
  - C4. Land use
    - I8. Landscape Respect
  - C5. Emissions
    - I9. CO_2 Emission

II/I

Site Location Selection

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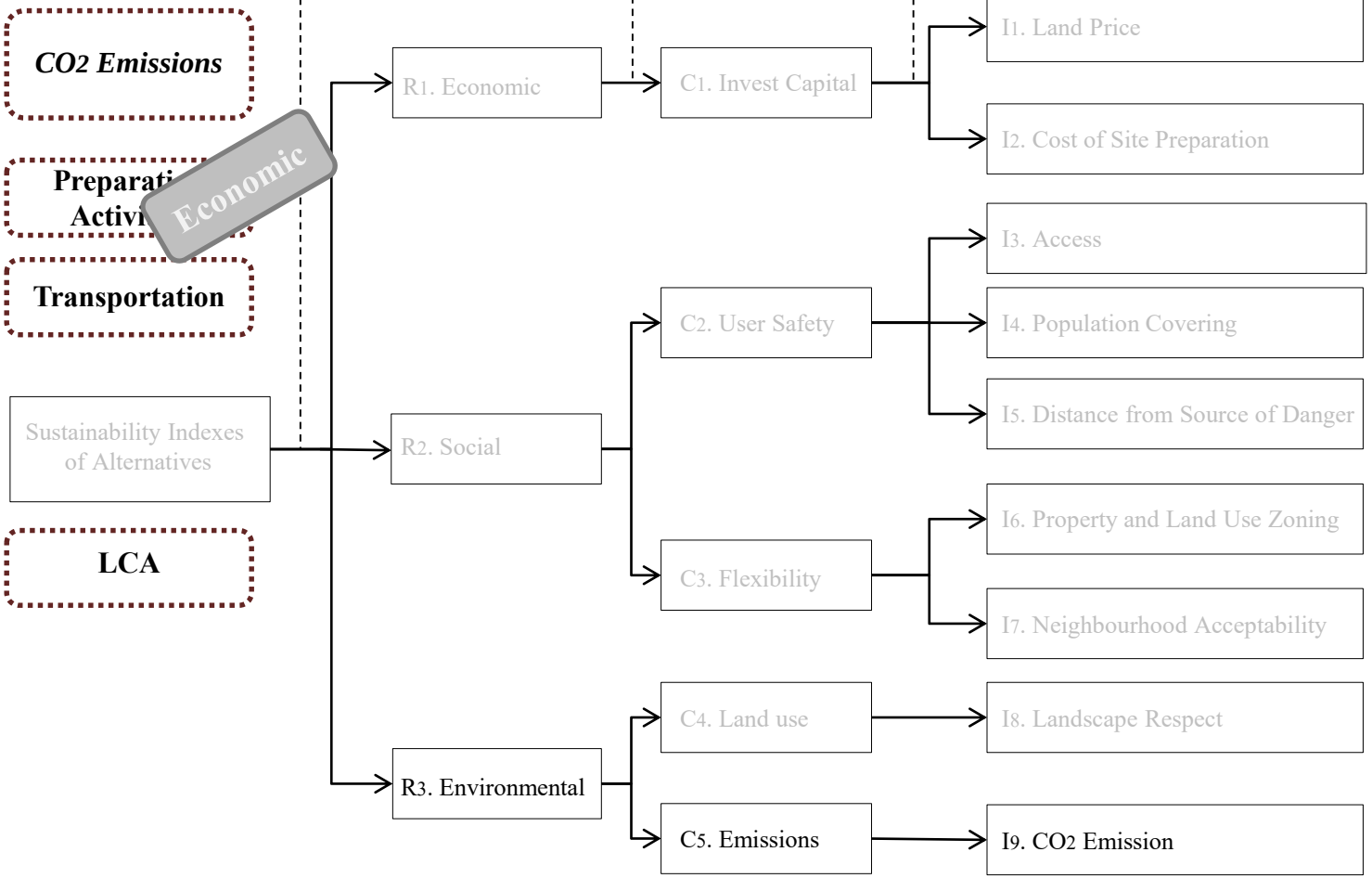
$$V_s = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i}$$

$$V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{i,k}} \cdot V_{CR_{i,k}}$$

$$V = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind})$$



II/I

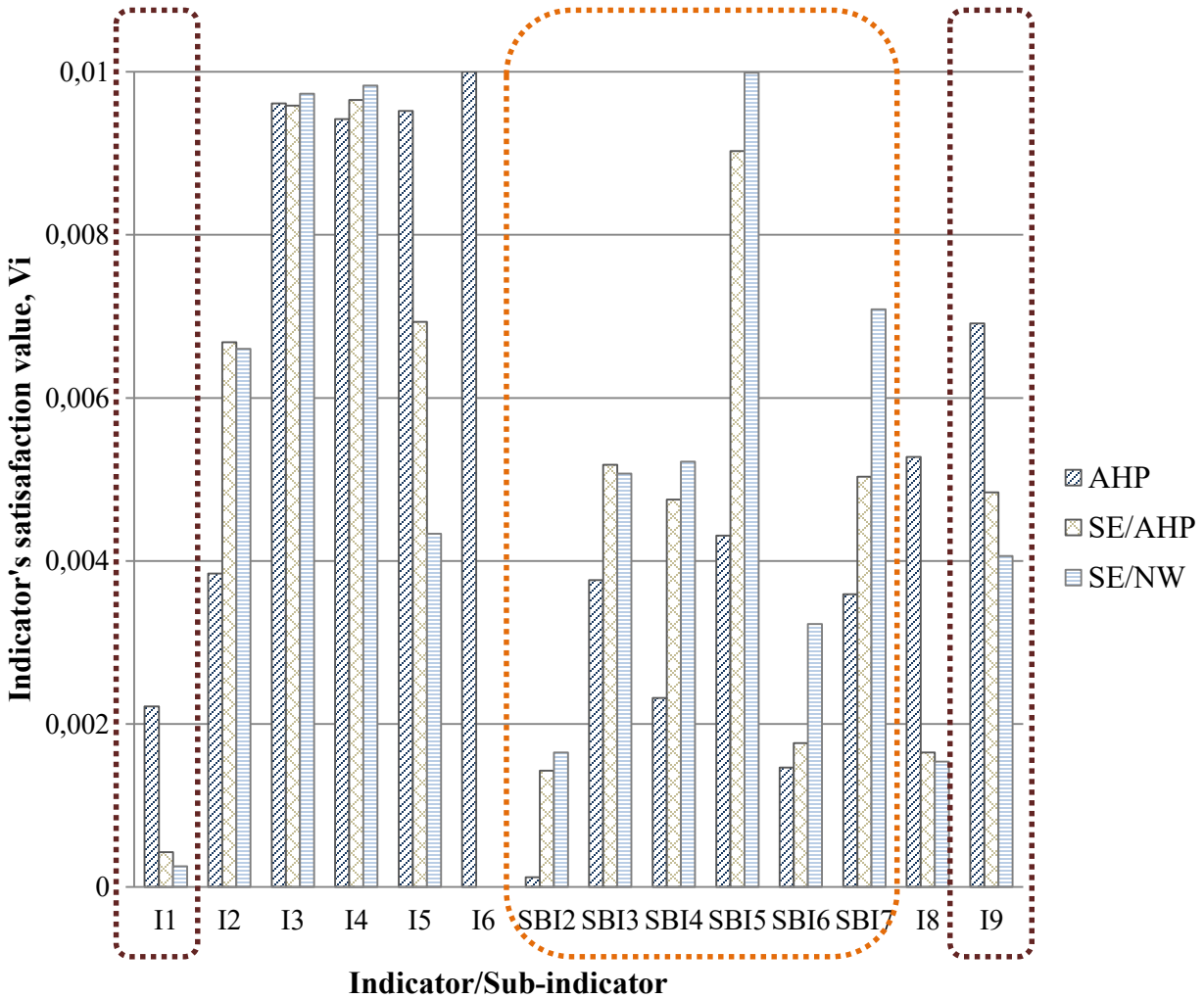


Fig. 8. 4. Values functions of the indicators and sub-indicators without considering weights based on applying the three methods for the optimal subsets

II/II

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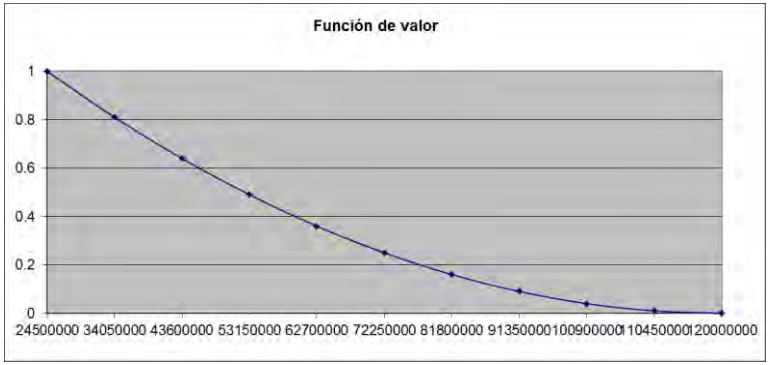
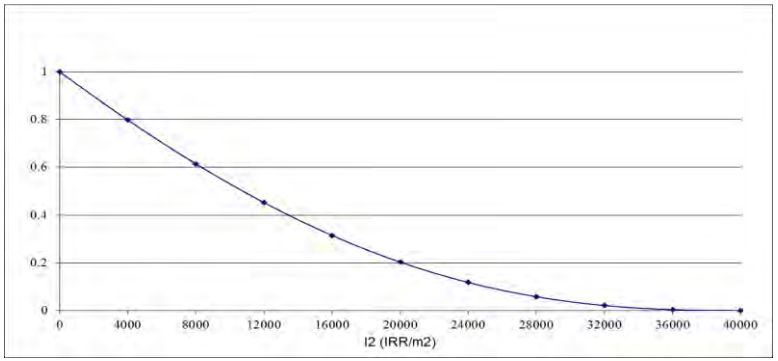
$$(X_1\%*V_{Ec})+(X_2\%*V_S)+(X_3\%*V_{En})=SI$$

II/II

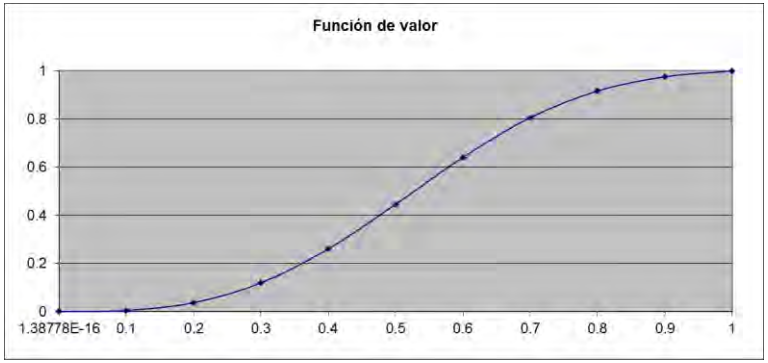
Site Location Selection (Annex)



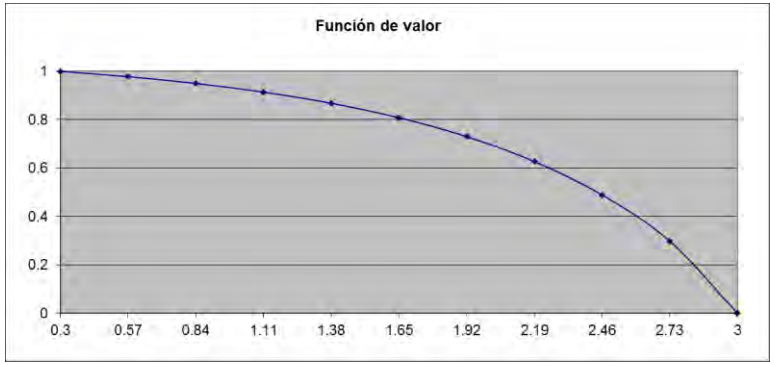
I1. Land Price



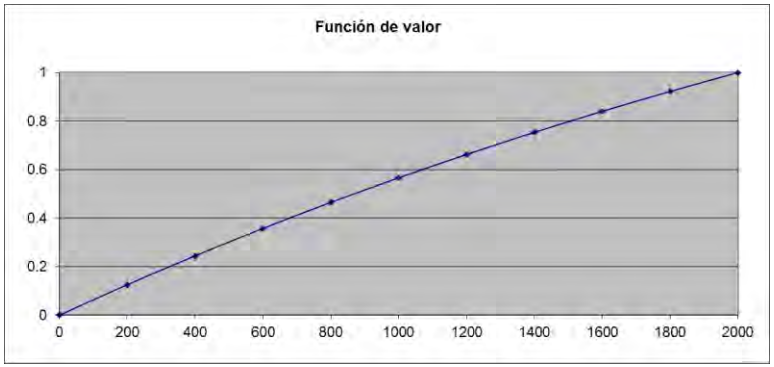
I2. Cost of Site Preparation



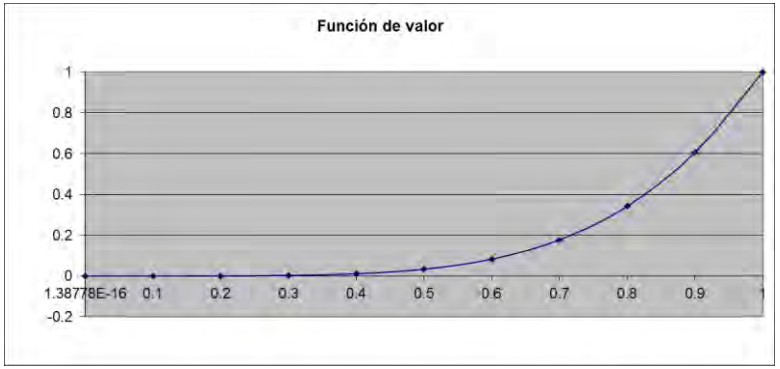
I3. Access



I4. Population Covering

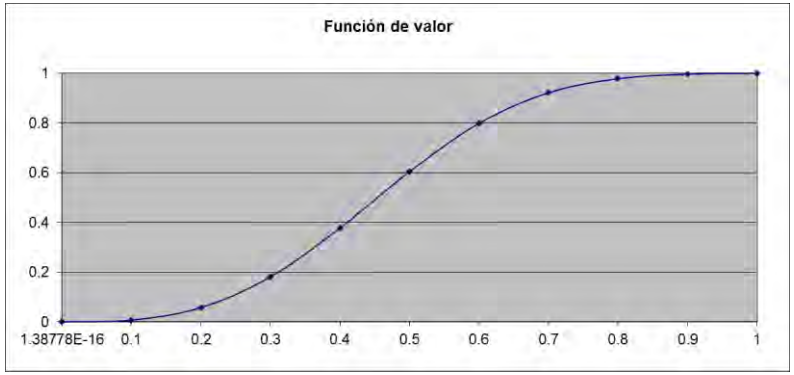


I5. Distance from Source of Danger

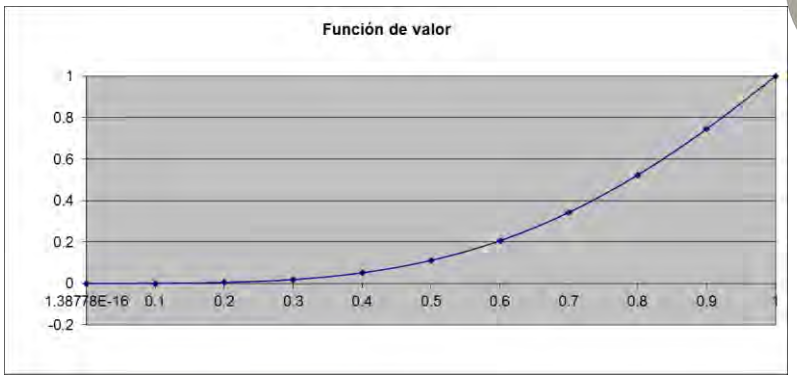


I6. Property and Land Use Zoning

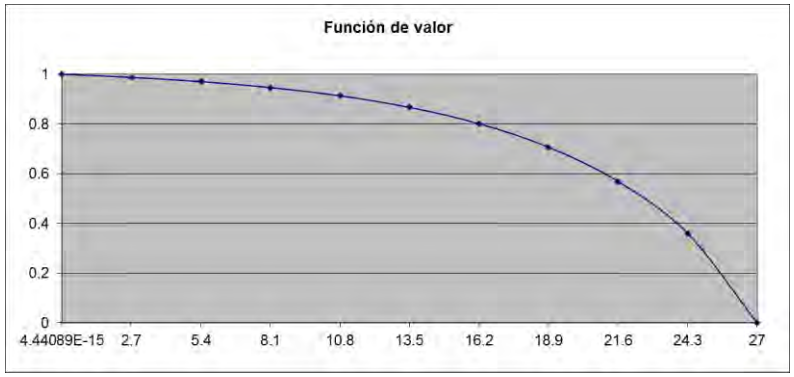
Site Location Selection (Annex)



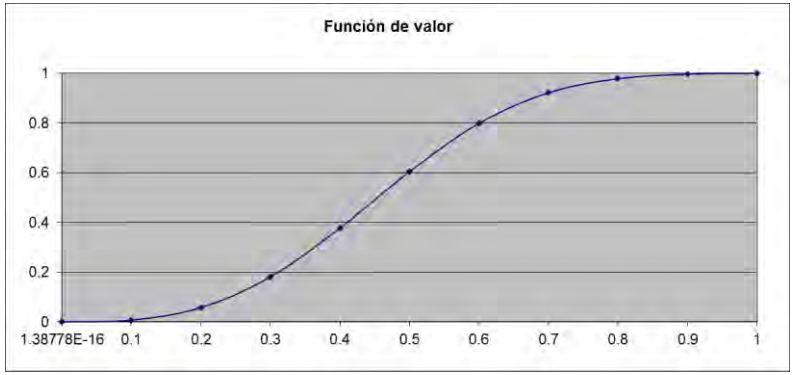
I7. Neighbourhood Acceptability



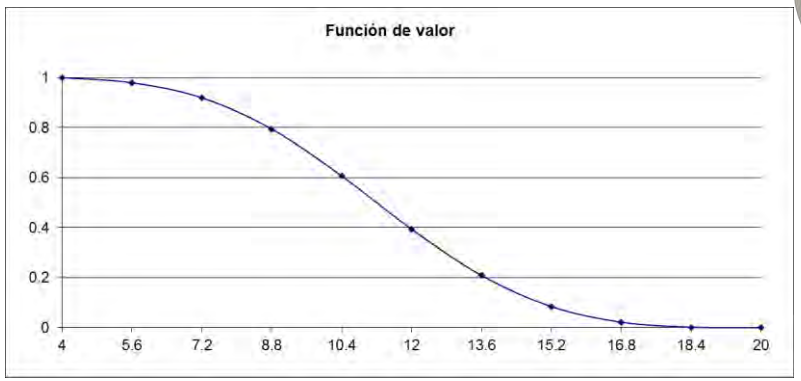
I8. Landscape Respect



I9. CO2 Emission

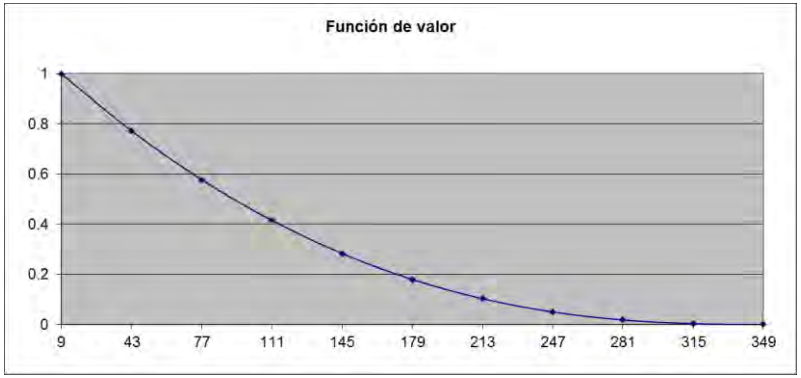


SubI3-1. DP Access

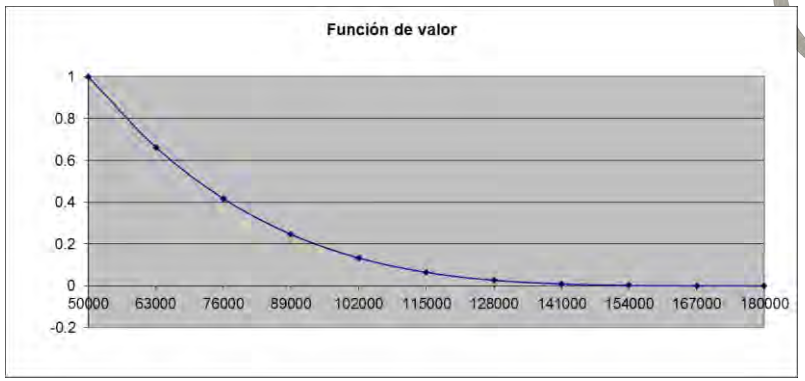


SubI3-2. Emergency Service Access

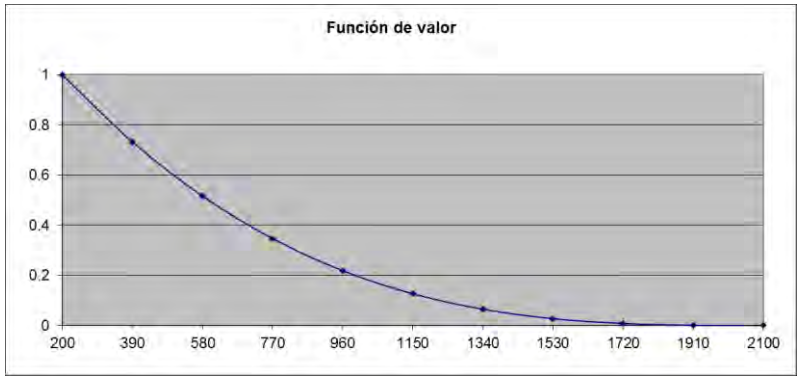
Site Location Selection (Annex)



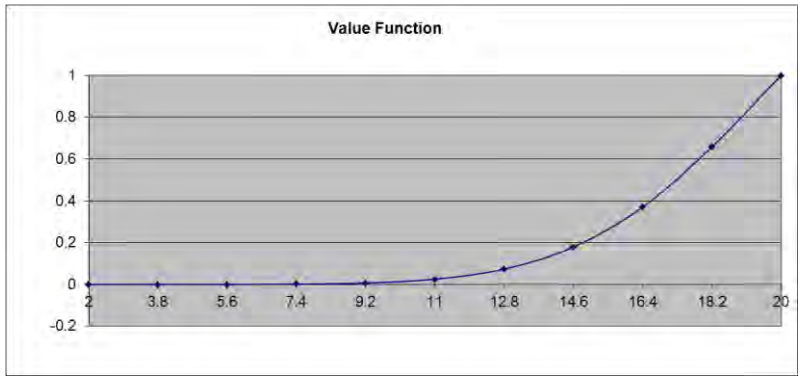
SubI7-1. Density



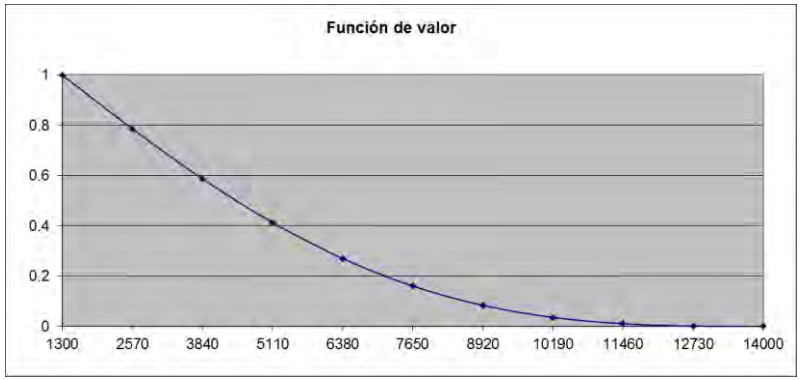
SubI7-2. Hospital



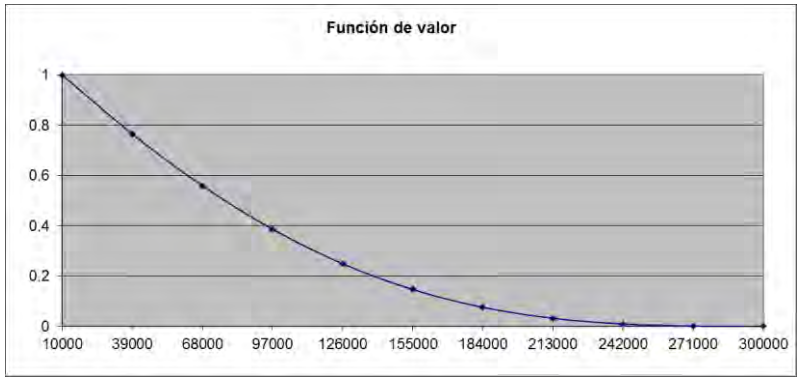
SubI7-3. School



SubI7-4. Green Area

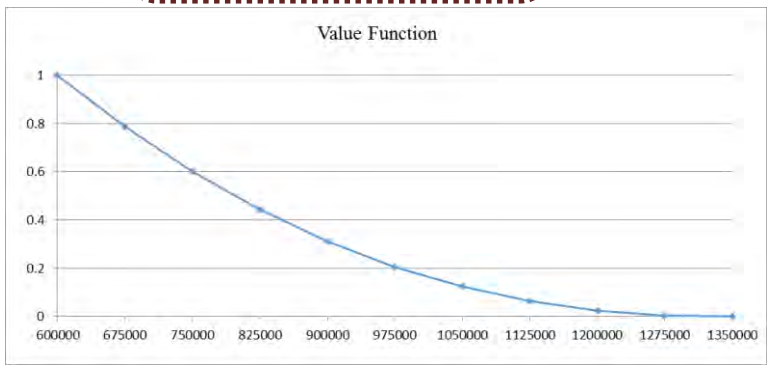


SubI7-5. Police Station

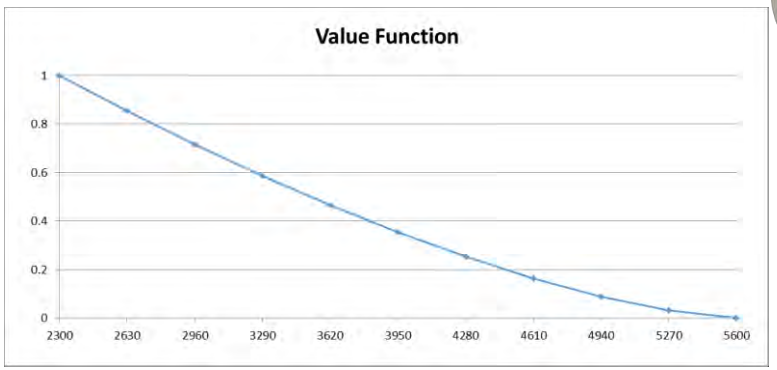


SubI7-6. Fire Station

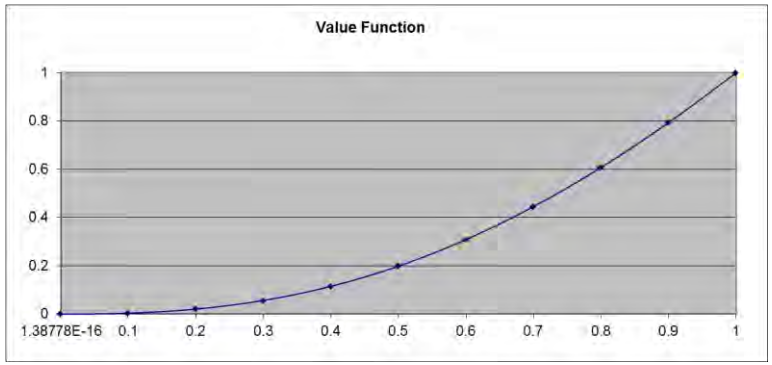
Temporary Housing Units(Annex)



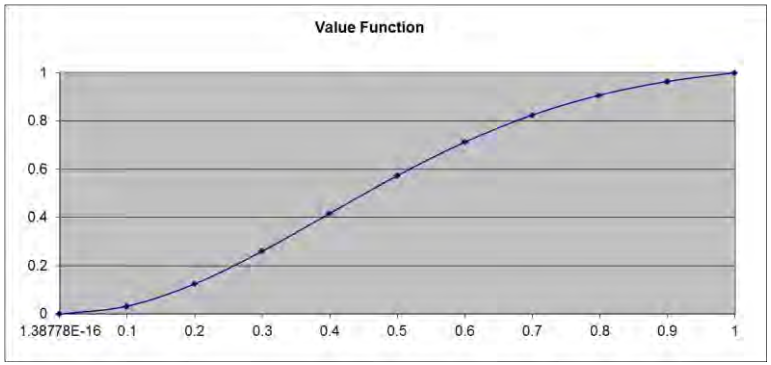
I_1. Building Cost



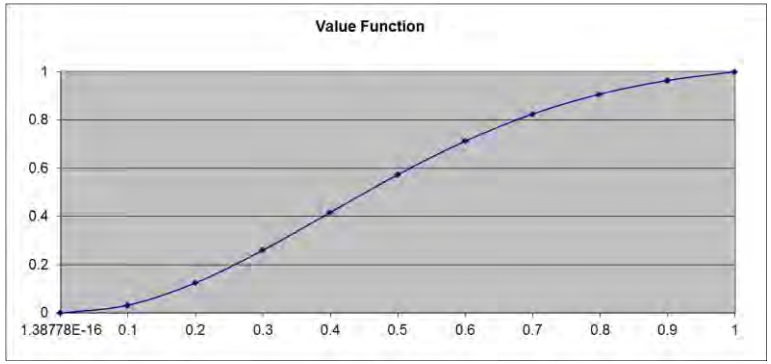
I_2. Reusability Cost



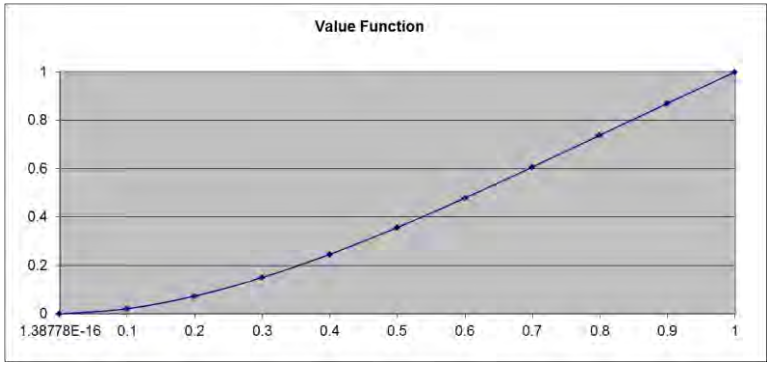
I_3. Construction Time



I_4. Risk Resistance

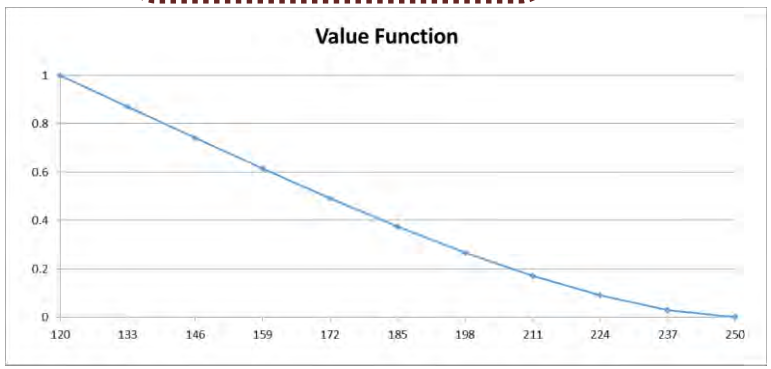


I_5. Comfort

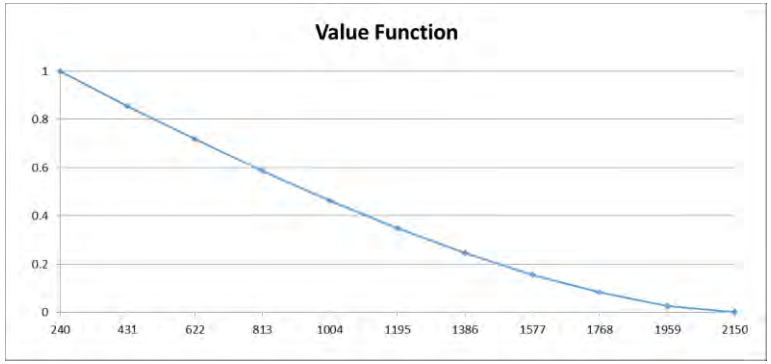


I_6. Compatibility

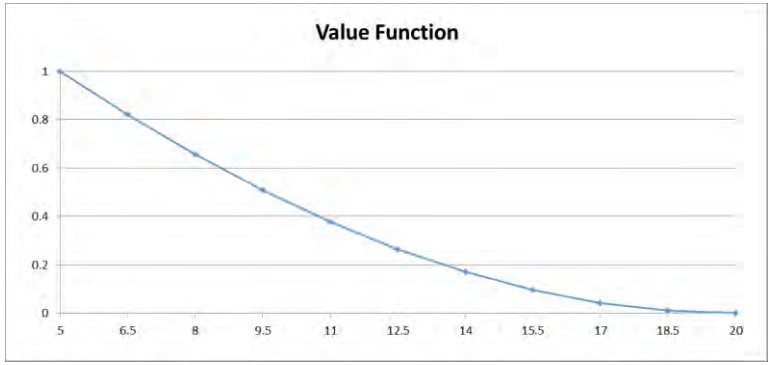
Temporary Housing Units(Annex)



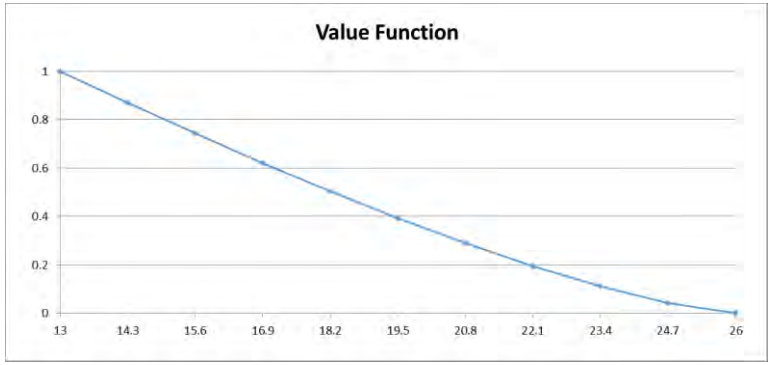
I_7. Energy Consumption



I_8. Water Consumption

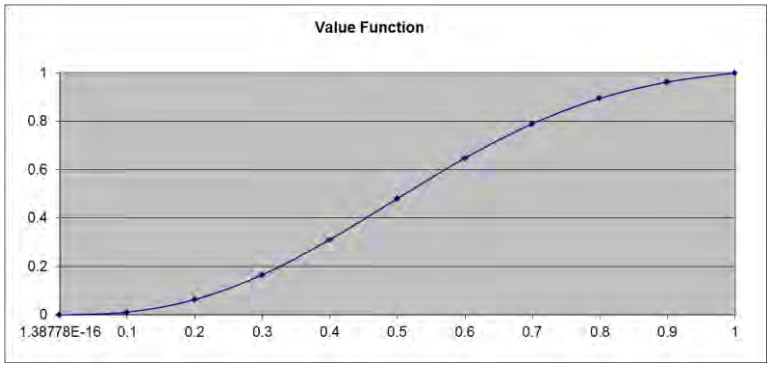


I_9. Waste Material

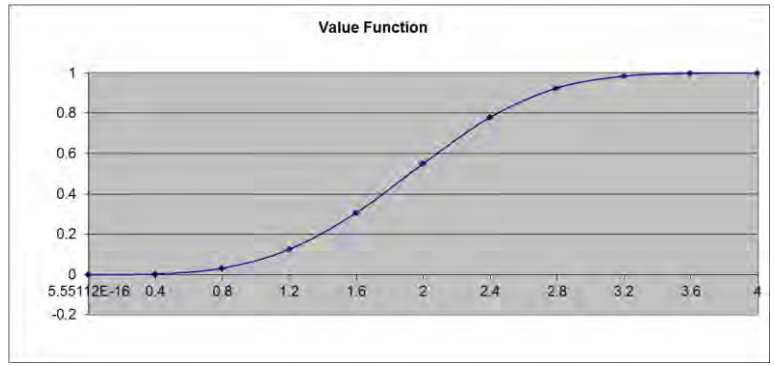


I_{10}. CO_2 Emissions

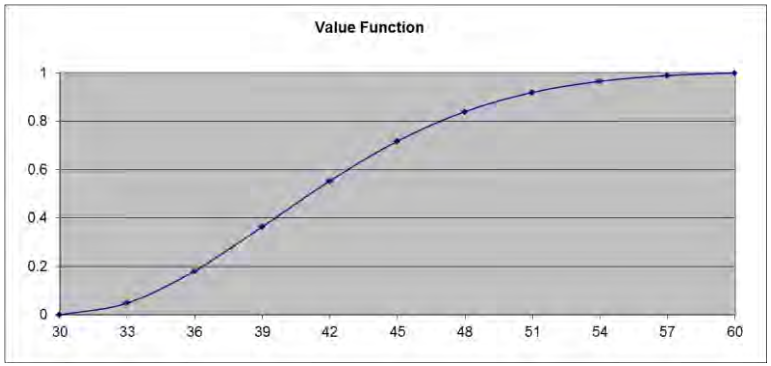
Temporary Housing Units(Annex)



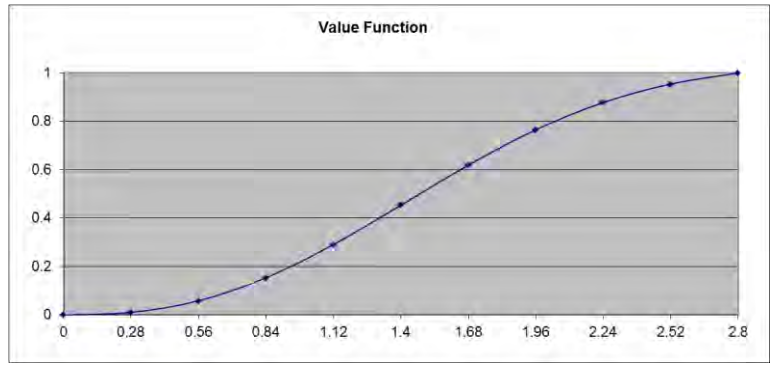
Sub $I_{4\text{-}1}$. Natural Disaster Risk



Sub $I_{4\text{-}2}$. Fire Resistance

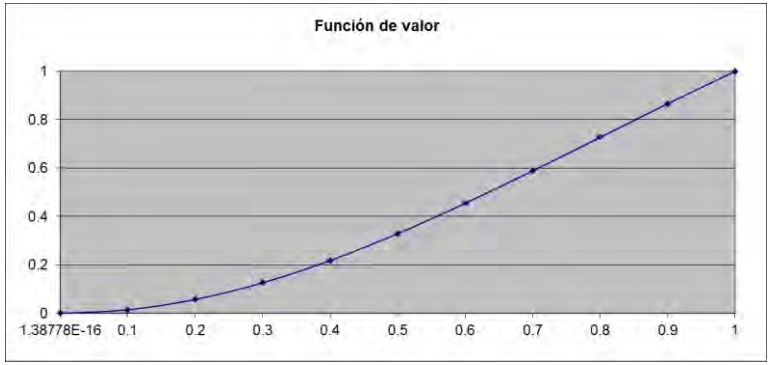


Sub $I_{5\text{-}1}$. Acoustic

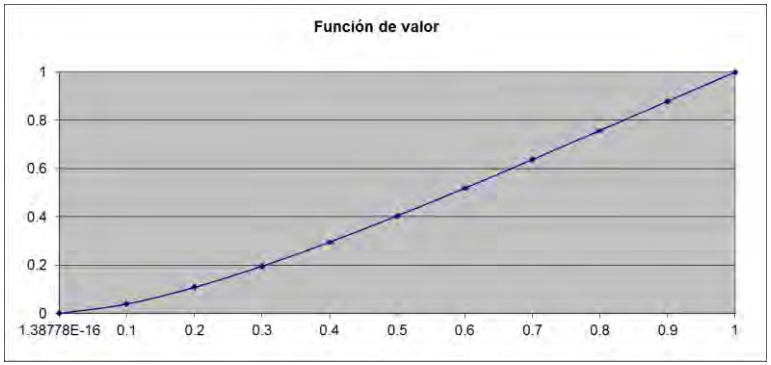


Sub $I_{5\text{-}2}$. Thermal Resistance

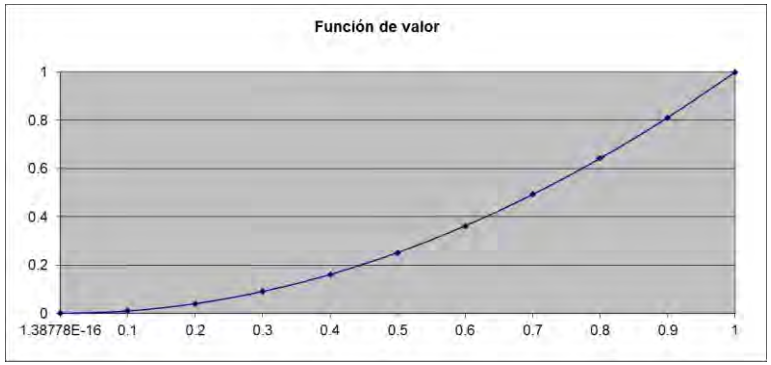
Temporary Housing Units(Annex)



Sub $I_{6\text{-}1}$. Cultural Acceptance



Sub $I_{6\text{-}2}$. Flexibility



Sub $I_{6\text{-}3}$. Skilled Labour