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

PhD. Candidate

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Thesis Directors

PhD. Albert de La Fuente
PhD. Oriol Pons

Doctoral Program in
Construction Engineering

Barcelona, September 2016
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 Ban

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
Displaced Population

Protracted displacement following disasters worldwide in 2014/2015

Introduction

Descriptive State of the Art

Operational

Conclusion

16,000

Italy
L'Aquila earthquake, 2009
16,000

Pakistan
Attabad landslide and flood, 2010
2,900
Monsoon floods, 2012
31,000

Bangladesh
Cyclone Aila, 2009
13,100

Japan
Tohoku earthquake/tsunami and nuclear accident, 2011
230,000

Philippines
Typhoon Bopha/Pablo, 2012
At least 140,000
Typhoon Haiyan/Yolanda, 2013
13,300

13,000

Indonesia
Siocanjo mudflow, 2006
13,000

Mozambique
Floods, 2013
26,000

Zimbabwe
Tolwe-Mukorsi floods, 2014
20,000

Nigeria
Floods, 2012
Up to 16,500

Colombia
Granadito landslide, 2010
2,900

Haiti
Earthquake, 2010
64,700
United States
Superstorm Sandy, 2012
39,200

Location of protracted situations recorded as ongoing in 2014/2015

- Floods
- Earthquake
- Landslide
- Storm
- Volcanic eruption
Population Exposure to Natural Hazards

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

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

Source: World Bank 2009

Introduction

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Conclusion
Temporary Housing

Post-Disaster Temporary Housing definition

Post-Disaster Temporary Housing Types

Available Accommodations

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

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

Introduction

Descriptive

Operational

Conclusion
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 Characteristics

Introduction
Descriptive
Operational
Conclusion
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

<table>
<thead>
<tr>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
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<tr>
<td>Choosing the most suitable temporary housing strategy</td>
<td>Selecting an optimized site location</td>
<td>Selecting the most sustainable area subsets from various alternatives</td>
<td>Selecting the most optimal THU alternative in terms of sustainability</td>
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Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

**Literature Review**
- Thirty-two Researches

**Case Study**
- Five Recovery Programs

**Sustainability**
- Twenty Researches

**Decision-Making**
- Six Models

**Main Vertexes**
- Lack of Precise Information
- Decision-Making Mistakes
  - Site Location
  - Units Technology

**Descriptive**
- Sustainability Requirements

**Operational**
- Decision-Making Requirements

**General Strategy**
- Site Location
- Set of Sites
- Unit Technology
Methodology

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

Designed Models
- AHP
- MIVES
- Knapsack
- Shannon’s Entropy
- LCA

Operational

Problem Definition & Finding Reasons

Dividing & Organizing Issues

Designing Models

Introduction
Descriptive
Operational
Conclusion
Descriptive

Integrated Approach

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
Which are the main requirements involved in post-disaster accommodation strategies and the constituents?

Which are the differences between implemented post-disaster accommodation strategies?
### Case Study

<table>
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Case Study

Introduction

Descriptive

State of the Art

Operational

Conclusion

Input

Real Case

Disaster (Hazard/Incident)

Population

Chosen Strategy

Possible Case

Another Strategy

Another Strategy

Processing

Interactions

Priorities

Factors

Outcome & Impacts

Real Results

Satisfaction of User

Satisfaction of Producers

Satisfaction of Third-Parties

Possible Results

Another Result

Possible Result

Another Result

Missed Link

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

Turkey - 1999

Iran - 2003

Indonesia - 2004

USA - 2005

Italy - 2009
Integrated Approach

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
Integrated Approach

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

Choice Phases

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

**Decision-Making Algorithm**

- Start of Selecting Suitable PDA
  - **Filtering**
    - Availability
      - No
        - Is possible to provide from abroad?
          - Yes
            - Assigning in the Alternative List
          - No
        - Is there any other alt.?
          - Yes
            - Defining Outcomes of Using Alternatives
          - No
            - Comparing Results
  - Conditions
    - No
    - Yes

Fig 3.5. Decision-making process algorithm of PDA
Integrated Approach

Integrated Approach for Dealing with Post-Disaster Accommodations

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

Journal of Disasters
Descriptive

Sustainability

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
What is the sustainability of post-disaster housing?

Findings

Sustainability index can vary for different areas.

Complex Problem

Concerns
Requirements
Limitations and Impediments
Potentials

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

Decision-Making Models
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
  - TOPSIS
  - AHP
  - GIS
  - MADM

- Temporary Housing Selection

Fuzzy Optimizing
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
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
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.
Operational

A Steps Scenario Strategy

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
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.
A Steps Scenario Strategy

Introduction

Descriptive

Operational

Conclusion

Step Scenario Strategy

Displaced Population

Temporary Housing Units

Host Families

Alternatives

Displaced Population

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
A Steps Scenario Strategy

Step Scenario Strategy

1

Sustainability Index

0

Step 1
Step 2
Step 3
Step N

DP-Step 1
DP-Step 2
DP-Step 3
DP-Step N

DP numbers/TH Alternatives

Displaced Population

Introduction
Descriptive
Operational
Conclusion

Alternatives

Host Families
Temporary Housing Units

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
A Steps Scenario Strategy

Step Scenario Strategy

1. Step 1
2. Step 2
3. Step 3
4. Step N

DP-Step 1
DP-Step 2
DP-Step 3
DP-Step N

Displaced Population

Sustainability Index

0
1

DP numbers/TH Alternatives

Alternatives

Host Families

Operational

Conclusion

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

A Steps Scenario Strategy

Step Scenario Strategy

Displaced Population

Sustainability Index

DP numbers/TH Alternatives

Alternatives

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Conclusion

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Introduction
A Steps Scenario Strategy

Step Scenario Strategy

1 0

Sustainability Index

Step 1 Step 2 Step 3 Step N

DP-Step 1 DP-Step 2 DP-Step 3

DP-Step N

DP numbers/TH Alternatives

Displaced Population

Alternatives

Host Families

Temporary Housing Units

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
A Steps Scenario Strategy

Suggested Model

Initial Phase

Three Vertices
- Natural Disaster
- Local Characteristics
- Local Potentials
- Affected Population
- Temporary Housing Qualities

Intermediate Phase

Selecting Most Suitable Temporary Housing

TH No. Covers DP
Yes
Set of Alternatives (Final Result)
No
Can TH No. be increased?
Yes
Selecting Second Level Suitable TH
No
Few Experts
Initial Alternatives

Final Phase

Rapid Decision
- Requirements
  a) Economic
  b) Social
  c) Environmental

Operational

Conclusion
A Steps Scenario Strategy

Sustainability indexes of temporary housing

**Sustainability Concept**

**Essential Factors**

<table>
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<th>Economic</th>
<th>Social</th>
<th>Environmental</th>
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<td>Health</td>
<td>Pollution</td>
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<td>Maintenance Cost</td>
<td>Well-being</td>
<td>Reusability</td>
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<td>Culture</td>
<td>Consumption</td>
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### A Steps Scenario Strategy

#### Analysing

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<th>Shannon’s Entropy</th>
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<td><strong>C</strong></td>
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<tr>
<td><strong>T</strong></td>
<td><strong>Tent</strong></td>
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<td><strong>U</strong></td>
<td><strong>Housing Unit</strong></td>
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</tbody>
</table>

#### Twenty-two Weights Scenarios

(P: private yard of DP’s previous housing; C: camp site; T: tent; U: unit/THU)
Increasing social weights by the Entropy
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
Operational

Site Location Selection I

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

**Site Location Selection**

**Methodology**

1. Data Collection
2. Site Location Characteristics
3. MIVES
4. Evaluating Sustainability Index
5. Final Results
6. Stakeholders Definition
7. Requirements Definition
8. Local Requirements
9. Estimation of Displaced Population
10. Determination of Alternative Sites
11. Demanded Area

**Introduction**

**Descriptive State of the Art**

**Operational State of the Art**

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

Introduction

Descriptive

State of the Art

Operational

Center for Earthquake and Environmental Studies of Tehran (CEST)

Japan International Cooperation Agency (JICA)

Site Location Selection

Tehran

8.15 Million

686.3 km²
～ (70,000 ha)

18,000 Casualties

610,000 Displaced Population

90,000 Damaged Residential Buildings
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

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Descriptive

Site Location Selection

Tehran

160,000 Displaced Population

100 ha

Six Alternatives

Twenty-three Sites

Four Individual Sites

Two Alternative Sets

A1-A4

B1-B5

C1-C14, B2, B4, and B5

Site A1

Site A2

Site A3

Site A4

Set B

Set C
Introduction

Descriptive

Operational

Conclusion

Sustainability Indexes of Alternatives

R1. Economic

C1. Invest Capital

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

I7. Neighbourhood Acceptability

I8. Landscape Respect

I9. CO2 Emission

R2. Social

C2. User Safety

R3. Environmental

C3. Flexibility

C4. Land use

C5. Emissions

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

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

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

Descriptive

Operational

Conclusion

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

Site Location Selection

Sustainability Indexes of Alternatives

DP Access

Emergency Services Access

R1. Economic

C1. Invest Capital

I1. Land Price

I2. Cost of Site Preparation

I3. Access

C2. User Safety

I4. Population Covering

I5. Distance from Source of Danger

I6. Property and Land Use Zoning

I7. Neighbourhood Acceptability

I8. Landscape Respect

I9. CO2 Emission

R2. Social

C3. Flexibility

R3. Environmental

C4. Land use

C5. Emissions

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

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

\[ V = \sum_{i=1}^{j} \lambda_{I_k} \cdot V_{I,k}(x_{ind}) \]

\[ V_{S} = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i} \]

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

\[ V = \sum_{i=1}^{j} \lambda_{I_k} \cdot V_{I,k}(x_{ind}) \]
Site Location Selection

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

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Density

School

Sustainability Indexes of Alternatives

Green Area

Hospital

Police

Fire Stations

R1. Economic

C1. Invest Capital

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

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

I7. Neighbourhood Acceptability

I8. Landscape Respect

I9. CO2 Emission

R2. Social

C2. User Safety

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

R3. Environmental

C3. Flexibility

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

C4. Land use

C5. Emissions

\[ V_{i,k}(x_{ind}) = \sum_{i=1}^{j} \lambda_{i,k} \cdot V_{i,k}(x_{ind}) \]
## Site Location Selection

### Analysing

**Six Alternatives**

**Twenty-three Sites**

### Weight Assignment

### Meetings & Seminars

- University Professors & Local Experts

### Characteristics

### Value of Indicator

### Sustainability Indexes of Alternatives

<table>
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<th>Alternative</th>
<th>I</th>
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Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

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Site Location Selection

Analysing

Site A1

Site A2

Site A3

Site A4

Land Price (I1), Neighbourhood Acceptability (I7), Emissions (I9)

Accessibility (I3) and Population Cover (I4)
Fig. 7.6. Sustainability index (I) and requirement values for the six alternatives
Site Location Selection

Analysing

Sixteen Weights Scenarios

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

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Conclusion

**Site Location Selection**

**Analysing**

Model Validation

Decision-Making Models

- TOPSIS
- ELECTRE
- SAW

Weight Assignment system

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

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<th>MIVES (SE/W)</th>
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<th>TOPSIS (SE/NW)</th>
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Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
Multi-criteria Decision-Making Method for Sustainable Site Location of Post-Disaster Temporary Housing in Urban Areas


Journal of Construction Engineering and Management

Volume 142, Issue 9 (September 2016)
Operational

Site Location Selection II

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
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.
Site Location Selection

Nineteen Alternative Sites (S1-S19)

Areas: From 2.3 to 40.0 ha

Knapsack

50 ha ≤ Area < 55 ha

Sustainability Index

MIVES
Site Location Selection

Results

Weight System

AHP | SE/AHP | SE/NW
---|---|---
\[ S_2, S_4, S_5, S_6, S_{17}, S_{18}, S_{19} \] | \[ S_3, S_4 \] | \[ S_2, S_3 \]

Set

SI

\[ 0.52 \] | \[ 0.60 \] | \[ 0.69 \]

Table:

<table>
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<tr>
<th>Subset weights</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>B</th>
<th>C</th>
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<tr>
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<td>AHP</td>
<td>AHP</td>
<td>SE/AHP</td>
<td>SE/AHP</td>
<td>SE/AHP</td>
<td>SE/NW</td>
<td>SE/NW</td>
<td>SE/NW</td>
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<td>0.55</td>
<td>0.49</td>
<td>0.66</td>
<td>0.69</td>
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</table>
Site Location Selection

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

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
Fig. 8.5. Assigned weights to the indicators and sub-indicators by the three methods.
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

Site Location Selection

Introduction

Descriptive

Operational

Conclusion

Sensitivity Analyze

Twenty-eight Requirements’ Weighing Distributions

AHP

SE/AHP

Economic

Social

Environmental

Diverse Sets

Fig. 8.6. Frequency of each site (Ni) depending on the weighting technique

Alternative Site

S2, S4, S5, S6, S17, S18, S19

S3, S4

AHP

SE/AHP

Introduction

Descriptive

State of the Art

Conclusion

Operational

State of the Art

Operational

Conclusion
Fig. 8. 7. Sustainability indexes of the chosen subsets by AHP and SE/AHP based on twenty-eight weights scenarios.
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

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
Operational

Temporary Housing Units Selection

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
The **objective** of this chapter is to present a model for selecting the optimized temporary housing unit technology by considering local characteristics and sustainability.
Methodology

MIVES

Initial Choice Phase

Local characteristics

Temporary Housing Features

Appropriate Temporary Housing (except temporary housing unit)

Middle Choice Phase

Requirements Definition

Alternatives Selection

Final Choice Phase

Decision-Making Model

Analysis

Appropriate Temporary Housing Unit

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)

Ministry of Defence

26,900 Units on Private Properties

9,005 in 23 Camps

Introduction

Descriptive

Operational

Conclusion
Housing Units Selection

Bam Temporary Housing Units

Eight Alternatives

- 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

Indicator Definition

R1. Economic
- C1. Implementation Cost
- I1. Building Cost
- C2. Reusability Cost
- I2. Maintenance Cost

R2. Social
- C3. Safety
- I3. Construction Time
- I4. Risk Resistance
- I5. Comfort
- C4. Customization
- I6. Acceptability

R3. Environmental
- C5. Resources Consumption
- I7. Energy Consumption
- C6. Emissions
- I8. Water Consumption
- I9. Waste Material
- I10. CO2 Emission

National Building Regulation
International Codes

Sustainability Indexes of Alternatives

University Professors
Local Experts

Introduction
Descriptive
Operational
Conclusion
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

Indicator Definition

Natural Disaster Risk

Fire Resistance

Acoustics Range

Thermal Resistance

Cultural Acceptance

Skilled Labor

Flexibility

Sustainability Indexes of Alternatives

R1. Economic

R2. Social

R3. Environmental

C1. Implementation Cost

C2. Reusability Cost

C3. Safety

C4. Customization

C5. Resources Consumption

C6. Emissions

I1. Building Cost

I2. Maintenance Cost

I3. Construction Time

I4. Risk Resistance

I5. Comfort

I6. Acceptability

I7. Energy Consumption

I8. Water Consumption

I9. Waste Material

I10. CO2 Emission

Introduction

Descriptive

Operational

Conclusion
Housing Units Selection

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

Analysing

Sustainability Index

Technology Characteristics

Material (Components)

Value of Indicators

Operational

Introduction

Descriptive

Conclusion

AHP

Seminar

University Professor

HFIR’s Expert

State of the Art

Operational Sustainability Index

Parameters

Building Cost

Construction Time

Acoustic Range

Waste

Thermal Resistance

Others

CO₂ Emissions

Thermal Resistance

Fire Resistance
### Result

<table>
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<tr>
<th></th>
<th>I</th>
<th>VR1</th>
<th>VR2</th>
<th>VR3</th>
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<th>VC2</th>
<th>VC3</th>
<th>VC4</th>
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<td>0.43</td>
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<td>CMU</td>
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<td>0.61</td>
<td>0.02</td>
<td>0.43</td>
<td>0.52</td>
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**Fig. 9.6. Requirements values for the four alternatives**
Sensitivity Analyze

Environmental Indicator Assessment

Fig. 9.7. Environmental indicator values for the four alternatives
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

Fig. 9.8. Sustainability indexes of the four technologies with different requirement weights (economic (Ec), social (S), and environmental (En))
Multi-criteria decision-making method for assessing the sustainability of post-disaster temporary housing units technologies: A case study in Bam, 2003


Journal of Sustainable Cities and Society

Volume 20, January 2016, Pages 38–51

Received 2 July 2015, Revised 20 September 2015, Accepted 21 September 2015, Available online 25 September 2015
Conclusion
Conclusions

Main Conclusions

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

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

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

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 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.
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.
Conclusions

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.
First, that all possible steps should be taken to alleviate human suffering arising out of calamity and conflict, and second, that those affected by disaster have a right to life with dignity and therefore a right to assistance (Sphere Project, 2004).
Annex
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).
Urban Area Characteristics

Why is necessary to consider urban and rural areas individually?

- High Density
- Land Scarcity
- Land Price
- Displaced Population Abilities and Requirements
- Slums
- Lack of statistics
- Unsuitable shelters quality

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

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

<table>
<thead>
<tr>
<th></th>
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<td>830,022</td>
<td>845,291</td>
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<td>South-eastern Asia</td>
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<tr>
<td>Oceania</td>
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<td>427</td>
<td>468</td>
<td>515</td>
<td>534</td>
<td>563</td>
<td>591</td>
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</tbody>
</table>

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

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
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: Negative Effects Economic, Social, Environmental
Temporary Housing Characteristics

What are main reasons of Post-disaster housing problem?

Disaster -> Damages -> Displaced Population

- Climate Conditions
- Political Issues
- DP Conditions
- DP Pressures
- Others

- Short time construction
- Large amount of units

Human Errors

Sustainability Problems
- Environmental
- Social
- Economic
Temporary Housing Characteristics

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

- Rejection
  - Other Alternatives
    - Available
      - Yes
        - Perfect Results
          (It should be assessed)
    - No
      - Reality
        - Forced
          - Negative Effects
            - Minimize Negative Effects
        - Real Cases
          - Nothing

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-germans-children.org

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
This literature review is organized into three categories: (1) temporary housing *generic factors*, (2) *sustainability* aspects, and (3) *decision-making models*.

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

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

- 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

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

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.
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).
Integrated Approach

Post-disaster Housing Properties

**Provision**

- **Location**
  - Not Available (Need to be constructed)
  - Available (Does not need to be constructed)

- **Site Location**

- **Site Arrangement**
  - Prefabricated
  - Supply Kit

- **Construction System**
  - On-site
  - Community-Built
  - Self-Built

- **Labour**
  - Third party
  - Contractor

**Dispersed Settlement**

**Mass Settlement**

**Ready-Made**

**Community-Built**

**Self-Built**

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.

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

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.

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

Post-disaster Housing Properties

Provision

- Location
  - Site Location
  - Mass Settlement
  - Ready-Made
  - Supply Kit
- Site Arrangement
  - Prefabricated
  - On-site
  - Community-Built
  - Self-Built
- Construction System
  - Participation
  - Third party
  - Contractor
- Labour
  - Conventional
  - Non-conventional
- Material
  - Shape
  - Storey
- Form
  - Not Available (Need to be constructed)
  - Available (Does not need to be constructed)
Integrated Approach

Post-disaster Housing Properties

Second Life

Time-Scale

Provision

PDA Arrangement

Storage

Reuse

Landfill

Complete

Components

Property Condition

Function

Location

Others

Same

Others

Source: Hakan Arslana, Nilay Cosgun, 2008

Dining hall formed from four housing Units, Duzce

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

Post-disaster Housing Properties

Second Life

- Time-Scale
  - Provision
    - Storage
    - Complete
    - Property Condition
    - Function
    - Location
      - Same
      - Others
    - Components
      - Complete
      - Others
      - Same
    - Landfill
    - Reuse
      - Same
      - Others

- Second Life
  - Complete

PDA Arrangement

Case Study

Turkey, 1999, UMCOR,
Cassidy Johnson, 2007

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

The Requirements of Sustainability

- Sustainability Area
  - Economic
  - Social
  - Environmental

Fig. 4.2. Main requirements of PDH sustainability

Limitations to achieve sustainability

- Research Limitation
- Operational Barriers
  - Establishing a universal sustainability strategy
  - Characteristics of recovery program
What is the misunderstanding of sustainability?

Indigenous Material and Technologies

High Sustainability Index

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

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.
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

Planning → Provision/Construction → Operation → Second life

Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas
A Steps Scenario Strategy

Life cycle phases of temporary housing

Planning → Provision/Construction → Operation → Second life

- Planning:
  - Timing
  - Expense
  - Correspondence with Local Technologies
  - Resources Consumption (water, energy, material)
  - CO₂ Emission
  - Waste Material
  - Other Environmental Pollutions

- Operation:
  - Maintenance Cost
  - Culture
  - Health
  - Well-being
  - DP Distribution

- Second life:
  - Transition Timing
  - Transition Expense
  - Resources Consumption (water, energy, material)
  - Waste Material
  - CO₂ Emission
  - DP Desire to leave
Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas

Site Location Selection

Introduction

Case Study

Descriptive

MIVES

Main Chapters

Conclusion

Site Preparation

Utilities Quality

R1. Economic

C1. Invest Capital

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

I7. Neighbourhood Acceptability

I8. Landscape Respect

I9. CO2 Emission

R2. Social

C2. User Safety

R3. Environmental

C3. Flexibility

C4. Land use

C5. Emissions

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

V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{lk}} \cdot V_{CR_{lk}}

V = \sum_{i=1}^{j} \lambda_{lk} \cdot V_{lk} (\delta_{ind})

\delta Site Preparation

Utilities Quality

Sustainability Indexes of Alternatives

\delta
Introduction

Descriptive State of the Art

MIVES State of the Art

Main Chapters

Case Study

Conclusion

Site Location Selection

Population Covering

Maximize Coverage DP

Distribute Sites

Sustainability Indexes of Alternatives

\[ V_i = \sum_{i=1}^{j} \lambda_{R_i} \cdot V_{R_i} \]

\[ V_{R_k} = \sum_{i=1}^{j} \lambda_{CR_{lk}} \cdot V_{CR_{lk}} \]

\[ V = \sum_{i=1}^{j} \lambda_{lk} \cdot V_{lk} (\text{ind}) \]

R1. Economic

C1. Invest Capital

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

I7. Neighbourhood Acceptability

I8. Landscape Respect

I9. CO2 Emission

R2. Social

C2. User Safety

R3. Environmental

C3. Flexibility

C4. Land use

C5. Emissions

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

Introduction

Descriptive State of the Art

MIVES State of the Art

Main Chapters

Conclusion

**Distance from Source of Danger**

\[ V_i = \sum_{j=1}^{J} \lambda_{R_i} \cdot V_{R_i} \]

\[ V_{R_k} = \sum_{j=1}^{J} \lambda_{CR_{lk}} \cdot V_{CR_{lk}} \]

\[ V = \sum_{i=1}^{I} \lambda_k \cdot V_{lk} (S_{ind}) \]

---

**Danger Level**

**R1. Economic**

- C1. Invest Capital
  - I1. Land Price
  - I2. Cost of Site Preparation

- C2. User Safety
  - I3. Access
  - I4. Population Covering

- C3. Flexibility
  - I5. Distance from Source of Danger

- C4. Land use
  - I6. Property and Land Use Zoning

- C5. Emissions
  - I8. Landscape Respect

- I9. CO2 Emission

**R2. Social**

**R3. Environmental**

**Sustainability Indexes of Alternatives**
Fig. 8. 4. Values functions of the indicators and sub-indicators without considering weights based on applying the three methods for the optimal subsets
(X_1\%*V_{Ec})+(X_2\%*V_S)+(X_3\%*V_{En})=SI
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
I. Site Location Selection (Annex)

I.7. Neighbourhood Acceptability

I.8. Landscape Respect

I.9. CO2 Emission
Site Location Selection (Annex)

SubI3-1. DP Access

SubI3-2. Emergency Service Access
Temporary Housing Units (Annex)

- **I₁. Building Cost**
- **I₂. Reusability Cost**
- **I₃. Construction Time**
- **I₄. Risk Resistance**
- **I₅. Comfort**
- **I₆. Compatibility**
Temporary Housing Units (Annex)

- I7. Energy Consumption
- I8. Water Consumption
- I9. Waste Material
- I10. CO₂ Emissions
Temporary Housing Units (Annex)

Sub I₄.1. Natural Disaster Risk
Sub I₄.2. Fire Resistance
Sub I₅.1. Acoustic
Sub I₅.2. Thermal Resistance
Temporary Housing Units (Annex)

Sub I₆.1. Cultural Acceptance

Sub I₆.2. Flexibility

Sub I₆.3. Skilled Labour