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Agha Weam NASAN[1,2], Janusz SZPYTKO[2]
[1]*Aleppo University, Syria*
[2]*AGH University of Science and Technology (Akademia Górniczo-Hutnicza)*

THE CONCEPT OF RISK ANALYSIS OF ACTIONS TAKEN IN THE RECONSTRUCTION OF TECHNICAL INFRASTRUCTURE IN THE AREAS AFTER THE DISASTER ON THE EXAMPLE OF SYRIA

Koncepcja analizy ryzyka działań podejmowanych przy odbudowie infrastruktury technicznej na terenach po katastrofie na przykładzie Syrii

Abstract: *The subject of the article is the time-cost analysis of the risk of actions taken in the reconstruction of technical infrastructure (in particular housing) in the areas after the disaster on the example of Syria. As a result of the analysis of actions taken at the reconstruction of the technical (housing) infrastructure in the areas after the disaster, an attempt was made to identify the inconveniences in the management of the risk of targeted activity after the incident. Requests for efficient planning of technical (residential) infrastructure projects have been developed, including foreseeable future natural hazards.*
Keywords: risk assessment, post-disaster infrastructure, reconstruction concept model

Streszczenie: *Przedmiotem artykułu jest czasowo-kosztowa analiza ryzyka działań podejmowanych przy odbudowie infrastruktury technicznej (w szczególności mieszkaniowej) na terenach po katastrofie na przykładzie Syrii. W rezultacie analizy znanych z literatury działań podejmowanych przy odbudowie infrastruktury technicznej (mieszkaniowej) na terenach po katastrofie, dokonano próby identyfikacji zaistniałych niedogodności w zakresie zarządzania ryzykiem aktywności celowej po zdarzeniu. Opracowano wnioski w zakresie skutecznego planowania projektów infrastruktury technicznej (mieszkaniowej) z uwzględnieniem możliwych do przewidzenia przyszłych zagrożeń typu naturalnego.*
Słowa kluczowe: ocena ryzyka, infrastruktura po katastrofie, koncepcja modelu odbudowy infrastruktury

1. Introduction

Disaster is defined as “a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources” [1].There are three main types of disasters: (1) natural from forces in nature such as tropical storms, extreme heat or extreme cold, floods, earthquakes, and landslides, (2) natural disasters by humans such as Mudslides from deforestation, Famine and Desertification, (3) man-made disasters such as conflict and accidents [2].

In the recent decades, disasters have been increasing more and more around the world with destructive impacts [3]. Disasters cause a huge damage to the environment, people and technical infrastructure (in particular transport and housing). Housing is usually the element that is most extensively damaged or lost, and often represents the greatest share of loss in the total impact of a disaster on the national economy [4]. Housing reconstruction involves not only rebuilding houses, but also rehabilitation or reconstruction of infrastructure as an essential element linked to housing [5]. Where access and quality of infrastructure are key indicators priorities which infrastructure facilities need immediate reconstruction [6].

However, Post-Disaster Housing Reconstruction (PDHR) has been considered as one of the least successful projects in terms of implementation [7]. Where, post-disaster housing reconstruction projects are more complex than normal situations. In addition, PDHR projects include several challenges and risks with chaotic and dynamic environment [8].

Due to the crucial role of Post-Disaster Housing Reconstruction (PDHR) in human development and solving social and economic problems, there has been an increased worldwide interest to conduct risk management processes for more successful Post-Disaster Housing Reconstruction (PDHR) [9].

The concept of risk is defined as "uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality". Risk is the product of these two factors: the probability that the event might occur and the expected consequences of an event [10].

$$\text{Risk Importance Index (RII)} = \text{Probability} \times \text{Impact} \tag{1}$$

Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project. The objectives of project risk management are to increase the probability and/or impact of positive risks and to decrease the probability and/or impact of negative risks, in order to optimize the chances of project success [10].

A risk cannot be managed unless it is first identified and assessed. The concept of risk identification and analysis has been adopted in this paper towards more effective planning and successful response actions in post-disaster housing reconstruction.

This paper is organized as follows: In section 2, we introduce research target, then the used research methodology to meet the objectives of this research has been clarified in section 3. Section 4 presents research results represented firstly by general information

about research materials, then content analysis of previous related literature has been conducted towards investigating the key risks in Post-Disaster Housing Reconstruction (PDHR). In addition, section 4 presents time-cost risk analysis in the areas after the disaster on the example of Syria. Finally, we summarize our contributions and the conclusion in section 5.

2. Research target

This paper focuses on the concept of risk analysis of actions taken in the reconstruction of technical infrastructure, particularly housing, towards more effective planning for successful post-disaster housing reconstruction. The main target is broken down into three sub-objectives as follows:

- Defining & Classifying the Key Risks in Post-Disaster Housing Reconstruction (PDHR);
- Time-Cost Risk Analysis in the areas after the disaster on the example of Syria;
- Investigating the high–priority risks in terms of Time & Cost on the example of Syria.

3. Research methodology

An exploratory mixed approach has been used to meet the target of this research, this methodology is divided into three main stages: The first stage is qualitative in nature where data is collected via Literature Review of 30 related research materials ranging from 2008 to 2018 to build a checklist of the key risks in post disaster housing reconstruction.

While the second stage is Questionnaire Survey, which include questionnaire and semi-structured interviews, with /40/ experts involved in housing reconstruction on the example of Syria. The aim of this questionnaire survey is to check the adequacy of the initial Risk checklist in the selected Case study (Syria) as well as collect the required data for each risk (Probability /Impact on Cost/ Impact on Time). The third stage is Content Analysis where data obtained from the second stage will be used to perform Time-Cost Risk Analysis on the example of Syria. Moreover, the highest – priority risks in terms of Time & Cost will be determined on the example of Syria.

4. Results

4.1. General Information about Research Materials

Altogether 30 research materials for investigating risks in PDHR have been reviewed. In this section, we will present the results of descriptive analysis of these materials:
Year of publication: Altogether 30 research materials for PDHR, during the period from 2008 until 2018, have been reviewed. Fig .1 shows the number of reviewed materials per year.

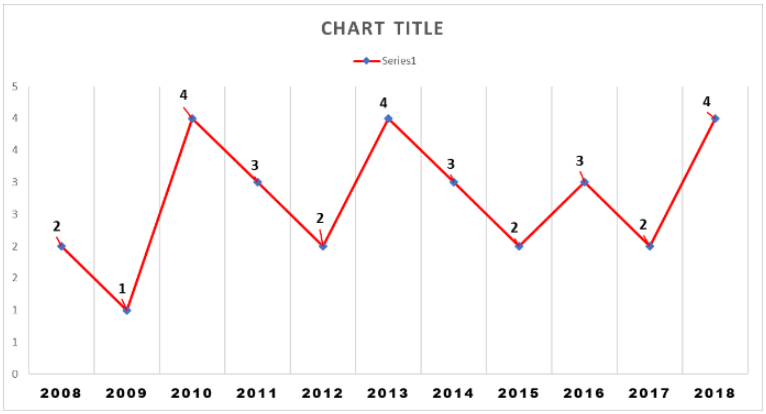

Fig. 1. Number of research materials between 2008 and 2018

Geography of Research Materials: The related research materials were from different countries and continents. Most of them are based in the Europe (50 per cent), followed by Asia and Australia (20 per cent), and America (10 per cent), fig. 2.

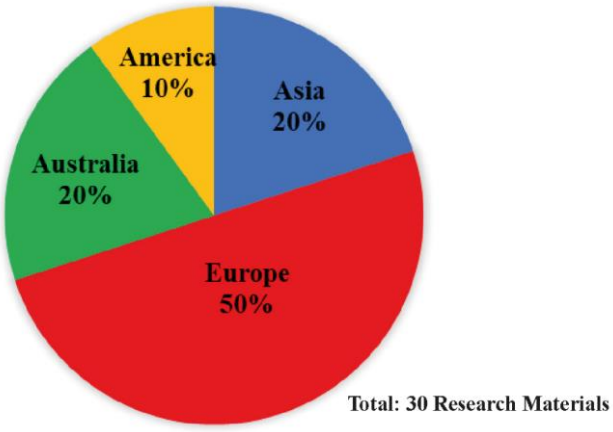

Fig. 2. Geography of research materials

4.2. Building a checklist of the Key Risks in PDHR

Altogether 30 research materials were reviewed to identify the potential risks in post-disaster housing reconstruction (PDHR). Through the qualitative content analysis of these materials, forty-five (45) risks have been extracted in post disaster housing reconstruction (PDHR).

Risks can be generally categorized in several ways according to its nature, impact, or with the project work breakdown structure. In this research. These (45 risks) were classified according to its nature within six categories as follows:

Technical (11 risks), Managerial & Organizational (11 risks), Resources (8 risks), Financial (4 risks), Environmental (7 risks) and Health& Safety (4 risks), table1.

Table 1

Risk Checklist in Post-Disaster Housing Reconstruction (PDHR)

	Code	Risk Name	References
Technical	TR01	Unclear Reconstruction Strategy	[4], [8], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23]
	TR02	Site Conditions	[13]
	TR03	Difficult Access to the Reconstruction Site	[8], [11], [12], [24]
	TR04	Inappropriate Land/ Use Planning	[12], [13], [19], [23], [25], [26], [27]
	TR05	Lack of Housing Damage Assessment Database	[8], [11], [17]
	TR06	Inadequate Project Plans	[8], [11], [12], [14], [17], [19], [20], [21], [28]
	TR07	Tight Schedule	[8], [11], [14], [15], [16]
	TR08	Insufficient Procedures for Quality Assurance and Management	[12], [14], [18], [19], [23], [25], [26], [28], [29]
	TR09	Unsuitable Design / Design Variations	[8], [11], [13], [14], [24], [28]
	TR10	Climate Conditions	[13]
	TR11	Risk of Using New Technology (due to the absence of expertise)	[29]
Man	MOR01	Unclear Contract	[8], [11] , [17], [27]

table 1 cont.

	MOR02	Problems with land tenure/rights/validation	[8], [11], [14], [17], [18], [19], [24], [29]
	MOR03	Insufficient Regulatory Mechanisms for Building Codes Enforcement	[8], [11], [12], [13], [17], [19], [22],[25], [26], [30]
	MOR04	Inappropriate & Rapid Selection of Contractors	[15], [16], [19], [28], [31]
	MOR05	Lack of Knowledge and Experience	[8], [11], [12], [13], [14], [18], [19], [20], [21], [30], [32], [33]
	MOR06	Ineffective Communication and Coordination among all the Involved Entities	[4], [5], [8], [11], [12], [13], [14], [15], [16], [17], [19], [20], [21], [24], [25], [26], [27], [28], [29], [30], [33], [34]
	MOR07	Unclear Stakeholders Roles and Responsibilities	[5], [8], [11], [12], [17], [19],
	MOR08	Lack or Inadequate Monitoring and Supervision	[13], [14], [19], [26]
	MOR09	Inadequate pre-qualification / Training of participating organisations	[8], [11], [12], [13], [14], [17], [19], [20], [21], [25], [26], [30], [33]
	MOR10	Lack of Community involvement	[4], [5], [8], [11], [12], [13], [14] , [17],[18], [19], [20], [21], [22], [23], [24], [25], [26], [30], [31], [33], [34], [35], [36]
	MOR11	Delays in Procurement Processes Arrangements	[15], [16], [24], [32]
Resources	RR01	Inadequate Project Resourcing Plan	[12], [14], [15], [16], [18], [19], [29], [30]
	RR02	Resource Allocation Problems	[12], [13]
	RR03	Material Supply Shortages	[8], [11], [12], [13], [14], [17], [18], [19], [23], [27], [29], [30]
	RR04	Poor Supply Quality (wrong and damaged material delivery)	[12], [13], [29]
	RR05	Lack or Shortage of Local Builders and Skilled Workers.	[8], [11], [12], [13], [14], [15], [16], [19], [20], [21], [23], [26], [29], [30], [33]

table 1 cont.

	RR06	Insufficient Numbers of Surveyors/Facilitators for Damage Assessment	[8], [11], [17]
	RR07	Competition for resources from other reconstruction projects	[15], [16]
	RR08	Lack of Guarantees on Imported Materials	[12]
Financial	FR01	Funding Problems	[8], [11], [12], [13], [14], [17], [19], [24], [25], [26], [27], [29], [31], [35], [36]
	FR02	Price Fluctuation	[8], [11], [12], [14], [15], [16]
	FR03	High Transportation Costs	[8], [11], [12], [15], [16], [32]
	FR04	High Overheads	[34]
Environmental	ER01	Ineffective Use of Natural Resources	[30]
	ER02	Ineffective Construction Waste Management	[19], [32]
	ER03	Lack of Utilization Debris Materials	[8], [12]
	ER04	Environmental Impact of Reconstruction Processes (Emissions)	[12], [29]
	ER05	Pollutions of Water	[32]
	ER06	Pollutions of Air	[32]
	ER07	Pollutions of Noise	[32]
Health& Safety	HSR01	Lack of Health and Safety Regulations	[12], [14], [19], [25], [26], [30]
	HSR02	Absence of Safety Supervisor during Reconstruction Processes	[30]
	HSR03	Insufficient Awareness of Unsafe Conditions in the Reconstruction Environment	[12], [13], [17], [20], [21], [25], [26], [30], [33]
	HSR04	Reuse of Substandard and Hazardous (Salvage) Materials	[12], [32]

4.3. Time-Cost Risk Analysis on the example of Syria:

After defining and classifying all the potential risks (45 risks) in post-disaster housing reconstruction (PDHR) in the previous stage. Risk analysis was performed by conducting questionnaire survey with /40/ experts involved in housing reconstruction on the example of Syria. The aim of this questionnaire survey is to check the adequacy of the risk checklist in the selected case study (Syria) as well as collect the required data for each risk (Probability /Impact on Time / Impact on Cost). Where experts were asked to assess the level of probability for each risk and its impact on time and cost separately using five-point scale {Very High (5), High (4), Medium (3), Low (2), Very Low (1)} .

The results revealed the adequacy of the risk checklist in the selected case study (Syria). Also, through the analysis of expert answers, the most likely risks and risk category were determined as well as the risks and risk category with the highest impact on cost & time. Furthermore, the Risk Importance Index (RII) in terms of time and cost was calculated for each risk and risk category depending on equation (1). Figure 3&4 illustrate the risk categories ranked descending according to Risk Importance Index (RII) in terms of time and cost respectively.

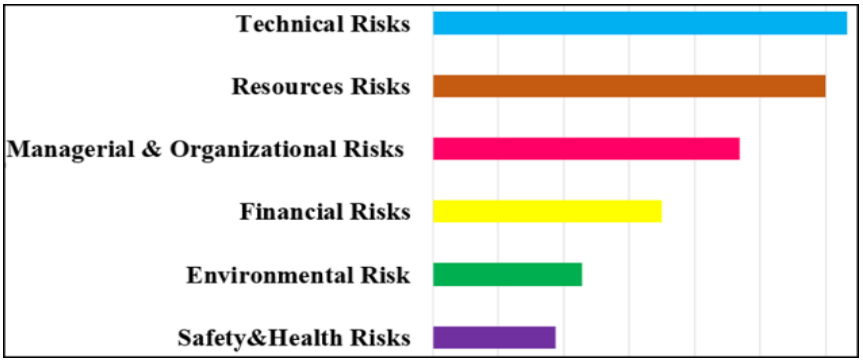

Fig. 3. Risk categories according to RII in terms of time

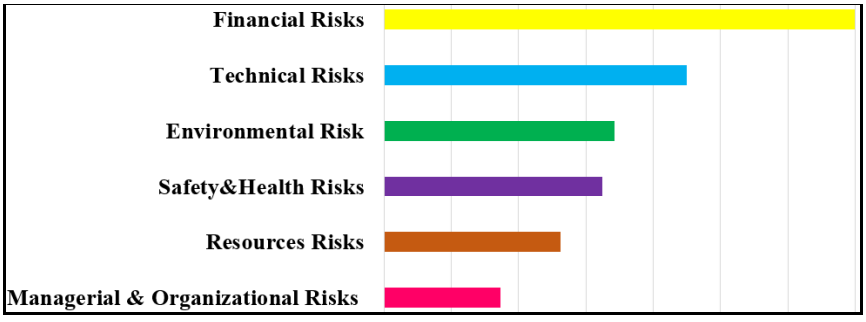

Fig. 4. Risk categories according to RII in terms of cost

It is worth noting that Technical Risks category is the most important in terms of time, while Financial Risks category is the most important in terms of cost.

4.4. Investigating the High-Priority Risks in terms of Time & Cost

After calculating the Risk Importance Index (RII) in terms of time and cost for each risk and risk category. These results were adopted to develop Risk Matrix in post-disaster housing reconstruction (PDHR). Where Risk Matrix is a grid for mapping the probability of each risk occurrence and its impact on project objectives if that risk occurs. This matrix presents the guideline to evaluate the relative priority of individual risks [10].

In this research, Risk Matrix (Probability*Impact) was developed on the example of Syria. Where the Codes of the 45 risks were mapped within Risk Matrix depending on Risk Importance Index (RII) in terms of Time and Cost. The color indication was used to evaluate risks as a Low-Priority (green), Middle-Priority (yellow) and High-Priority (red).

Figure 5 depicts the Risk Matrix in terms of time, where "TR06: Inadequate Project Plans" and "RR01: Inadequate Project Resourcing Plan" are the high-priority risks in terms of time. Moreover, risks in post-disaster housing reconstruction (PDHR) are classified in terms of time as following: 15 risks high-priority, 17 risks middle-priority and 13 risks low-priority.

		Risk Impact on Time				
		Very High (5)	High (4)	Medium (3)	Low (2)	Very Low (1)
Risk Probability	Very High (5)	TR06 , RR01			TR08	FR02 , ER06, ER07 , HSR03
	High (4)	TR07, TR10, MOR06	TR03, MOR09, RR02, RR07	TR09		FR04 , ER04, ER05 , HSR01, HSR02
	Medium (3)	MOR04	MOR07, MOR08, RR03, RR05	TR02, TR05, RR06, FR03	ER02, ER03	
	Low (2)	MOR11, FR01	TR01, MOR05	TR11, MOR01	TR04, RR04	ER01, HSR04
	Very Low (1)				MOR02, RR08	MOR03, MOR10

Fig. 5. Risk Matrix in terms of time

Figure 6 depicts the Risk Matrix in terms of cost, where "FR02: Price Fluctuation" is the high-priority risk in terms of cost. Moreover, risks in post-disaster housing reconstruction (PDHR) are classified in terms of cost as following: 7 risks high-priority, 17 risks middle-priority and 21 risks low-priority.

Risk Probability	Risk Impact on Cost: Very High (5)	High (4)	Medium (3)	Low (2)	Very Low (1)
Very High (5)	FR02		TR06	TR08, RR01, HSR03	ER06, ER07
High (4)	TR09, FR04		TR03	TR07, MOR09, RR02, HSR02	TR10, MOR06, RR07, ER04, ER05, HSR01
Medium (3)		ER02, ER03	TR02 ,TR05, RR06, FR03	MOR04, MOR08	MOR07, RR03, RR05
Low (2)			TR01, ER01	TR04 , MOR05, RR04, HSR04	TR11, MOR01, MOR11, FR01
Very Low (1)					MOR02, MOR03, MOR10, RR08

Fig. 6. Risk Matrix in terms of cost

5. Conclusion

This research approaches the nature of Post Disaster Housing Reconstruction (PDHR) environment and the critical need for applying Risk Management principles in PDHR towards achieving project objectives, minimizing losses and maximizing profits.

This research will contribute to practical knowledge by introducing an integrated methodology of Risk Analysis where Checklist of all the potential risks in PDHR (45 risks) was firstly developed. Also, this research presents the example of Syria as a case study to assess all the potential risks. Moreover, Risk matrix in terms of Time and Cost was developed to evaluate the relative priority of all previous risks and determine the high - priority risks from the beginning for more effective planning and successful response actions.

All above, this research lays the foundation for more research in the field of risk analysis in PDHR using different case studies towards further analysis and more successful management of housing reconstruction.

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