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Research Article

A Framework for Assessing Sustainability in Post-Disaster Reconstruction Projects on The Example of Syria

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Abstract

A disaster has the potential to cause significant damage to the environment, impact the wellbeing of individuals and affect every aspect of the urban system. The severity of disasters has increased in recent years because of not only the damage and loss of life but also the unsustainable nature of post-disaster reconstruction efforts. The reconstruction of infrastructure following a disaster is a dynamic and complex process, distinct from the construction of new infrastructure in non-disaster scenarios. It is therefore imperative that post-disaster reconstruction projects adopt a more development-oriented approach, incorporating the characteristics and strategies of sustainability.

This research addresses the nature of the post-disaster reconstruction environment and the critical necessity of ensuring the sustainability concept. This research proposes a novel and effective framework that is well-suited to the dynamic and complex nature of post-disaster reconstruction projects. The proposed framework comprises 50 key indicators, identified based on previous studies, which collectively contribute to the achievement of sustainability across its five dimensions. The framework is comprised of five dimensions, namely economic, social, environmental, technical and institutional. A questionnaire survey was conducted with the participation of 40 experts involved in post-disaster reconstruction projects in Syria. The objective was to assess the adequacy of the key indicators checklist and to determine the importance of each indicator. The relative importance of each indicator and the average importance of each dimension were calculated in order to determine which dimension was the most important. This was found to be the technical dimension. The findings of this study will facilitate the implementation of effective and sustainable management strategies for post-disaster reconstruction projects. This can be achieved by adopting the proposed framework and utilising sustainability indicators from the outset, thus preventing failure, enhancing resilience and reducing future vulnerabilities in the built environment.

Keywords: *Post-Disaster Reconstruction, Sustainability, Indicators, Assessment, Sustainable Reconstruction.*

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Introduction

In recent decades, the number of disasters has increased globally, with a notable rise in the destructive impact of such events (Guha-Sapir et al., 2010). A disaster can be defined as a significant disruption to the functioning of a community or society, resulting in extensive human, material, economic or environmental losses and impacts that exceed the affected community's or society's capacity to cope using its own resources (United Nations International Strategy for Disaster Reduction, 2009).

The United Nations Disaster Relief Organization (UNDRO) has identified three distinct phases following a disaster: immediate relief (days 1-5), rehabilitation (days 5-30), and reconstruction (days 30+). This paper will focus on the reconstruction phase, as it represents a crucial period for rebuilding social and economic assets, particularly in developing countries where affected communities are vulnerable to homelessness and severe humanitarian conditions (Bilau et al., 2018).

The field of post-disaster reconstruction (PDR) is replete with challenges. Moreover, reconstruction projects should not merely aim for the physical restoration of damaged or destroyed assets to pre-disaster levels; they should also pursue a form of reconstruction that is oriented towards development. This entails adapting strategies towards developmental projects (Amaratunga & Haigh, 2011). Furthermore, disasters are regarded as an opportunity to enhance the process of development through more sustainable practices (Amaratunga & Haigh, 2011). In order to surmount the myriad challenges that may arise and to achieve successful post-disaster reconstruction (PDR), it is imperative that the concept of sustainability be integrated throughout the entire lifecycle of reconstruction projects.

In 2007, UNEP defined sustainable post-disaster reconstruction (SPDR) as "an integrated approach to reconstruction, whereby environmental, technical, economic, social and institutional concerns are considered in each stage and activity of reconstruction to ensure optimal long-term results, not only in housing design and construction activities, but also in the provision of related infrastructure such as water supply and sanitation systems" (*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007).

This definition indicates that there are five key dimensions towards achieving sustainable reconstruction, which can be summarized as follows: These comprise economic, social, environmental, technical and institutional considerations. Furthermore, this definition allows for the formulation of a long-term strategy based on multiple and interrelated criteria, thereby enhancing the principles of "build back better".

In the aftermath of reconstruction processes following the Indian Ocean tsunami disaster in 2004, the phrase "Building Back Better (BBB)" became increasingly prevalent. This was accompanied by the development of a framework of key propositions for "Building Back Better" (Kennedy et al., 2008; Mannakkara et al., 2018).

The importance of the sustainability concept for post-disaster reconstruction (PDR) has been emphasised by numerous researchers (Caimi et al., 2013; Chang et al., 2010; F. Z. Ismail et al., 2017; Mohtat & Zargar, 2018; Peng et al., 2013; Tucker et al., 2014; Yi & Yang, 2013).

The majority of these studies concentrate on the formulation of practical guidelines and the identification of optimal practices through case studies, with the objective of ensuring sustainability in post-disaster reconstruction (*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bosher et al., 2007; Da Silva, 2010; F. Z. Ismail et al., 2017; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012). Others have presented a case study that elucidates certain aspects of the sustainability concept and the obstacles to its implementation (Lizarralde et al., 2009; Mohtat & Zargar, 2018; Ong et al., 2016).

Nevertheless, the number of published studies addressing the development of a framework for enhancing the sustainability concept remains limited, primarily due to the contemporary nature of the sustainability concept and the absence of concentrated interest in defining the key indicators for achieving sustainability in post-disaster reconstruction projects.

Additionally, the majority of extant frameworks address a single aspect of sustainability, such as community participation (Sadiqi et al., 2017), sustainable design (Blanco-Lion et al., 2011; Randall, 2010; Tucker et al., 2014), or resource management (Chang et al., 2010, 2011).

Conversely, Yi & Yang (2013) devised an operational framework comprising seventeen (17) sustainable factors for enhancing the sustainability performance of post-disaster reconstruction. Furthermore, the authors conducted a questionnaire survey pertaining to the Wenchuan Earthquake in China with the objective of acquiring a perceived importance index of the 17 selected factors and determining the critical factors for sustainable post-natural disaster reconstruction.

However, the authors did not categorize the selected factors within the framework of sustainability dimensions and failed to consider a number of other factors related to cultural, institutional and economic aspects. It must be acknowledged that the results of this study may not be directly applicable to other disaster types or countries.

In light of the aforementioned literature, it is evident that the existing frameworks for assessing sustainability in post-disaster reconstruction projects are inadequate. While existing literature addresses sustainability issues in the context of post-disaster reconstruction projects, there is currently no comprehensive framework that includes all the key indicators for assessing sustainability in such projects, taking into account the classification of these indicators within the sustainability dimensions.

In a field beset with challenges typically encountered in post-disaster reconstruction projects, there is an urgent need to draw upon existing literature on the subject, investigating the key indicators and developing a suitable framework for assessing sustainability in post-disaster reconstruction projects. This research will elucidate the aforementioned process.

Research Target

The objective of this research is to assist decision-makers in achieving successful and sustainable post-disaster reconstruction (PDR) projects by adapting a more effective framework that is better suited to the dynamic and complex nature of post-disaster reconstruction projects. The proposed framework incorporates the principal indicators that facilitate the attainment of sustainability, encompassing the five key dimensions of economic, social, environmental, technical and institutional factors.

Additionally, this research presents a case study of Syria as a means of assessing the relative importance of each indicator and the average importance of each dimension, with a view to determining the most important dimension and indicators.

Research Methods

In order to achieve the objective of this research, an exploratory mixed approach has been employed, comprising three principal stages. The following section provides an overview of the research methodology tools employed at each stage of the process.Literature Review

The initial stage was qualitative in nature, comprising a comprehensive literature review of 45 related research materials published between 2007 and 2018. The primary objective of this stage was to derive insights from previous and ongoing reconstruction programmes and identify the key indicators for achieving sustainability in post-disaster reconstruction. This section will present general information about the research materials in question.

Year of publication

A total of 45 research materials pertaining to SPDR were subjected to review over the course of a 12-year period, spanning from 2007 to 2018. **Figure 1** illustrates the number of research materials reviewed on an annual basis.

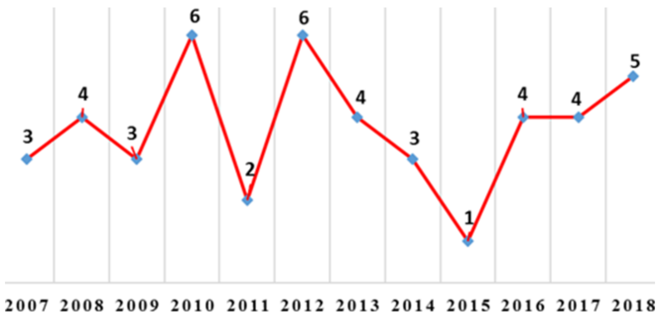

Figure 1. Number of Research Materials Between 2007 and 2018 [Own Study]

Despite the vital role of the sustainability concept in effective post-disaster reconstruction, the number of published studies remains insufficient.

Research Material Type:

In order to meet the research objectives, a review was conducted of a variety of related research materials, including research papers, books, and handbooks. **Figure 2** illustrates the distribution of the reviewed research materials by type. The majority of the reviewed research materials were research papers (84 per cent).

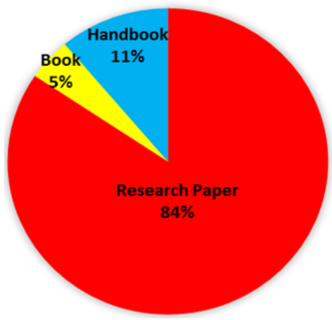

Figure 2. Distribution of Reviewed Research Materials by Type [Own Study]

Geography of Research Material

The geographical scope of the reviewed research materials encompassed a diverse range of countries and continents. The majority of the research materials were based in Europe (51%), followed by Asia (24%), Australia (16%), and America (9%), as illustrated in **Figure 3**.

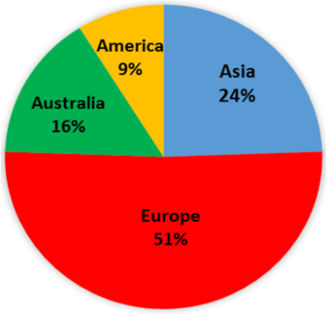

Figure 3. Geography of Research Materials [Own Study]

A total of 14 disasters were presented as case studies in some of the selected research materials, as detailed below: The 1962 Buin-Zahra earthquake (Iran), the 1995 Dinar Earthquake (Turkey), the 1999 Colombia Earthquake (Colombia), the 2001 Gujarat earthquake (India), the 2004 Indian Ocean Tsunami (Indonesia, Sri Lanka), the 2007 Cyclone Sidr (Bangladesh), the 2007 Peru earthquake (Peru). The 2008 Bihar flood in India, the 2008 Wenchuan earthquake in China, the 2009 Victorian Bushfires Recovery in Australia, the 2009 Cyclone Aila in Bangladesh, the 2010 Haiti earthquake in Haiti, the 2011 Christchurch earthquake in New Zealand and the 2013 Balochistan earthquakes in Pakistan.

It is evident that the majority of these case studies are situated in Asia (65 per cent), the continent that experiences the highest number of disasters and which is home to the majority of developing countries. **Figure 4** illustrates the geographical distribution of the case studies included in the selected research materials.

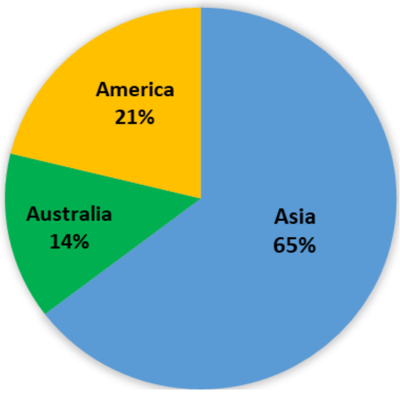

Figure 4. Geography of Case Studies in the Selected Research Materials [Own Study]

Although the majority of these researchers were based in developed countries, they have been drawn to focus on case studies, particularly from developing countries, where resources are scarce, populations are vulnerable and needs are acute.

Questionnaire Survey

The second stage of the study was a questionnaire survey, which included the administration of a questionnaire and semi-structured interviews to /40/ experts involved in reconstruction projects in Syria. The mean number of years' experience was 21.5.

The principal objective of this phase was to ascertain the suitability of the indicators checklist, which had been identified in the preceding phase, and to evaluate the significance of each indicator in the selected case study (Syria). The experts were requested to evaluate the level of importance of each indicator using a five-point Likert scale, with the following categories: {Very High (5), High (4), Medium (3), Low (2), and Very Low (1)}.

The following section presents the demographic data of the participants in the questionnaire survey, including their educational background, areas of specialization and their role in the project.

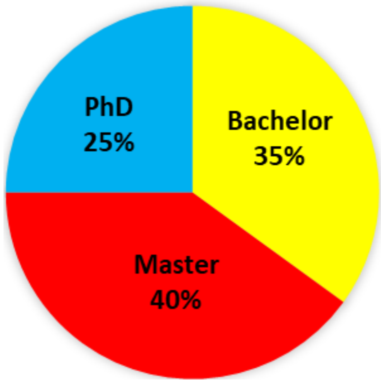

Figure 5. Education of Participants in the Questionnaire Survey [Own Study]

A total of 40% of the participants in the questionnaire survey have obtained a master's degree in engineering. **Figure 6** illustrates that 45% of participants are architects and 55% are civil engineers.

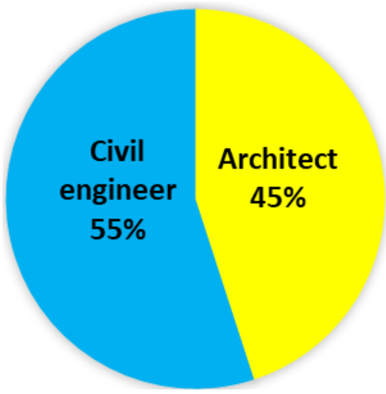

Figure 6. Specialization of Participants in the Questionnaire Survey [Own Study]

Figure 7 illustrates the role of participants in the questionnaire survey, wherein 40% of participants assume the role of project managers.

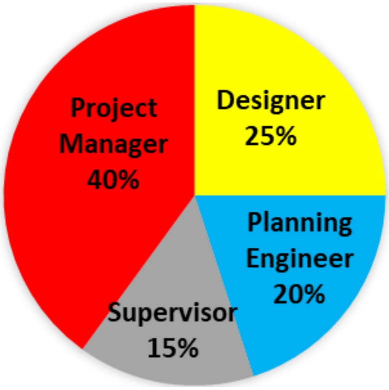

Figure 7. The Role of Participants in the Questionnaire Survey [Own Study]

Descriptive Analysis

The third stage was descriptive analysis, whereby data obtained from the second stage were employed to calculate the relative importance of each indicator and the average importance of each dimension. Furthermore, the most significant sustainability indicators were identified for each dimension.

Results and Discussions

The key indicators for sustainable post disaster reconstruction:

The results of the quantitative content analysis demonstrate that 82.2% of the reviewed research materials developed practical guidelines and presented best practices through case studies for ensuring sustainability in post-disaster reconstruction or explained some aspects of sustainability and the obstacles to its implementation or developed a framework for enhancing the sustainability concept without taking into consideration the indicators classification within the sustainability dimensions. Conversely, only 17.8% of the reviewed research materials classified the indicators within dimensions.

Within 17.8% of the reviewed research materials that classified the indicators within dimensions: 6.7% within the economic, social and environmental dimensions (3D), 2.2% within the economic, social, environmental and institutional dimensions (4D), and 8.9% within the economic, social, environmental, technical and institutional dimensions (5D). **Figure 8** illustrates this distribution.

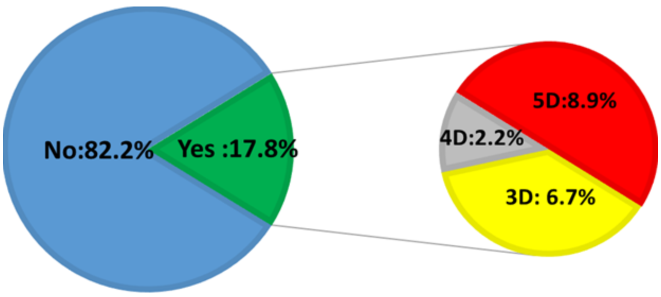

Figure 8. Overview of the Indicator's Classification According to Sustainability Dimensions

Nevertheless, the existing frameworks are lacking in that they do not encompass a comprehensive set of key indicators for evaluating sustainability in post-disaster reconstruction projects. Furthermore, those frameworks do not classify these indicators within the established sustainability dimensions.

This research has identified and classified fifty key indicators for sustainable post-disaster reconstruction (SPDR) within five dimensions (5D): economic (5 indicators), social (6 indicators), environmental (7 indicators), technical (20 indicators), and institutional (12 indicators). **Table 1** delineates the principal indicators for attaining sustainability in the context of post-disaster reconstruction (SPDR), classified within the 5D framework.

It is evident that the technical dimension encompasses the greatest number of indicators (20), followed by the institutional dimension, which comprises 12 indicators, then the environmental dimension with 7 indicators, the social dimension with 6 indicators, and finally the economic dimension with 5 indicators (**Figure 9**).

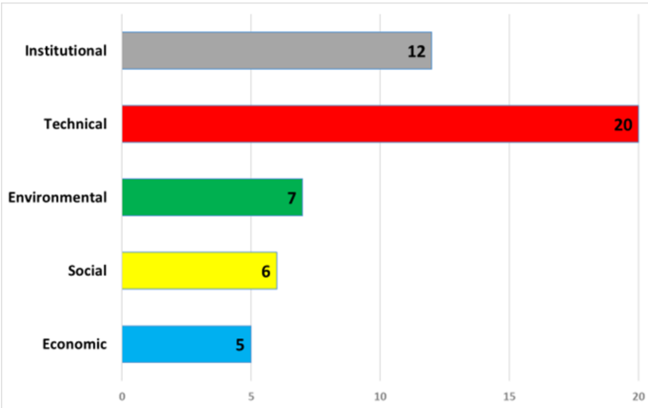

Figure 9. Indicators for SPDR Classified within Five Dimensions [Own Study]

Although a relatively holistic perspective was applied in the research, it is possible that some indicators were overlooked as a result of the design of the research methodology. The focus is on the key indicators, with no attempt to examine the related sub-indicators. For example, Indicator T11, entitled "Appropriate reconstruction methods to suit local contexts – cultural conditions", was mentioned, but the related sub-indicators, such as "Preserving cultural heritage", were overlooked.

It is recommended that future research expand the findings by investigating sub-indicators related to each key indicator of the fifty indicators, taking into account local sub-indicators in different countries.

Table 1. The Key Indicators for Sustainable Post Disaster Reconstruction (SPDR) [Own Study]

	Id	Indicator Name	Reference
skatEconomic	Ec1	Flexible & sufficient Funding Plan	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Da Silva, 2010; Francis et al., 2018; Liu et al., 2016; Lizarralde et al., 2009; Mannakkara et al., 2018; Ophiyandri et al., 2013; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	Ec2	Cost-Effectiveness	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Blanco-Lion et al., 2011; Caimi et al., 2013; Chang et al., 2010; Francis et al., 2018; Islam et al., 2018; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Randall, 2010; Roseberry, 2008; Sadiqi et al., 2012; Schneider, 2012; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014; Vahanvati, 2018; Vahanvati & Mulligan, 2017) .
	Ec3	Planning for livelihood support	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Blanco-Lion et al., 2011; Da Silva, 2010; Islam et al., 2018; Lu & Xu, 2016; Randall, 2010; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	Ec4	Designing to suit local contexts-economic conditions	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Blanco-Lion et al., 2011; Bornstein et al., 2013; Caimi et al., 2013; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Ophiyandri et al., 2013; Sadiqi et al., 2012; Schneider, 2012; Tucker et al., 2014)
	Ec5	Available local resource market	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Chang et al., 2010, 2011; Da Silva, 2010; Francis et al., 2018; Lizarralde et al., 2009; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Yi & Yang, 2013)
Social	S1	Consideration of Different Social Needs	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Da Silva, 2010; Dikmen, 2008; Francis et al., 2018; Islam et al., 2018; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Peng et al., 2013; Rafi et al., 2017; Randall, 2010; Sadiqi et al., 2012, 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
	S2	Well Organized Community participation	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed, 2011; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Blanco-Lion et al., 2011; Chang et al., 2011; Da Silva, 2010; Dikmen, 2008; Francis et al., 2018; Guarnacci, 2012; Islam et al., 2018; D. Ismail et al., 2014; F. Z. Ismail et al., 2017; Kennedy et al., 2008; Liu et al., 2016; Lizarralde et al., 2009; Lu & Xu, 2016; Lyons, 2009; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Ong et al., 2016; Ophiyandri et al., 2013; Peng et al., 2013; Rafi et al., 2017; Randall, 2010; Sadiqi et al., 2012, 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
	S3	Involving women in project (Equal opportunities between women and men)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Da Silva, 2010; Kennedy et al., 2008; Lizarralde et al., 2009; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	S4	Improving the quality of human life	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Francis et al., 2018; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	S5	Designing to suit local users' needs and living conditions	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Blanco-Lion et al., 2011; Bornstein et al., 2013; Caimi et al., 2013; Da Silva, 2010; Dikmen, 2008; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Ophiyandri et al., 2013; Peng et al., 2013; Randall, 2010; Sadiqi et al., 2012,

			2017; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	S6	Wider access to integrated public services	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Kennedy et al., 2008; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
Environmental	En1	Effective use of natural resources	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Blanco-Lion et al., 2011; Caimi et al., 2013; F. Z. Ismail et al., 2017; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Randall, 2010; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	En2	Ecology-friendly construction method to suit climatic conditions and environmental considerations	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Caimi et al., 2013; Da Silva, 2010; Francis et al., 2018; F. Z. Ismail et al., 2017; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Randall, 2010; Roseberry, 2008; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	En3	Environmentally friendly site management Minimizing surrounding emissions and Pollutions of (water, air, noise)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Blanco-Lion et al., 2011; Bornstein et al., 2013; Caimi et al., 2013; Francis et al., 2018; F. Z. Ismail et al., 2017; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Randall, 2010; Roseberry, 2008; Schneider, 2012; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014)
	En4	Designing to achieve Suitability for recycling	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Blanco-Lion et al., 2011; Da Silva, 2010; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Lu & Xu, 2016; Randall, 2010; Schneider, 2012; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	En5	Effective waste management (Low generation & disposal)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Blanco-Lion et al., 2011; Francis et al., 2018; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Randall, 2010; Roseberry, 2008; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Yi & Yang, 2013)
	En6	Selection of environmentally responsible suppliers and contractors	(Da Silva, 2010; Lizarralde et al., 2009; Lu & Xu, 2016; Randall, 2010)
	En7	Re-usability / Recycling capacity of debris	SKAT & IFRC (2012); Lu &Xu (2016); Lizarralde et al (2009); Klenk (2010); Ismail et al (2017); Schneider (2012); Blanco-Lion et al (2010); UNEP (2007)
Technical	T1	Appropriate land-use planning	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; Mannakkara et al., 2018; Palliyaguru & Amaratunga, 2008; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014; Yi & Yang, 2013)
	T2	Appropriate Site Selection (accessible and safe)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bosher et al., 2007; Chang et al., 2011; Dikmen, 2008; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Ong et al., 2016; Ophiyandri et al., 2013; Peng et al., 2013; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Sun et al., 2009; Tucker et al., 2014)
	T3	Effective Project Plan	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Chang et al., 2011; Da Silva, 2010; Francis et al., 2018; Hidayat & Egbu, 2010; D. Ismail et al., 2014; Lizarralde et al., 2009; Mannakkara et al., 2018; Ophiyandri et al., 2013; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	T4	Establish the project team's high professional staff (Availability of expertise & knowledge and	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Chang et al., 2011; Da Silva, 2010; D. Ismail et al., 2014; Lizarralde et al., 2009; Lu & Xu, 2016; Ophiyandri et al., 2013;

	skills)	Skat – Swiss Resource Centre and Consultancies for Development, 2012)
T5	Multilateral Coordination & Effective communication among all the stakeholders.	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed, 2011; Bilau et al., 2017, 2018; Bosher et al., 2007; Chang et al., 2010, 2011; Da Silva, 2010; Francis et al., 2018; Guarnacci, 2012; Hidayat & Egbu, 2010; D. Ismail et al., 2014; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Ophiyandri et al., 2013; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Yi & Yang, 2013)
T6	Effective project resourcing plan	(Bilau et al., 2017, 2018; Chang et al., 2010, 2011; Da Silva, 2010; Duyne Barenstein & Pittet, 2012; Hidayat & Egbu, 2010; Islam et al., 2018; D. Ismail et al., 2014; Kennedy et al., 2008; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
T7	Suitable Building Materials	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Blanco-Lion et al., 2011; Bornstein et al., 2013; Bosher et al., 2007; Caimi et al., 2013; Chang et al., 2010; Da Silva, 2010; Duyne Barenstein & Pittet, 2012; Guarnacci, 2012; Islam et al., 2018; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Peng et al., 2013; Randall, 2010; Roseberry, 2008; Schneider, 2012; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014; Yi & Yang, 2013)
T8	Mobilization and recruitment of local builders	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Caimi et al., 2013; Da Silva, 2010; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Tucker et al., 2014; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
T9	Designing to increase Durability (resistant to hazards) and stability	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Blanco-Lion et al., 2011; Bornstein et al., 2013; Bosher et al., 2007; Caimi et al., 2013; Da Silva, 2010; Islam et al., 2018; F. Z. Ismail et al., 2017; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Palliyaguru & Amaratunga, 2008; Rafi et al., 2017; Randall, 2010; Schneider, 2012; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Sun et al., 2009; Tucker et al., 2014; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
T10	Flexibility for future expansion	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Da Silva, 2010; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
T11	Appropriate reconstruction methods to suit local contexts - cultural conditions	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Bosher et al., 2007; Caimi et al., 2013; Guarnacci, 2012; D. Ismail et al., 2014; F. Z. Ismail et al., 2017; Liu et al., 2016; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Ophiyandri et al., 2013; Peng et al., 2013; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
T12	Adoption of innovative sustainable construction technology	(Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Bosher et al., 2007; Islam et al., 2018; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Lu & Xu, 2016; Mohtat & Zargar, 2018; Randall, 2010; Singh et al., 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
T13	Integrated risk reduction & management	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; Jha et al., 2010; Kennedy et al., 2008; Lizarralde et al., 2009; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Palliyaguru & Amaratunga, 2008; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Yi & Yang, 2013)
T14	Effective quality management (Assurance/Control)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Da Silva, 2010; Francis et al., 2018; Islam et al., 2018; D. Ismail et al., 2014; Lizarralde et al., 2009; Mannakkara et al., 2018; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for

			Development, 2012)
	T15	Maintaining safe, healthy, and socially just working conditions	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Da Silva, 2010; D. Ismail et al., 2014; Lizarralde et al., 2009; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	T16	Conduct regular monitoring and evaluation(M&E) of construction activities	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Da Silva, 2010; D. Ismail et al., 2014; Lizarralde et al., 2009; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Sun et al., 2009)
	T17	Establishment of Appropriate repair & maintenance programs	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed & Charlesworth, 2015; F. Z. Ismail et al., 2017; Lizarralde et al., 2009; Mohtat & Zargar, 2018; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	T18	Building the capacities of the participants (Provide skills training programs to support and strength the local skills)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Ophiyandri et al., 2013; Rafi et al., 2017; Randall, 2010; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	T19	Implement disaster management educational campaigns and the ability to guide the community	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; D. Ismail et al., 2014; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Mohtat & Zargar, 2018; Ophiyandri et al., 2013; Rafi et al., 2017; Randall, 2010; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
	T20	Learning from previous experience	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bosher et al., 2007; Lizarralde et al., 2009; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017)
Institutional	I1	Clear project contract on eligibility / /responsibility of donors all aid agencies, the beneficiaries and the implementing partners	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed, 2011; Da Silva, 2010; Francis et al., 2018; Guarnacci, 2012; Islam et al., 2018; D. Ismail et al., 2014; Lizarralde et al., 2009; Mannakkara et al., 2018; Ophiyandri et al., 2013; Peng et al., 2013; Randall, 2010; Sadiqi et al., 2017; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
	I2	Clear responsibility and support of government departments	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Ahmed, 2011; Da Silva, 2010; Francis et al., 2018; Guarnacci, 2012; Islam et al., 2018; D. Ismail et al., 2014; Lizarralde et al., 2009; Lu & Xu, 2016; Mannakkara et al., 2018; Ophiyandri et al., 2013; Peng et al., 2013; Randall, 2010; Sadiqi et al., 2017; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
	I3	Provision of building permits and planning permissions	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Lizarralde et al., 2009; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	I4	Effective cooperation between communities, local governments and private sector	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Chang et al., 2011; Da Silva, 2010; Jha et al., 2010; Kennedy et al., 2008; Lizarralde et al., 2009; Lu & Xu, 2016; Lyons, 2009; Mohtat & Zargar, 2018; Randall, 2010; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012; Vahanvati, 2018; Vahanvati & Mulligan, 2017; Yi & Yang, 2013)
	I5	Consider the overall development concerns and priorities of partners and stakeholders (donor, national and local partners, etc.)	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Lizarralde et al., 2009; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
	I6	Choosing an appropriate procurement strategy	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Chang et al., 2011; F. Z. Ismail et al., 2017; Lizarralde et al., 2009;

		Randall, 2010; Roseberry, 2008; Schneider, 2012; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I7	Access to appropriate method of humanitarian assistance	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Da Silva, 2010; Islam et al., 2018; Sadiqi et al., 2017; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I8	Adopting & improving resilient safe building Codes and Regulations	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; Kennedy et al., 2008; Mannakkara et al., 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I9	Adopting regulations and standards for energy saving design & low-carbon reconstruction practices	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Lu & Xu, 2016; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I10	Adopting Regulations and standards for quality management	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Bosher et al., 2007; Da Silva, 2010; Francis et al., 2018; Kennedy et al., 2008; Mannakkara et al., 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I11	Incorporate lessons learnt into revising policies and procedures for future disaster management practices	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Da Silva, 2010; Lizarralde et al., 2009; Mannakkara et al., 2018; Skat – Swiss Resource Centre and Consultancies for Development, 2012)
I12	Appropriate procedures for handling- over	(*After the Tsunami: Sustainable Building Guidelines for South-East Asia*, 2007; Bilau et al., 2017, 2018; Da Silva, 2010; Randall, 2010; Skat – Swiss Resource Centre and Consultancies for Development, 2012)

The importance for indicators on the example of Syria

Following the delineation of the pivotal indicators checklist for sustainable post-disaster reconstruction (SPDR) in the preceding phase, it is imperative to assess the suitability of the indicators checklist in the selected case study (Syria) and identify the most crucial indicators within each dimension, as well as determine the most significant dimension in the selected case study (Syria).

A questionnaire survey was conducted with 40 experts involved in post-disaster reconstruction projects, with Syria as a case study. The results demonstrated the suitability of the indicators checklist for SPDR in the selected case study (Syria).

The data obtained from the questionnaire survey were subjected to analysis in order to calculate the Relative Importance Index (RII) of each indicator, in accordance with the methodology set forth by Waris et al. (2014) Equation (1).

$$RII = \frac{\sum W}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \qquad (1)$$

W = weighting as assigned on Likert's scale by each respondent in a range from 1 to 5,

A = Highest weight (here it is 5)

N =Total number in the sample (here it is 40).

Moreover, the average importance of each dimension was determined.

Table 2 delineates the indicators for achieving sustainability in post-disaster reconstruction within the economic dimension, arranged in descending order of the relative importance index. It also presents the average importance of this dimension.

Table 2. The Relative Importance of the Economic Indicators [Own Study]

No	Indicator Name	RII
Ec1	Flexible & sufficient Funding Plan	92.5%
Ec2	Cost-Effectiveness	89 %
Ec4	Designing to suit local contexts-economic conditions	87.5%
Ec3	Planning for livelihood support	74%
Ec5	Available local resource market	72%
Average Importance for Economic Dimension.		83%

It is evident that the "Flexible & sufficient Funding Plan" is the most crucial indicator within the economic dimension, as indicated by its highest relative importance index (92.5%).

Table 3 delineates the indicators that facilitate sustainability for post-disaster reconstruction within the social dimension, arranged in descending order of relative importance according to the index. It also presents the average importance of this dimension. In the social dimension, the indicator "Designing to suit local users' needs and living conditions" is of the greatest importance, with the highest relative importance index (86.5%).

Table 3. The Relative Importance of the Social Indicators [Own Study]

No	Indicator Name	RII
S5	Designing to suit local users' needs and living conditions	86.5%
S4	Improving the quality of human life	75.5%
S6	Wider access to integrated public services	74%
S2	Well Organized Community participation	73.5%
S1	Consideration of Different Social Needs	70%
S3	Involving women in project (Equal opportunities between women and men)	65%
Average Importance for Social Dimension.		74.1%

Table 4 delineates the indicators for attaining sustainability in post-disaster reconstruction within the environmental dimension, arranged in descending order of relative importance according to the index. It also presents the average importance of this dimension. The indicator "Designing to achieve suitability for recycling" is of the utmost importance within the environmental dimension, as indicated by its highest relative importance index (88.5%).

Table 4. The Relative Importance of the Environmental Indicators [Own Study]

No	Indicator Name	RII
En4	Designing to achieve Suitability for recycling	88.5%
En3	Environmentally friendly site management Minimizing surrounding emissions and Pollutions of (water, air, noise)	84%
En2	Ecology-friendly construction method to suit climatic conditions and environmental considerations	83.5%
En7	Re-usability / Recycling capacity of debris	78%
En5	Effective waste management (Low generation & disposal)	77.5%
En6	Selection of environmentally responsible suppliers and contractors	75.5%
En1	Effective use of natural resources	66%
Average Importance for Environmental Dimension.		79%

Table 5 delineates the indicators pertaining to the realization of sustainability in post-disaster reconstruction within the technical dimension, arranged in descending order of relative importance according to the index. Additionally, it presents the average importance of this dimension. The indicator "Adoption of innovative sustainable construction technology" is of the greatest importance within the technical dimension, with a relative importance index of 92.5%.

Table 5. The Relative Importance of the Technical Indicators [Own Study]

No	Indicator Name	RII
T12	Adoption of innovative sustainable construction technology	92.5%
T5	Multilateral Coordination & Effective communication among all the stakeholders.	91%
T9	Designing to increase Durability (resistant to hazards) and stability	91%
T7	Suitable Building Materials	90%
T11	Appropriate reconstruction methods to suit local contexts - cultural conditions	89.5%
T4	Establish the project team's high professional staff (Availability of expertise knowledge & skills)	89%
T13	Integrated risk reduction & management	87%
T14	Effective quality management (Assurance/Control)	85%
T15	Maintaining safe, healthy, and socially just working conditions	85%
T16	Conduct regular monitoring and evaluation(M&E) of construction activities	83.5%
T17	Establishment of Appropriate repair & maintenance programs	83.5%
T18	Building the capacities of the participants (Provide skills training programs to support and strength the local skills)	82.5%
T19	Implement disaster management educational campaigns and the ability to guide the community	82.5%
T20	Learning from previous experience	82.5%
T3	Effective Project Plan	82%
T6	Effective project resourcing plan	78.5%
T8	Mobilization and recruitment of local builders	77.5%
T2	Appropriate Site Selection (accessible and safe)	77%
T10	Flexibility for future expansion	77%
T1	Appropriate land-use planning	72.5%
Average Importance for Technical Dimension.		84%

Table 6 delineates the indicators for attaining sustainability in post-disaster reconstruction within the institutional dimension, arranged in descending order of relative importance according to the index. It also presents the average importance of this dimension. The indicator "effective cooperation between communities, local governments and the private sector" is identified as the most important within the institutional dimension, with a relative importance index of 91%.

Table 6. The Relative Importance for the Institutional Indicators [Own Study]

No	Indicator Name	RII
I4	Effective cooperation between communities, local governments and private sector	91%
I1	Clear project contract on eligibility / roles /responsibility of donors all aid agencies, the beneficiaries and the implementing partners	89%
I8	Adopting & improving resilient safe building Codes and Regulations	87%
I9	Adopting regulations and standards for energy saving design & low-carbon reconstruction practices	87%
I10	Adopting Regulations and standards for quality management	87%
I11	Incorporate lessons learnt into revising policies and procedures for future disaster management practices	79%
I2	Clear responsibility and support of government departments	78%
I5	Consider the overall development concerns and priorities of partners and stakeholders (donor, national and local partners, etc.)	77%
I6	Choosing an appropriate procurement strategy	75%
I12	Appropriate procedures for handling- over	75%
I7	Access to appropriate method of humanitarian assistance	73%
I3	Provision of building permits and planning permissions	69%
Average Importance for Institutional Dimension.		80.7%

Once the Relative Importance Index (RII) had been calculated for the fifty key indicators within the five dimensions. As previously stated, the dimensions are economic, social, environmental, technical, and institutional. The indicators were then classified according to the Relative Importance Index (RII), as illustrated in **Table 7**.

Table 7. The Indicators Classification according to RII for each dimension [own study]

	Very High (80-100%) (27 Indicators)	High (60-80%) (23 Indicators)	Medium (40-60%)	Low (20-40%)	Very Low (0-20%
Economic	Ec1; Ec2; Ec4	Ec3; Ec5			
Social	S5	S1; S2; S3; S4; S6			
Environmental	En2; En3; En4	En1; En5; En6; En7			
Technical	T3; T4; T5; T7; T9; T11; T12; T13; T14; T15; T16; T17; T18; T19; T20	T1; T2; T6; T8; T10			
Institutional	I1; I4; I8; I9; I10	I2; I3; I5; I6; I7; I11; I12			

Table 7 demonstrates that all fifty indicators were classified according to the calculated RII within only two groups: those of very high importance (27 indicators) and high importance (23 indicators).

Figure 10 illustrates the percentage distribution of the principal indicators for each dimension according to RII, classified into two groups (Very High/High).

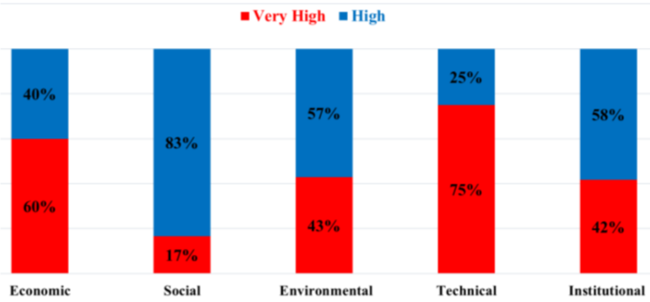

Figure 10. The Distribution of the Key Indicators for Each Dimension According to RII

It is evident that the majority of the economic and technical indicators were classified as being of very high importance, whereas the majority of the social, environmental and institutional indicators were classified as being of high importance.

The aforementioned factors contribute to the significance of this section, as it serves to assess the suitability of the selected case study indicators. Secondly, the most important indicator within each dimension must be identified, as well as the most important dimension in the selected case study, which in this instance is Syria.

Notwithstanding the classification of all these indicators according to RII within only two categories (very high, high), there is an urgent need to determine the most important indicators within each dimension, taking into consideration the ranking of importance of these indicators in terms of achieving SPDR.

It is also noteworthy that the technical dimension is the most important, with an average importance rating of 84%. This is followed by the economic dimension, which also has an average importance rating of 83%. The institutional dimension has an average importance rating of 80.7%, while the environmental dimension has an average importance rating of 79%. The social dimension is the least important, with an average importance rating of 74.1%. This is illustrated in **Figure 11**.

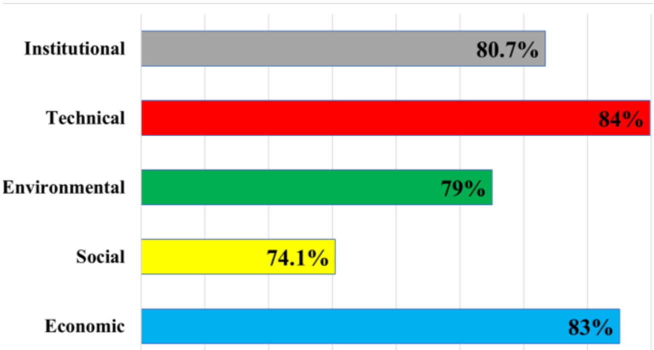

Figure 11. The Average Importance for each Dimension

The aforementioned results will assist reconstruction planners and practitioners in evaluating the most crucial dimensions, namely the technical dimension, and in assigning greater significance to the ranking of these indicators within each dimension, thereby facilitating the attainment of sustainable and successful post-disaster reconstruction projects.

Conclusions

The issue of sustainable post-disaster reconstruction (SPDR) is regarded as a pivotal challenge, necessitating the identification and assessment of pivotal sustainability indicators from the outset of post-disaster reconstruction projects.

This paper emphasises the necessity of ensuring sustainability in post-disaster reconstruction projects. The optimal integration of five key dimensions – economic, social, environmental, technical and institutional – is essential for achieving sustainability. This paper puts forward a novel and efficacious framework that is well-suited to the dynamic and intricate nature of post-disaster reconstruction projects. The proposed framework comprises a checklist of all the key indicators necessary for achieving sustainability, amounting to 50 in total. The aforementioned indicators were classified according to five dimensions: The framework comprises five economic, six social, seven environmental, twenty technical and twelve institutional indicators.

In comparison to previous research, there is currently no comprehensive framework that encompasses all the essential indicators for achieving SPDR. The existing frameworks tend to focus on a specific aspect of sustainability, while failing to adequately address the multitude of indicators that are crucial for evaluating the full spectrum of sustainability dimensions. This framework contributes to the existing body of knowledge by providing post-disaster reconstruction planners and practitioners with a more comprehensive checklist of all the key sustainability indicators, classified within five dimensions: economic, social, environmental, technical and institutional.

Furthermore, this paper employs the example of Syria as a case study to evaluate the relative importance index (RII) of each indicator and ascertain the most pivotal indicator within each dimension, with a view to determining the ranking of importance of indicators in the context of sustainable and successful post-disaster reconstruction projects. Moreover, the average importance of each dimension was calculated in order to ascertain which dimension was the most important in achieving SPDR.

Although the case study presented here is country-specific, it is hoped that the findings will provide a basis for future research to identify other sub-indicators related to each key indicator of the fifty key indicators, taking into account local sub-indicators in other disaster contexts and different countries. It is therefore evident that further research is required in this field with the objective of achieving a more resilient and sustainable built environment in the aftermath of disasters.

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