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ARTICLE

Multi-criteria sustainability risk management for post-war residential re-construction: the case of Damascus

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Abstract
The Syrian conflict nine years of destruction have had catastrophic influence on the built environment. Post-war Residential Re-construction Projects (PRRP) have been one of the most challenging and controversial responsibilities. PRRP play vital role in building back to better level of sustainability, mitigating risks and resilience, providing housing for traumatised displaced people while coping with the war consequences. Hitherto, more sustainable PRRP are found to be riskier for construction professionals compared to traditional projects. Sustainability Risk Management (SRM) can be a challenging mission where multiple interrelated criteria exist. This research is set to identify and assess sustainability risks associated with more sustainable PRRP in Damascus and to understand how the Syrian construction professionals perceive these risks. The research study enhances a survey and interviews' findings to develop a multi-criteria SRM framework that can be perceived as a decision-support tool to assess sustainability risks in Damascus PRRP. The survey revealed that while the sustainability risk categories weightings are 38%, 24%, 39% for economic, environmental and social risks respectively, the overall response categories weightings are 44%, 31%, 25% for economic, environmental and social responses respectively. The top five risks found are: expenses exceed anticipated, absence of sustainable technology, delays in planning for alternative social homes, unclear allocation of responsibilities and lack of qualified professionals. The interviews looked beyond the current prevailing approaches to sustainability risks while assessing the proposed multi-dimensional conceptual framework. The research framework enhances interrelatedness in management principles among: sustainability assessment, RM and multi criteria decision making in the post-war context. These findings are significant as this is the first-hand experience gathered from Damascus PRRP. It symbolises a turning point in Syrian construction; from traditional to sustainable housing, which will positively influence construction companies' sustainability awareness in reconstruction process.

Keywords Sustainability · Build back better · Risk management · Residential buildings · Reconstruction · Syria · Post-war

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1 Introduction

The Syrian war has had catastrophic influence on the built environment. The Syrian crisis has caused massive damage to the Syrian major cities' infrastructure with catastrophic humanitarian consequences. The housing sector is the first-hardest hit, accounting for 65% of the war total damages (WBG, 2017). This has led to the displacement of 11 million (half of the Syrian population), out of which 8 million have been internally displaced seeking safety (Khaddour, 2021a). The constant waves of migrants have become influential factor in the life of major cities like Damascus, the capital of Syria, consisting of its residents and immigrants (permanent and temporary). This population make it challenging for Damascus to provide housing to the groups that have been socially, culturally and economically established in this major city (Abdin, 2017). Damascus therefore suffers from these phenomena that hinder its Post-war Residential Re-construction Projects (PRRP) planning and its post-war developmental, socioeconomic and environmental structures.

There is a pressing need for a series of re-construction sustainable measures, in order to minimize the risks and maximize the opportunities that post-conflict presents. The post-war reconstruction in Syria needs to embrace sustainability especially in terms of energy efficiency and socio-economic acceptability (Ahmed et al., 2017). This will support achieving "build back better" (BBB) for post-disaster recovery and reconstruction, proposed by the Third World Conference on Disaster Risk Reduction in 2015 (Holden et al., 2017; Leal Filho et al., 2019). The conference identified three BBB interrelated strategic goals: risk management, sustainable development and climate change (Holden et al., 2017). Therefore, risk management and the response to climate change are the foundation for achieving sustainability broad goals in post-war reconstruction. In Syria, the recent government led BBB plans and programs are challenged by the limited resources, increased traditional building material prices and energy costs and poor regulatory incentives by the government (Khaddour, 2021b; Hassan & Beshara, 2019).

Sustainable projects are found to be riskier for construction professionals compared to traditional projects (El-Sayegh et al., 2018; Ismael & Shealy, 2018; Rafindadi et al., 2014). Sustainability risks may occur due to adopting new techniques that require density of project decisions because of sustainability goals in addition to common goals such as cost, schedule, and safety. This is not surprising as sustainable buildings utilize the up-to-date construction technology and innovative building materials to achieve sustainability; thus, these processes are potentially plagued with complex risks (Khaddour, 2021b). Without prior experience, the outcomes of sustainable projects appear risky (El-Sayegh et al., 2018). For example, there are potential problems in using innovative building materials because they may not have undergone adequate testing or a shortage of qualified personnel to use them properly. Moreover, handling authority regulatory requirements (e.g., contractor selection, using land, and recycling) is frequently not straightforward. Therefore, the risks associated with more sustainable building requirements need to be managed appropriately to achieve PRRP objectives.

Conversely, the term risk in this research means the uncertainties that have negative impact on achieving project objectives. In this sense, RM is a formal process of identifying, analysing and responding to risks throughout the project lifecycle (Ismael & Shealy, 2018). More importantly, sustainability risk management (SRM) is integrating sustainability perspectives to project RM (Shealy et al., 2017). Also, SRM encourages additional considerations (economic, environmental and social) to traditional RM focus (time, cost and quality).

Assessing sustainability risks in construction industry can be a challenging mission as multiple interrelated criteria exist (Khaddour, 2021b). As a solution, multi criteria decision making (MCDM) can be enhanced for assessing sustainability multiple interrelated criteria based on each country's local housing characteristics (Hosseini et al., 2016). In fact, MCDM has already been used to assess sustainability and to make decisions on: selecting sustainable site location of post-disaster temporary housing in urban areas (Hosseini et al., 2016), assessing building-integrated green technologies (Si et al., 2016), and choosing the best sustainable option for construction management. Erdogan et al. (2019) recommended enhancing MCDM for more sustainable construction management and solving seventeen categories related to construction technology problems. It can be concluded that, as risk is an integral part of decision making, RM is one of the MCDM uses.

Despite of the increased international awareness to SRM as a critical part of any successful construction management strategy, the Syrian construction sector has not shown any interest in this area. Out of the limited prior research on RM practices in Syria, Maya (2016) investigated a number of PRRP performances and recorded weak performance particularly with regards to cost and duration caused by the weak use of project management techniques in general and RM in particular. Similarly, Dabag (2015) argued that most PRRP failed to accomplish the planned objectives. The research found that RM maturity for 20 PRRP was 1.8 on a scale of 1–5; the lowest ranking within the nine construction management knowledge areas (Dabag, 2015). This indicates a sturdy relationship between risk managing and PRRP success. The absence of structured RM process for PRRP was replaced by project manager's judgment (Dabag, 2015). This was supported by Amoudi (2016) who identified the top five risks in PRRP (on scale of 1–5) as follows: increased material prices at 4.79, shortage of finance at 4.7, fuel shortage at 4.7, unclear contractor specification at 4.7 and shortage of material and equipment at 4.67. The mentioned risks were neither categorized nor comprehensive to include the PRRP's sustainability risks. Thus, prior research agreed that RM should be a critical part of PRRP construction management strategy in order to improve Syrian construction professionals' ability to assess sustainability risks and therefore reduce the risk of PRRP failure. Thus, SRM appear to be hard to implement in the Syrian context. This is because the importance and the causes of risks vary within construction projects depending on the social, cultural, economic, political and environmental conditions, which differ from country to another (Ismael & Shealy, 2018; Rafindadi et al., 2014). For that, a multi-criteria SRM approach is required to consider PRRP multiple variables: construction techniques and approaches, community characteristics, stakeholder priorities, the geographic location, regional energy sources and the post war economic, social and environmental situation.

Since Syria is recovering from a long-term conflict, significant risks may prevent the implementation of sustainable PRRP. While PRRP sustainability risks reduction is becoming increasingly recognised as a key challenge for BBB, very little work has been undertaken to date to identify how this could be done. Therefore, identifying PRRP potential sustainability risk factors and weights of perceived probability plays a vital role in improving PRRP performance and achieving sustainability objectives. Syrian construction companies are in a pressing need for a series of environmental socioeconomic risk measures. This research study develops an integrated management framework of sustainability levels, RM functions and MCDM for sustainable PRRP in Damascus. The used approach will assess Syrian construction professionals setting priorities and managing risks systematically for more sustainable PRRP which can be a novel way for improving PRRP performance in Damascus post-war context. This research will conceptually justify multi-criteria SRM feasibility and benefits meriting future research.

2 Research objectives

Before, during and after the war, Syria has faced several risks caused by the adoption of ill-considered decisions towards sustainable residential projects, which was proposed as a solution for informal residential settlements in big cities. In fact, the organizational decision making errors of Syrian non-sustainable urban planning have influenced the escalation of the Syrian crisis in the first place (Abdin, 2017). Being a large metropolis, Damascus introduced the term sustainable residential projects in the 2000s to address the massive issue of informal settlements (Clerc, 2015). Hitherto, the competition between upgrading regularization or renewal (destruction and reconstruction) for informal settlement has delayed decisions making and implementation in Damascus (Clerc, 2015). The beginnings of the so called "Arab Spring" elsewhere in the region influenced the orientation of these projects towards more socially acceptable options for regularization (Abdin, 2017). In return, war destruction, displacements, economic collapse, resources limitation, running out of petroleum and shortage on electricity supplies, have led to put all sustainable residential projects options back on the table for reconsideration in the prospects of future reconstruction (Khaddour, 2023). This has challenged Syrian construction companies with a pressing need for a series of environmental socio-economic risk measures (Abdin, 2017). Therefore, all sustainability risks involved in the decision making procedure should be considered.

As sustainability in PRRP is a multi-criteria and multi participant procedure, it was necessary to limit the scope of the research and to concentrate on identifying the major sustainability risks and response measures from Damascus construction companies' perspective. This approach can provide decision makers the necessity to consider the three parameters in PRRP assessment process (sustainability levels, RM, and MCDM). Further benefits of used approach include that it helps to organize SRM process efficiently, to reduce the MCDM complexity and subjectivity and decrease possible disagreements between the team members.

Drastically, the data used for calculating sustainability risks in previous international research are different to those used in Syria due to the differences in social, demographic and economic conditions and so the results are of limited value. In the light of the very minimal information available regarding sustainability risks in Syria's PRRP, this research is set to identify and assess sustainability risks associated with more sustainable PRRP in Damascus and to understand how the Syrian house builders perceive these risks. This paper looks beyond the current prevailing approaches to sustainability assessments and explores sustainability risks and responses in order to provide a multi-criteria SRM framework. In order to understand how the Syrian construction professionals, perceive risks associated with more sustainable PRRP, the aims of the research described in this paper are:

- To identify major sustainability risks affecting the process of PRRP in Damascus.
- To assess identified risks based on their risk severity (impact and probability).
- To identify major risk responses and mitigation measures that could be taken to improve sustainability of PRRP.
- To assess identified risk responses and to classify selected responses into one of the three risk allocation types (avoid, mitigate, transfer).
- To develop multi-criteria SRM framework that can be perceived as a decision-support tool to assess risks in Damascus PRRP.

3 Damascus PRRP metamorphosis

Damascus is Syria's principal city. It is surrounded by the lands of the Governorate of Rural Damascus, as can be seen in Fig. 3a. The city of Damascus is integrated with its surroundings, to such an extent that it is impossible to differentiate the administrative boundaries separating them in the contiguous built-up areas. For this research study the term Damascus metropolis comprises the city and its contiguous surroundings in order to form an accurate picture of the situation in the city. This is because it is impossible to obtain any separate data or indicators for the city of Damascus without its contiguous surroundings (Abdin, 2017).

Damascus is the second hardest hit city in the Syrian conflict, flowing from Aleppo, with a destruction percentage of about 55% (ESCWA, 2016). Nowadays, the difficulty of finding accommodation is one of the main problems facing the poor and middle classes incomes due to the giant gap between house prices and incomes (Wind & Ibrahim, 2020). As a result, informal residential settlements have constantly expanded to such an extent that they form a ribbon along the main roads around the city and even extend to the agricultural land in Ghouta and the state-owned land on the slopes and foothills of Mount Qasioun, as can be seen in Fig. 1. About twenty informal settlements have been established within Damascus boundaries, Fig. 2, which are virtually surrounding the city from all sides, as can be noticed in Fig. 3b. These settlements are mainly intended for residential purposes; housing about 50% of the city's inhabitancy (Kassouha, 2020). The fairly standard features of these informal settlements are: high population density of 400 to 1,200 persons per hectare, insouciant construction, narrow street width, absence of green spaces, irregularly connected to public infrastructural services (sewers, drinking water, electricity, telephones, roads) and partly or totally destroyed during the conflict (Abdin, 2017; Clerc, 2015), as can be seen Fig. 2. Damascus' destruction is concentrated in the informal settlements with 16% of destruction in "Gouta Sharkia" informal settlements of: Barza, Kaboun, Jobar, Zamalka, Irbeen and Ain Tarma. Besides, "Douma" and "Harsta" districts were affected with 19%

Fig. 1 Informal settlements (Mezeh 86) built on the slopes of Qassiun mount not far from Damascus city centre. (*Source*: the author camera, 2021)

Fig. 2 Partly distroied informal settlement which is included in Damascus post-war upgrading programme

of distruction, while "Jaramana" and "Akraba" at 6.5% damage and in the "Gouta Garbia" and "Dahiet Koudsaya" neighbourhoods at 13.5% (ESCWA, 2016).

The city of Damascus is administered in accordance with the areas shown in Fig. 3(a). Damascus City Governorate can be seen in the middle whereas the Governorate of Rural Damascus comprises four geographical districts: the Eastern Ghouta district, the Southwestern Ghouta district, the Barada River Valley region, and the mountainous district. Fig. 3 indicates an unprecedented growth during the conflict, which led to a vast expansion of informal settlements forming a ring around Damascus city. The public authorities have acquired vast areas of land, without appropriate compensation, for numerous PRRP which have not been implemented yet. Fig. 3(d) shows the areas of armed conflict (in green). Since the beginning of the Syrian conflict in 2011, numerous incidents took place in conservative neighbourhoods of Damascus. Damascus rural areas and even some of the city's suburbs witnessed many battles, and the whole city suffered from road closures, a proliferation of security checkpoints. This led to mass migration from the conflict zones to safer parts of Rural Damascus. Figure 3b–d, illustrates the constant relationship among the informal settlements districts (in yellow), the areas of armed conflict (in green) and the location of the announced PRRP (in pink). Figure 3 demonstrates the accumulated housing planning mistakes that had a direct or indirect influence in triggering the crises. It is the failure to address communities' ethnic, regional, tribal and confessional concerns in the planned and unplanned districts (Abdin, 2017). These communities feeling of injustice and marginalization was transformed into an armed conflict when it was aggravated by other special conditions (Abdin, 2017). Therefore, planning for more sustainable PRRP must consider a number of important issues: these communities housing demands, the post-war socioeconomic needs, and provision of the requisite health, safety and environmental services in PRRP performance and objectives.

Sustainable PRRP were planned in order to BBB in a way that eliminate the fast unplanned growth of Damascus. Damascus' re-construction plan focuses on re-building the informal housing/slums (Decree40, 2012). Basateen al-Razi (recently called al-Mazze 66 or Marota Sustainable City), al-Qaboun, Barzeh, al-Mazze 86, al-Tadhamun and al-Sumeriya are among the larger PRRP announced (Alqadri, 2019). The main drivers for sustainable PRRP are: the high cost of traditional building materials, energy shortage and prices in addition to predicted regulatory incentives (Kassouha, 2020). Furthermore, many plans and design suggestions for PRRP higher sustainability standards have been put forward. Hitherto, the planed PRRP appear to have high targets far from realistic ignoring the rapidly changing needs of the population (Kassouha, 2020). Marota City, illustrated in Fig. 4, is one example of the planned PRRP. This project aims to transfer an area that was once informal settlement and got destroyed during the war into a sustainable high-tech

luxury PRRP. Within this planning approach the government is challenged by overwhelming dilemmas; reinforcing sustainability policies and escalating PRRP production while maintaining profitability for investors and the state (Clerc, 2015). In this context, three important factors should be considered for more sustainable PRRP progress: 'experienced consortium', 'SRM' and 'flexible financial market' (Kassouha, 2020).

Notably, Syria post-war difficult political, economic, and technological circumstances impact the construction companies' ability to respond to risks occurrence during the construction activities which impact PRRP performance and objectives. Therefore, the most appropriate SRM for PRRP should be determined from the national conditions. To insure PRRP objectives (e.g. finishing within the stipulated time and cost, qualities, environmental protection and socio-economic returns), construction companies require: high design knowledge, technical experience, resources efficiency, effective construction management and cost investment. The poor performance of these indicators in the post-war situation may lead to higher level of potential sustainability risks which will impact PRRP objectives and performance. These hindrances can be reduced by enhancing SRM as decision-making tool to assess sustainability in PRRP.

4 SRM as a decision-making process for PRRP

There is a pressing need for more sustainable PRRP in order to BBB. This is due to multiple environmental benefits of sustainable buildings such as: improving ventilation, reducing waste, energy efficiency and water exhaustion, climate stabilization, conservation of natural resources, expansive spaces and biodiversity safeguard (Khaddour, 2021b). Additionally, sustainable housing economic benefits consist of: decrease functioning and servicing costs and raise income (selling payment or rent); power productivity and preservation of resources and materials (Atombo et al., 2015). PRRP social benefits, however, are: improving the quality of human life and the human living environment, including culture, health, education and intergenerational equity (Atombo et al., 2015).

Overlooking possible sustainability risks leads to negative outcomes (Khaddour et al., 2023). Atombo et al. (2015) explains that many sustainable buildings fall into a trap of assigning higher contingency fund which increases the project's overall cost or stops the project, if such fund is unavailable. In turn this will lead to negative consequences resulting in less incentive to adopt more sustainable projects in the long run. Previous research in the MENA region e.g., in Kuwait (Ismael & Shealy, 2018), Syria (Khaddour, 2021b), U.A.E. (El-Sayegh et al., 2018), Qatar (Jarkas & Haupt, 2015) discussed construction risks but fell short in identifying risks related to incorporating sustainability principles.

RM is known as one of the most important procedure in the area of project management because of the uniqueness of each construction project, environments, construction operation diverse techniques and different multiple uncertainties (Adeleke et al., 2016). A broadly defined risk comprises the probability of an event and its impact (Skitmore, 2017). RM is then the process by which risks are identified, assessed and used to inform decision making and planning future activities (Qin et al., 2016). This traditional RM is guided by International Standards Organisation (ISO), and guidelines of membership associations such as the Project Management Institute (PMI), whereas SRM is applying sustainability levels to traditional RM (Shealy et al., 2017). More importantly, SRM is a vital requirement for successful sustainable construction strategy (Atombo et al., 2015). SRM

Fig. 3 The characteristics of Damascus metamorphosis rural and urban environments during the conflict ▶ (Source: Abdin, 2017) a) Damascus metamorphosis: rural and urban administrative borders. b) Damascus Informal settlements (in yellow). c) The proposed but unimplemented PRRP (in pink) and d) The areas of armed conflict (in green)

comprises: (a) climate change, (b) boycotts, (c) environmental liability, (d) ecosystems, (e) social responsibility, and (f) managers and government officers' liability (Wijethilake & Lama, 2019). Although, previous literature reveals SRM benefits in achieving high quality environmental and social responsibility management, it provides limited evidence on why and how construction companies can be motivated to engage in SRM.

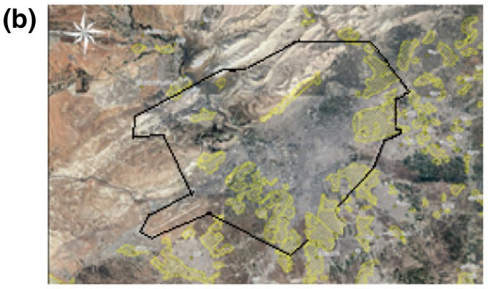
Given the dynamic nature of SRM impact on PRRP, SRM should be managed at different levels, such as organisational, individual, sectorial, national, and supranational (Wijethilake & Lama, 2019). On the organizational level, sustainability assessment can benefit from RM as a tool to assist construction companies with better decision-making criteria (Hussaini, 2016; Qui et al., 2016; MacAskill & Guthrie, 2014). This is because RM is the process of identifying and quantifying risks to inform decision making and plan future events.

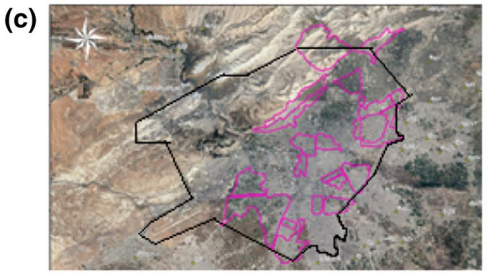
Therefore, multi-criteria SRM is required for Syrian PRRP as the causes of risks vary based on post-war social, economic, political and environmental conditions. For example, the selection of PRRP green technologies requires accounting for various criteria such as: economic (e.g., initial, operating and maintenance cost), environmental (e.g., Co2 reduction and energy efficiency) and social (e.g., occupant health and safety and jobs creation). Such multi-criteria SRM affects decision makers' priorities, which can be embodied as a method to support decision making. Simultaneously, MCDM can offer SRM framework: weight criteria, scoring alternatives method and synthesize of the final results (Hussaini, 2016; Qui et al., 2016).

MCDM consists of the following phases: (a) objective identification; (b) criteria development; (c) alternative generation, evaluation and selection; (d) implementation and monitoring (Si et al., 2016). Therefore, MCDM can be enhanced for handling the housing market uncertainty, dealing with multiple project requirements and comprising conflicting stakeholders' interests (Hosseini et al., 2016). Beside, MCDM can be used to apply the concept of value and weight to assess the risk probability and effect (Jarkas & Haupt, 2015). In turn, a synthesized list of construction sustainability challenges (negative risks) associated with PRRP, can be valuable for developing MCDM criteria that promote sustainability by influencing decision makers' objectives and priorities.tainability core values and sustainability risk manage-ment will be increased by the extent to whichstakeholders exert pressure for sustainability.tainability core values and sustainability risk manage-ment will be increased by the extent to whichstakeholders exert pressure for sustainability.

Figure 5 demonstrates similar characteristics in concepts and management principles among: sustainability assessment, RM and MCDM which make it feasible for interrelatedness. In this novel approach, SRM is not only a way to minimize negative risks within PRRP, but also a way to transfer sustainability risks into opportunities, which can lead to economical profitability, environmental and social advantages.


(a)
Barada River Valley
Mountainous
Damascus City
Eastern Ghouta
Southwestern Ghouta


(b)


(c)

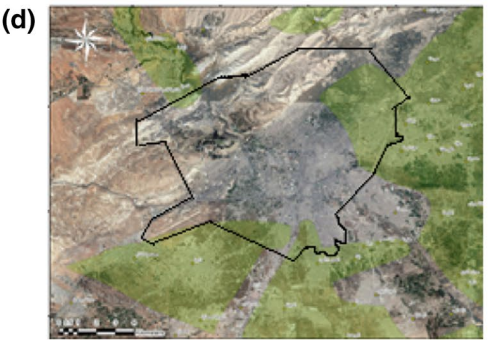

(d)

Fig. 4 Governmental and Commercial proposals for Marota project; a new planed sustainable PRRP in Damascus

5 Methods and materials

Figure 6 represents the workflow used in this study adapted for generating multi criteria SRM for PRRP in Damascus. The progress of work in this research consists of a number of steps.

5.1 Stage 1: Sustainability risks identification

The research starts with literature review on relevant articles using electronic databases. The literature review plan consists of establishing the purpose and protocol (Xia et al., 2018). Risk identification is the first stage in the SRM that anticipates risks which might impact PRRP sustainability objectives. Table 1 represents this research categorized list of PRRP sustainability risks that was developed based on relevant previous construction RM research, and the input of local industry experts, practitioners and professionals.

Risk elements associated with 20 papers were included and used to develop the synthesized list presented in Table 1. Previous studies attempted to identify sustainability risk factors implementation by conducting a literature review. Some studies adopted expert interviews to support risk identification; however, the number of experts in the interviews was only around three. These previous papers also evaluated risk factors using survey questionnaires.

Some authors viewed risks in sustainable building as economic, environmental and social responsibility risks (Kibert, 2016). Others referred to risks in sustainable building as non-traditional risks (Hosseini et al., 2016). One previous study identified and assessed risks in sustainable buildings in the UAE (El-Sayegh et al., 2018). The study the risk

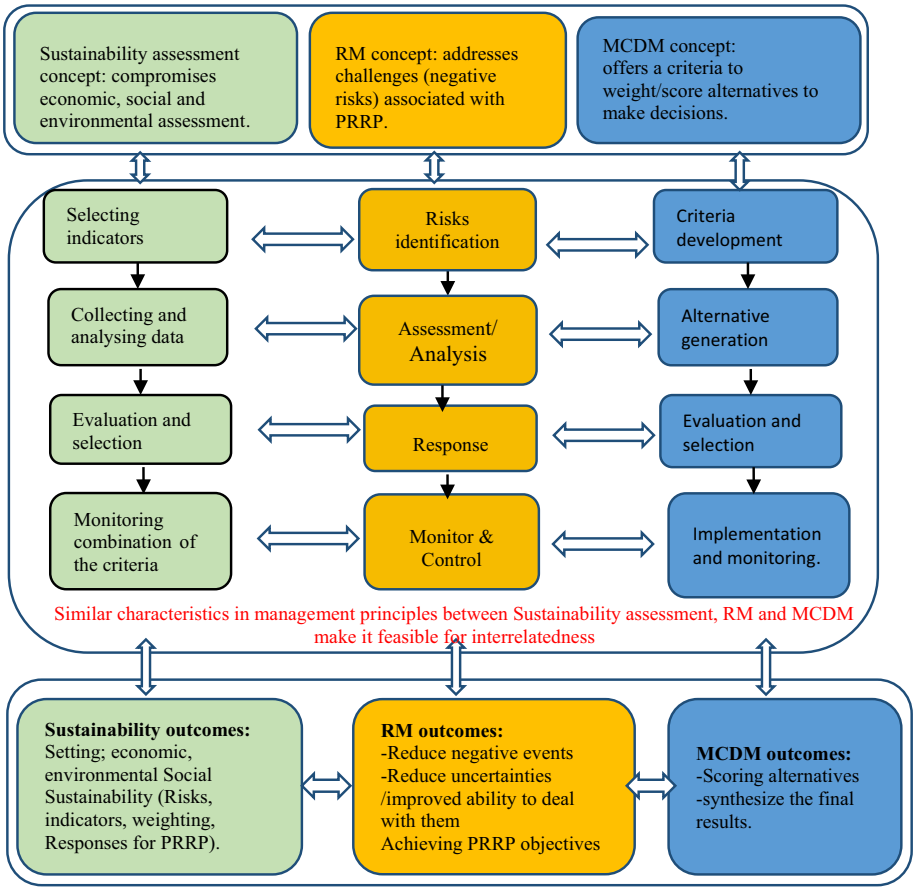


Fig. 5 Alignment among sustainability assessment, risk management, and MCDM processes

factors into five categories: management, technical, green team (stakeholders), green materials and technology, regulatory and economic. The result revealed that the top five critical risk factors were "shortage of clients' funding", "insufficient or incorrect sustainable design information", "unreasonably tight schedule for sustainable construction", "design changes", and "poor scope definition in sustainable construction" (El-Sayegh et al., 2018). In the same vein, Ismael and Shealy (2018) investigated risk factors associated with Sustainable buildings in Kuwait. The authors proposed nine risk categories: design, management, construction, material, technology, labour and equipment, external factors, finance and certification (Ismael & Shealy, 2018). The research findings specified that "inexperienced designers and contractors" and "high initial costs" have the highest severity rate, in Kuwaiti context. Another study by Hwang et al. (2017) investigated risks in sustainable residential buildings in Singapore. The research outcomes indicated that the key risks were "complex procedure to obtain approval", "overlooked high initial cost", "unclear requirements of owners", "employment constraint" and "lack of availability of green material and equipment".

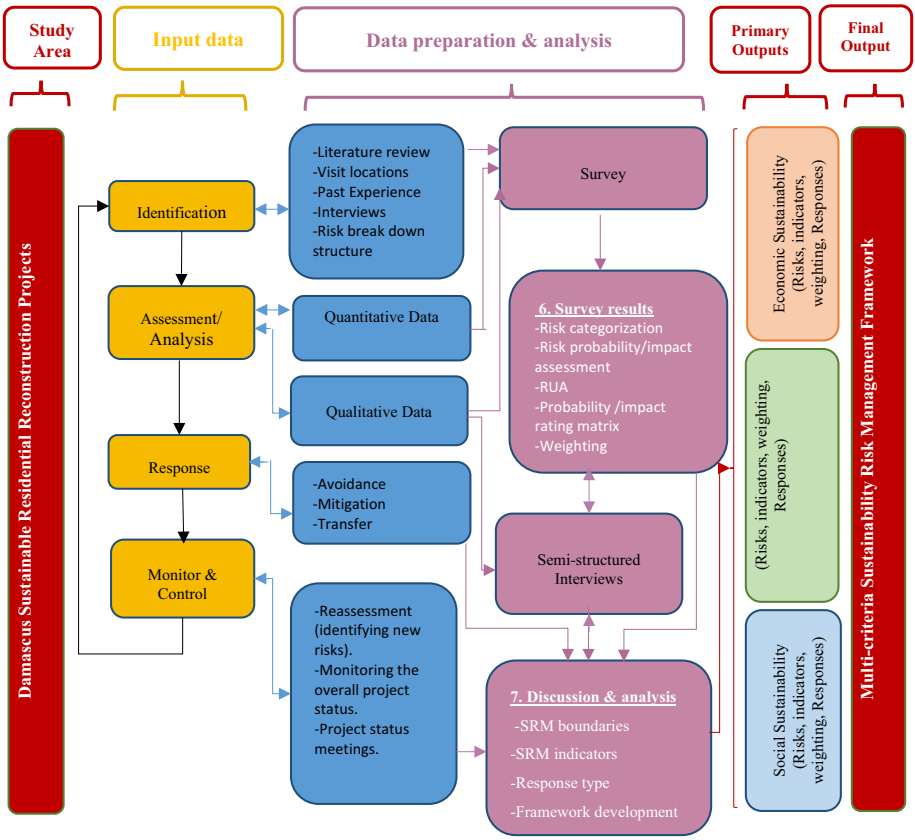


Fig. 6 Schematic illustration of workflow of the adapted methodology used for generating multi criteria SRM for Damascus PRRP

While building sustainability objectives are set by different international standards, sustainability risks meaningfully vary from one project to another with several conditions. From previous research, some of the risks found are unique to sustainable construction projects while others are applicable to both sustainable and traditional ones. Despite the few similarities in risks identification in previous research, the weightings of risks differ as a result of cultural economical, regional and political interests. By determining the high—priority risks from the beginning for more effective planning and successful response actions. This research study contributes to empirical knowledge by introducing an integrated methodology of sustainability risk identification where checklist of all the potential risk elements in PRRP will first be developed. Also, sustainability risk matrixes in terms of environmental, social and economic risk categories will be developed to evaluate the severity and therefore the relative priority of all previous risks.

An initial list of risks and their categories is summarized in Table 1. Table 1 is used to develop the risk elements in the survey. The survey then will measure both perceived probability of occurrence and level of impact of these risks in the context of

Table 1 Sustainability risks identification

Risk Categories	Source (Authors, year, country, research method)	Risks identification from previous research	Proposed key sustainability risks	
			Factors	Code
Economic Sustainability	(Ismael & Shealy, 2018, Kuwaiti, Survey) (El-Sayegh et al., 2018, UAE, Survey) (Amoudi, 2016, Syria, Survey) (Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Jarkas and Haupt, 2015, Qatar, Survey) (Qin et al., 2016, China, Survey) (Wijethilake & Lama, 2019, Sri Lanka, Survey) (Zhao et al., 2016, Singapore, Survey) (Sanchez-Cazorla et al., 2016, Global persepction, literature) (Harb & Abazid, 2018, Arab region, Literature)	-Higher than anticipated expenses, shortage of funds, construction inflation, fluctuation in exchange rates, and import/ export restrictions. -Technical difficulties: e-Employing materials and equipment with reduced life cycles or immediate aesthetic, lack of green material availability of green materials and equipment. -Complex procedures to obtain approvals; unclear contract conditions for claims, litigations, and for dispute resolution. -Construction schedule and cost impacts associated with delivering a sustainable building i.e. being fined for failing to meet sustainable building standards.	Higher than anticipated expenses & shortage of funds	R1
			Lack of availability of green materials and equipment	R2
			Unclear contracts' technical specifications and conditions	R3
			Being fined for failing to meet the project objectives	R4
			Poor constructability	R5
			Delays due to poor contract management	R6
Enviro. Sustainability	(Zuo and Couani, 2012, Australia, Survey) (Qin et al., 2016, China, Survey) (Wijethilake & Lama, 2019), Sri Lanka, Survey) (El-Sayegh et al., 2018, UAE, Survey) (Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Harb & Abazid, 2018, Arab region, Literature)	-The absence of sustainable reconstruction strategy and the lack of clarity of the sustainable related building standards. -Establishing conflicting standards and setting high targets. -The uncertainty in sustainable building design details and specifications. -Environmental impact, pollution, and energy consumption. -Damage to environmental and professional reputation.	The absence of sustainable reconstruction strategy and policies	R7
			Setting High Target for Green Mark Rating	R8
			Pollution	R9
			Energy Consumption	R10

Table 1 (continued)

Risk Categories	Source (Authors, year, country, research method)	Risks identification from previous research	Proposed key sustainability risks	
			Factors	Code
Social Sustainability	(Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Qin et al., 2016, China, Survey) (Rafindadi et al., 2014, Global perception, Survey, interviews) (Wijethilake & Lama, 2019), Sri Lanka, Survey) (Harb & Abazid, 2018, Arab region, Literature) (Jarkas and Humpt, 2015, Qatar, Survey)	-The absence of RM consideration, -The absence of alternative social homes, -Unclear allocation of roles and responsibilities, -Lack of qualified professionals with proper sustainable design experience, -Poor workmanship and -Health and safety e-Employment constraint.	The absence of Risk Management consideration	R11
			The absence of alternative social homes	R12
			Unclear allocation of roles and responsibilities	R13
			Lack of qualified professionals and poor workmanship	R14
			Health and safety constraint	R15

Damascus PRRP. This research risks categories comprise economic, social and environmental levels. This is due to the parallel emerging between the steps of typical sustainability assessment and that of risk management key steps outlined in ISO 31000 standard. The collected sustainability risks were synthesized based on the researcher's experience and the opinions of four Syrian built environment experts' (Two construction company general managers, one high status decision maker in Damascus Governorate and one construction management academic dean).

5.2 Stage 2: Sustainability risk assessment

The second step is risk analysis where data regarding the identified risks is collected and analyzed. There are two methods developed for analyzing the identified sustainability risks: the qualitative and the quantitative methods (MacAskill & Guthrie, 2014). The qualitative methods are used to priorities risks identified on a descriptive scale (PMBC, 2008) whereas the quantitative methods are applied to decide risks' probability and impact based on numeric assessments (Cooper et al., 2013). Furthermore, there is the semi-quantitative assessment approach, which compromises values and description resulted from both quantitative and qualitative methods (Crawford, 2010). Several factors should be considered for selecting the risk assessment methods (e.g., cost of using the method, adaptability, complexity, completeness, usability and validity) (Harb & Abazid, 2018). This research enhances the qualitative method as it seems more appropriate to explain than to quantify the risks faced by construction companies in Damascus PRRP.

This research adapts a step-by-step qualitative risk assessment approach from PMI (2008). This assessment approach comprises: risk categorization, risk probability and impact assessment, probability/impact risk rating matrix and Risk Urgency Assessment (RUA). Risk probability and impact assessment provides clear scale of probability ranging from 'very unlikely' to 'almost certain'. The impact scale varies from 'very low' to 'very high', as can be seen in Table 2. Table 2 represents the matrix of priority and impact score. The rating and the colours are allocated to reflect the ranking of each sustainability risk. While risk impact assessment investigates the potential effect on project sustainability objectives, risk probability assessment investigates the likelihood of each identified risk (PMBOK, 2008). Each risk listed in Table 1 is assessed in terms of the probability and the impact of its occurrence. Section 6.2 deals with combination of factors to prioritize risks according to impact multiplied by probability to find out which risk has low, moderate or high severity. Section 7 sheds light on graphical representations to request interviewees' elaboration on risks severity and how quick of response they require. List with risks prioritized by applying qualitative methods is utilized to bring attention to significant economic, environmental and social risks for Damascus PRRP.

Table 2 Probability/impact risk scales and rating matrix

Very high	(0.8)	0.08	O.240	0.400	0.560	0.720
High	(0.4)	0.040	0.120	0.200	0.280	0.360
Moderate	(0.20)	0.020	0.060	0.100	0.140	0.180
Low	(0.10)	0.010	0.030	0.050	0.070	0.090
Very low	(0.05)	0.005	0.015	0.025	0.035	0.045
Definition of Risk Impact Scales	**Impact** / **Probability**	0.1	0.3	0.5	0.7	0.9
	Definition of Risk Probability Scales	Very low	Low	Moderate	High	Very high

5.3 Stage 3: Risks response and monitoring

This step indicates what response, strategy and action should be selected regarding the assessed risks. The types of response strategies are:

1. the avoidance response: by looking at other alternatives in the project, many risks can be eliminated. Several activities can help to avoid potential risk e.g., detailed planning alternative approaches, regular inspections and training (Cooper et al., 2013);
2. the mitigation response: this response requires: contingency planning, quality assurance, contract terms and conditions and disaster recovery plans (Darnall and Preston, 2010) and
3. the transfer response: strategy is recommended when a risk can be managed by another actor who has a greater capability or capacity. The actors that the risks can be transferred to are, for example, the client, contractor, subcontractor, designer etc. depending on the risk's character. As a result, this could lead to higher costs and additional work, usually called risk premium (MacAskill & Guthrie, 2014).

For this research, 16 responses to negative sustainability risks were suggested based on literature review, author's experience as well as the views of the four Syrian built environment experts mentioned in the first stage. Furthermore, to determine the prevalent trend in the contractors' response to risk allocation for each factor, expert consultation was investigated to classify the selected responses into one of the three risk allocation strategies, that are "avoid", "mitigate" or "transfer". Table 3 is used to develop the survey instruments which measures possible responses means for Damascus PRRP.

The final RM monitoring step is considered vital for continuous supervision of identified risks, discovering new risks and tackling the previously assessed risks (PMBC, 2008). Besides, the monitoring phase aims to control the risks and to ensure the selected responses were necessary. This can be achieved by a number of techniques, for example: risk reassessment, monitoring, status meetings and risk register updates (Cooper et al., 2013). By monitoring the whole process and outcomes of SRM, the PRRP processes can be evaluated. This is also a way to improve PRRP performance since the pros and cons will be examined.

5.4 Stage 4: Survey design, sampling, and questionnaire development

The research study design combines primary and secondary data and uses mixed methods (both qualitative and quantitative). The mixed method approach enables breadth and depth of understanding of the research problem (Creswell and Plano Clark, 2011; Ihuah & Eaton, 2013). This research on SRM is multi-purpose in nature which is why the mixed method approach is a good tactic that will allow going beyond the survey questions to answer "what", "why", and "how" research questions through permitting interviewees different views and interpretation. Data for this research were primarily gathered through a questionnaire. Supplement interviews were also conducted to crosscheck the results of the survey and gain additional information.

First, to understand how the Syrian construction industry perceives risks associated with more sustainable PRRP, the relevant data is collected by a structured—close-ended—questionnaire. The survey technique is widely applied in RM research (Ismael & Shealy,

Table 3 Sustainability risks responses

Risk Response Categories	Source	Description of responses from previous research	Proposed sustainability risk responses	
			Response	Code
Economic Sustainability	(Ismael & Shealy, 2018, Kuwaiti, Survey) (El-Sayegh et al., 2018, UAE, Survey) Literature) (Amoudi, 2016, Syria, Survey) (Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Jarkas and Haupt, 2015, Qatar, Survey) (Qin et al., 2016, China, Survey) (Wijethilake & Lama, 2019, Sri Lanka, Survey) (Zhao et al., 2016, Singapore, Survey) (Sanchez-Cazorla et al., 2016, Global perseption, literature) (Harb & Abazid, 2018, Arab region, Literature)	-Constant design evaluation and verifications. -Devoting adequate resources to planning and research (e.g. using past successful sustainable residential projects as references). -Working with experienced insurance agent to receive better coverage. -Contract language to be precise and give provision to limit each party liabilities. **-Maintenance of high stable levels of local economic growth and employment:** 1 Allowing for contingency funds, 2 Improving project delivery and 3 Increasing profitability & productivity.	Allowing for contingency funds	RMM1
			Make sure that the contractor has enough knowledge and resources to perform the project	RMM2
			Devoting adequate resources to planning and research	RMM3
			Being active in the process and take an action when any problem occurs	RMM4
			Transferring risk by involving experts in the process	RMM5
			Well prepared bidding requirements	RMM6
			Make pressure on decisions being made on time	RMM7
Enviro. Sustainability	(Zuo and Couani, 2012, Australia, Survey) (Qin et al., 2016, China, Survey) (Wijethilake & Lama, 2019), Sri Lanka, Survey) (El-Sayegh et al., 2018, UAE, Survey) (Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Harb & Abazid, 2018, Arab region, Literature)	-Front end planning. -Evaluating the high target for green mark rating. -Implementing passive design instead of complicated active building design. **-Effective protection of the environment:** 1 Avoiding pollution, 2 Protecting and enhancing biodiversity, 3 Efficient use of resources, 4 Improved energy efficiency and 5 West management.	Highlighting al potential risks on workshops or meetings	RMM8
			Making adjustments in the project's environmental targets	RMM9
			Implementing passive design	RMM10
			Improved energy efficiency	RMM11
			Efficient use of resources and west management	RMM12

Table 3 (continued)

Risk Response Categories	Source	Description of responses from previous research	Proposed sustainability risk responses	
			Response	Code
Social Sustainability	(Hwang et al., 2017, Singapore-based construction companies, literature, survy and interviews) (Qin et al., 2016, China, Survey) (Rafindadi et al., 2014, Global perception, Survey, interviews) (Wijethilake & Lama, 2019), Sri Lanka, Survey) (Harb & Abazid, 2018, Arab region, Literature) (Jarkas and Humpt, 2015, Qatar, Survey)	-Chang management approach that comprises different design and social aspects. -Improve communication and coordination among projects stakeholders. -Develop training programs to upgrade workers' skills and knowledge of new technologies and materials. **-Social progress which recognizes the needs of everyone:** 1 Respect for staff, 2 Working with local communities and 3 Partnership working approach.	Chang management that comprises different design and social aspects	RMM13
			Enhanced communication and improving coordination among projects stakeholders	RMM14
			Developing training programs to upgrade workers' skills and knowledge of new technologies and materials	RMM15
			Transfer risk to the project team	RMM16

2018; Si et al., 2016; MacAskill & Guthrie, 2014; Zuo, 2012). The reasons underlying the selection of this data collection method are: (1) it is less intrusive and cost-effective when compared to interviews; (2) the ease of the questionnaire to most potential respondents and (3) the simplicity of returned responses analysis (Jarkas and Haupt, 2015).

The questionnaire used for this study comprises three sections. Section 1 handled information on the background of the respondent and general questions about the participants such as their position of work and years of experience. The questionnaire second section includes assessment for risks in PRRP likelihood and impact of each risk within the three categories proposed in Table 1. For each of the identified risks, respondents are asked to assess its probability and impact. The risk probability of occurrence using a Likert scale with numbers from one to five was applied (one being very low probability and five being very high probability). Then, for assessing the risks impact on PRRP, a Likert scale was also used with numbers ranging from one to five (one indicates very low impact and five indicates very high impact). The questionnaire third section includes assessment for risk responses proposed in Table 2. A similar Likert scale was also used here to assess the responses. The measurement scale of five levels was used in this questionnaire to ensure the credibility of the responses, as a narrower range scale undermines the validity and reliability of the results obtained (Hwang et al., 2017; Jarkas & Haupt, 2015). The first page in the questionnaire included an introduction about the research objectives, key terms explanation, survey procedure and confidentiality statement.

A pilot test was conducted on a sample of prospective respondents in order to establish a reasonable validity of the results obtained and assess the reliability of the questionnaire. The questionnaire was tested by four professionals, with each of them having more than 20 years of experience in Damascus construction industry, to review content validity, assess and provide feedback about the questions. Four face-to-face interviews were conducted to solicit comments on the readability, comprehensiveness and accuracy of the questionnaire. Their comments were incorporated into the final questionnaire. The aims of this test were to: (1) assess the clarity, comprehensibility, interpretation and appropriateness of the questions provided in capturing the major risk factors considered by Damascus PRRP construction professionals; (2) to test the range adequacy of response choices; (3) to assess the internal consistency of the questionnaire; and (4) to determine the efficiency with which the respondents complete the questionnaires (Jarkas and Humpt, 2015). Based on the test, a few changes were made to the survey: clarifying the meaning of specific risks, new risk mitigation measures were added, revisions were made to improve the readability and accuracy of the statements of the risks and responses and footnotes were added to explain the terminologies used.

As for the survey sample, the survey was distributed to a national sample of professionals currently working in Damascus' more sustainable PRRP. Examples from previous related literature found that RM in construction can be assessed from upstream (clients) and downstream (contractors) perspectives (Cooper et al., 2013; Ismael & Shealy, 2018). Prior related research also found no significant discrepancy between the perceptions of different stakeholders' groups (client, consultant, contractor, exogenous) about the sustainable project risks (Jarkas and Humpt, 2015; Rafindadi et al., 2014). Although RM issue is closely associated with the owners'/clients' decision-making inefficacy, it is attributed to the existing trend in the local construction industry where the public sector remains the largest client (Hwang et al., 2017). Therefore, owners and contractors must take the authority to manage risk elements and work from the feasibility phase onwards to tackle possible risk factors in time (Harb & Abazid, 2018). Therefore, the survey sample of this research includes: PRRP owners, public, public private partnership (PPP), and private contractors

who had to fulfil the following criteria: they should be Syrian and involved in Damascus new more sustainable PRRP. The following equation was implemented to determine the required sample size (Parasuraman 1990):

$$n_{\max} = \frac{z_q^2 \times s^2}{H^2} \tag{1}$$

n_{max}: sample size; s: estimated standard deviation in the population elements; z_q: normal standard-deviate value corresponding to a q% confidence level in the interval estimate; H: desired level of precision; Standard deviation for a normal distribution: $s = \frac{(\max value - \min value)}{6}$

The sample was selected from the 2019 classified construction companies list provided by Damascus Governorate Engineers Syndicate 2019 annual report containing 2230 contractors/companies (the total population) with 1 to 35 years of experience in the Syrian construction industry. The construction companies' years of experience were considered as the population's parameter. The standard deviation was estimated using Eq. (2):

$$s = \frac{(35-1)}{6} = 5.667 \tag{2}$$

As for a normal distribution assumption, the mean value (years of experience) was estimated using Eq. (3):

$$M = \frac{(35-1)}{2} = 16 \text{ years} \tag{3}$$

The mean value "years of experience" of the required sample was considered to be acceptable in the range $M \pm 2$ years, i.e. $H = 2$. To achieve that in 99% confidence level ($z_q = 2.575$), according to Eq. (1) the required sample size can be calculated as follows:

$$n_{\max} = \frac{2.575^2 \times 5.667^2}{2^2} = 53.25$$

A sample of fifty responses was assumed to be enough to give an indication of PRRP sustainability risks probability, impact and severity. 200 companies/ contractors operating in Damascus PRRP were selected and approached by a formal questionnaire along with an accompanying letter explaining the purpose of the survey. The survey was sent either by e-mail or in person to construction professionals with experience in sustainable PRRP. The professionals were selected based on available contact information and site visits to ongoing PRRP. Furthermore, in order to reduce or remove non-response bias, personally administered questionnaire is suggested by Sala and Lynn (2009). The authors proposed two-phase multi-mode survey design, where the postal survey is followed at the second phase by a telephone survey of non-respondents (Sala & Lynn, 2009). Therefore, this research study in-person survey administration included using in person visits, email and phone reminders as reminders to respond. Also, the researcher approached the General Managers or Directors for each company with a formal letter that summarizes the research objectives and requested the company's corporation. A total of 160 responses were collected from various types of construction parties (owners, consultants, project managers and contractors) who have experience in more sustainable PRRP. Only 97 responses were considered valid for data analysis. This constituted a response rate of 86.2% with the useful response rate being around 61%. This response rate may reflect Syrian construction companies'

confidentiality issues as well as the lack of time or incentive of the respondents. The survey was conducted since early February to the end of April 2019.

5.5 Stage 5: Semi-structured interviews

Previous research on RM in the construction industry has collected the required criteria from: literature review, surveys, interviews, workshops with stakeholders or from a combination of these methods. The vast majority of empirical research in sustainable built environment is highly dependent on both qualitative and quantitative methods in developing strategies, frameworks or code of practises. Multiple method contributes significantly to the extensive use of empirical and constructive studies (Khadour, 2010). Given this multiple method, there are three models for combined designs, according to Creswell and Plano Clark (2011). The Two-phase design approach in which the researcher proposes to conduct a qualitative phase of the study and a separate quantitative phase of the study; (2) Dominant-less dominant design. In this design the researcher presents the study within a single dominant paradigm with one small component of the study drawn from the alternative paradigm and (3) The mixed-methodology design. This design represents the highest degree of mixing paradigms. This research is a survey Dominant-interview less dominant design. The interviews here will be used to focus on developing the SRM framework in particular.

Prior similar research outlines the importance of collecting data from expert consultation through interviews for in-depth knowledge about interrelationships that could exist among sustainability criteria (Qin et al., 2016; Hosseini et al., 2016; Yang et al., 2016; Khaddour, 2021b). Likewise, for an effective implementation of the three pillars of sustainability into risk management and PRRP decision making criteria, this study adapted a survey method followed by a number of supplementary post-survey semi-structured interviews. The advantages of this type of interviews are reliability, control associated with more structured interviews aligned with flexibility of responses obtainable by less structured interviews (Wanous et al., 2003).

Aside from the small number that characterizes qualitative research, there is no specific rule for determining the number of sites or participants to be involved in mixed research approach. The sample size depends on the qualitative design being used (Creswell, 2014). From a review of many qualitative research studies, narrative research was found to include one or two individuals; phenomenology to typically range from three to ten; grounded theory, twenty to thirty; ethnography to examine one single culture-sharing group with numerous artifacts, interviews, and observations; and case studies to include about four to five cases (Creswell & Creswell, 2017). In qualitative interviews, face-to-face interviews, telephone interviews, or a focus group of six to eight interviewees can be conducted by the researcher (Creswell & Creswell, 2017). This is one viable approach to the interviews number. Another approach is the saturation grounded theory. This approach refers to researcher stop collecting data when the categories are saturated (Charmaz, 2006; Galletta, 2013). In other words, the idea of this approach is to stop conducting more interviews when gathering further data no longer reveals new properties or new insights.

Survey and semi-structured interviews were used in previous RM research. Semi-structured interviews are intended to grasp views and opinions from the participants. These interviews are usually few in number. Previous study by Giannakis and Papadopoulos involved a survey followed by face-to-face semi-structured interviews with managers of two companies one is based in UK and the other one in France (Giannakis and Papadopoulos,

2016). Another research by Edison et al. conducting a survey then interviewed four industry practitioners (managerial level) and three academics (professors in the study area) (Edison et al., 2013). The number of participants is often influenced by time, cost, and other practicalities (Creswell & Creswell, 2017). As this research semi-structured interviews are supplementing other data collection method, it was found sufficient to conduct only a few interviews with key informants from the study community.

The selection of interviewees was guided by two criteria: their experienced involvement in post-war re-construction in Damascus, and their likelihood of representing a particular consistency and SRM vision. This criteria for participant selection balanced representative of the range of perspectives and experiences in PRRP. Having a secured approval for this research from the author's university, the researcher was able to meet with district officials for the survey and interviews purposes. This research study interviews are conducted to acquire most accurate answers, explanations and qualitative interpretations based on the interviewees' opinions and experiences. Interviews were conducted among interested PRRP professionals with considerable experience in the Syrian construction industry. From the 11 respondents who expressed their interest in further interviews, the author prioritized those who offered representativeness in terms of position, experience, company's background projects. The researcher reviewed participants' companies activities and obtained information about interested candidates (position and professional memberships). Participants held leadership positions. Most interviews run an hour in length. The author ensured the confidentiality of the interviewees. The author recorded and took notes during the interviews after assuring interviewees of confidentiality. The interviewees status not only inspired this study, but also clued the SRM framework boundaries between sustainable regulations and standards and construction practices. The researcher continued interviewing subject expert participants until reaching a kind of saturation point where the interview data are no longer producing new thematical patterns. After conducting seven interviews, the documentation was found useful for the wider community of Damascus post-war construction.

The main objective of these interviews was to gain an overall understanding of how the perceived PRRP sustainability risks affect construction companies' decision making in practice. This research study followed the semi-structured interview protocol as described in Creswell and Plano Clark (2011). A semi-structured interview guide consisted of two levels of questions: main themes and follow-up questions. The main themes covered the main content of the study and within the interviewees are encouraged to speak freely about their opinions and experiences (Kallio et al., 2016). As can be seen in "Appendix 2", the study semi-structured interviews protocol includes a question list or certain specific points to be covered through the interview, probes to follow the research questions, space for recording the interviewee's comments on the developed SRM framework.

5.6 Stage 6: Framework development

This research study framework will be based on the alignment among sustainability assessment, RM processes and MCDM. Previous related studies suggested that the MCDM criteria should be collected comprehensively (Hosseini et al., 2016; Si et al., 2016). MCDM method requires a framework with three different categories: unique synthesis criterion approach, outranking synthesis approach and the interactive local judgment approach (Bhole & Deshmukh, 2018).

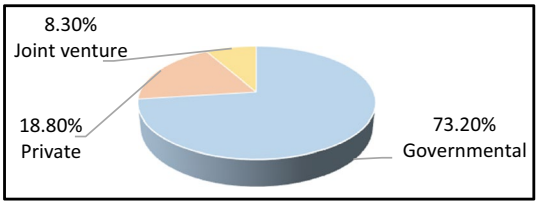


Fig. 7 Company sector

This study conceptual framework will rely on sustainability three pillars that consists of accumulating all PRRP dissimilar interpretation into a unique function. SRM economic criteria comprises: initial operation and maintenance cost, construction time, payback period, available incentives and other construction schedule and cost impacts (Si et al., 2016). Whereas, SRM environmental criteria may include: consumption of resources, environmental impacts, pollution, energy consumption, damages to environmental and professional reputation (Hosseini et al., 2016). Besides, the social criteria here have to deal with: unclear allocation of roles and responsibilities (Si et al., 2016), lack of qualified professionals for proper sustainable design (Quin, et al., 2016) and the absence of alternative social homes. This study framework will integrate RM process as an outranking synthesis approach to provide the preference to the decision-makers based on information available to explored PRRP sustainability risks. Hence, this method may be superior for Syrian construction professionals due to interactive and successive evaluation of the solution using mathematical calculation and programming tools to get the appropriate decision. Therefore, the framework will consider an interactive local judgment approach to propose alternate steps with multi objective to get successive compromising solutions.

6 Survey results

The next section presents the survey findings in terms of the respondents' background, risk probability/impact, RUA and risk response and mitigation measures.

6.1 Respondents backgrounds

This section reflects on the backgrounds of the respondents and their companies. The respondents represent various PRRP stakeholders. Figure 7 shows that 73.2% of the correspondents' company types were governmental which reflects the government leading role in PRRP. The results are seen representative as the public sector remains the largest PRRP client where RM is associated with the clients' decision-making inefficacy on one hand and attributed to the existing trend in the post-war local construction industry on the other. Unlike the private sector, the public sector's RM has to undergo a cycle of several authoritative approvals which may impede the progress of construction especially on PRRP, where the limited resources required may be beyond the ability of consortiums, let alone single contractors (Hwang et al., 2017).

Figure 8 shows the job titles of the respondents e.g., consultants (52.65%), contractors (16.50%) and project managers (12.40%). The types of the respondents' companies are

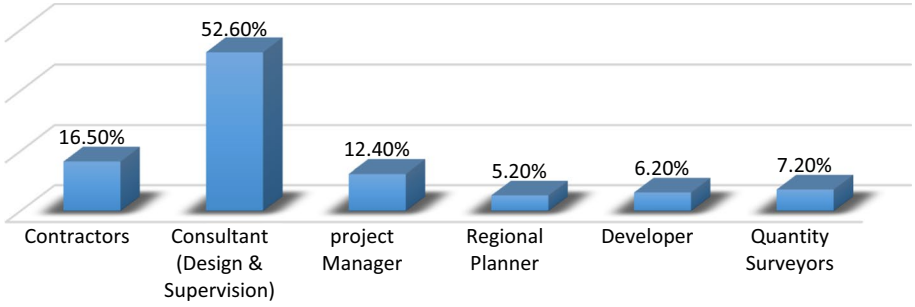


Fig. 8 Respondent job title

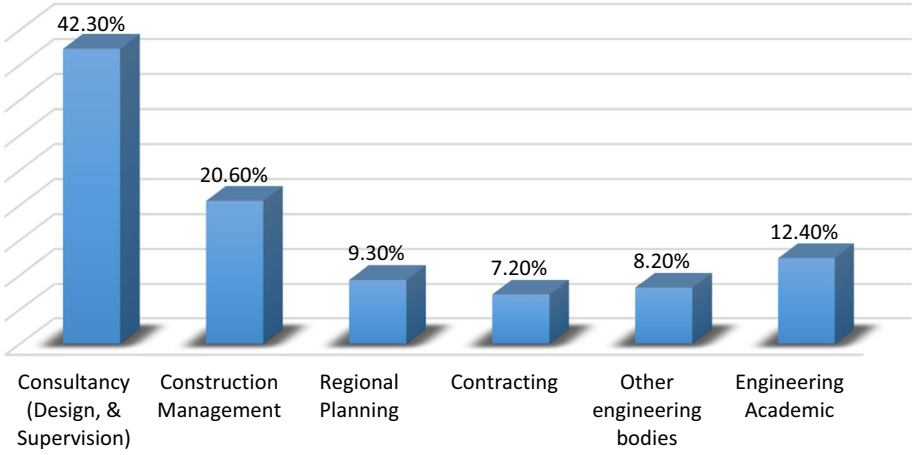


Fig. 9 Company type

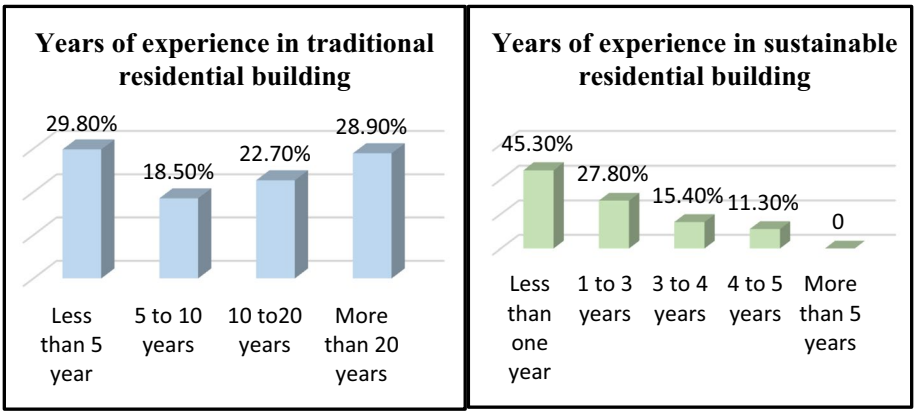


Fig. 10 Years of experience in traditional vs sustainable residential building

presented in Fig. 9. Furthermore, the senior positions and work experience in traditional residential building demonstrate that the respondents have sufficient knowledge of PRRP associated risks. It is evident that 28.9% of respondents had more than 20 years of work experience in traditional residential building while 45.30% of respondents had less than one year of experience in PRRP. More details of the distribution (in percentage) is shown in Fig. 10. This indicates that, as sustainable PRRP is still a new concept, the respondents had the required experience to address the research objectives.

6.2 Risk assessment

This section elaborates on the research first objective "To identify major sustainability risks affecting the process of PRRP in Damascus". The probability for each sustainability risk and its impact on the project's sustainability objectives were evaluated by the questionnaire's second section based on the scales provided in Sect. 5.2, Table 2.

The respondents were asked to estimate the probability of the sustainability's risk and also its impact on project's sustainability objectives. Table 4 shows the top risks found in Damascus PRRP with their corresponding rank. The Relative Importance Index (RII) for each risk was calculated using Eq. (4). RII, Eq. (4), is used to classify the risks which would have either a low, moderate or high level of importance. The risks were then ranked based on the calculated RII in Eq. (4). These risks were ranked according to Table 2 risk severity matrix.

$$R_{II} = \frac{\sum_{i=1}^{5} Wi \times Xi}{\sum_{i=1}^{5} Xi} \tag{4}$$

R_{II}: Relative Importance Index; Wi: Assigned weight, $Wi = 1, 2, 3, 4, 5 for i = 1, 2, 3, 4, 5$ respectively; Xi: Frequency of the i response. $i = 1, 2, 3, 4, 5$ Response category index for very low, low, moderate, high and very high respectively.

In Table 4, the risks coloured in red have the highest negative impact on the PRRP process and require immediate response. Table 4 demonstrates that social sustainability risks have the dominant weighting of 39% followed by the economic sustainability risks at 38% while the environmental sustainability risks weighted only 24%. The high social risks

Table 4 Damascus PRRP sustainability risks urgency assessment

Category weighting	Code	Identified Risk	Prob. RII	Impact RII	Severity Matrix	Rank
Economic (38%)	R1	Higher than anticipated expenses & shortage of funds	0.69	0.50	0.35	High
	R2	Lack of availability of green materials and equipment	0.59	0.50	0.30	High
	R3	Unclear contracts' technical specifications and conditions	0.55	0.46	0.25	Moderate
	R4	Being fined for failing to meet the project objectives	0.51	0.34	0.17	Low
	R5	Poor constructability	0.58	0.41	0.24	Moderate
	R6	Delays due to poor contract management	0.51	0.37	0.19	Low
Enviro. (24%)	R7	The absence of sustainable reconstruction strategy and policies	0.58	0.47	0.27	Moderate
	R8	Setting High Target for Green Mark Rating	0.60	0.36	0.22	Low
	R9	Pollution	0.55	0.37	0.20	Low
	R10	Energy Consumption	0.61	0.42	0.25	Moderate
Social (39%)	R11	The absence of Risk Management consideration	0.59	0.41	0.24	Moderate
	R12	The absence of alternative social homes	0.69	0.57	0.40	High
	R13	Unclear allocation of roles and responsibilities	0.64	0.53	0.34	High
	R14	Lack of qualified professionals and poor workmanship	0.61	0.53	0.33	High
	R15	Health and safety constraint	0.55	0.45	0.25	Moderate

weighting is due to the Syrian war: catastrophic humanitarian consequences, massive damages to the Syrian cities' infrastructure and the collapse of economic activities.

There are some similarities and contradictions to previous research. For example, the most significant risk in China's green projects was project funding problems (Zou and Couani 2012; Xia et al., 2018). In this research study, the severity of this risk takes the second place (higher than anticipated expenses) with a score of 0.35 while the highest rating is (absence of alternative social homes) at 0.40 reflecting the post-war housing demand. More similar risks associated with sustainable projects are additional cost due to green material and equipment and limited availability of green suppliers (El-Sayegh et al., 2018; Hwang et al., 2017). Other differences lie in the severity of the risk from one type of project to the other. In Kuwaiti, the wealthy Arabic country, Ismael and Shealy (2018) indicated that the negative risk with the highest severity for sustainable construction was (inexperienced construction professionals). In contrast, Singapore has more experienced professionals in the sustainable construction industry where (poor scope and insufficient sustainable design specifications) had much lower ranking (Hwang et al., 2017). Because of this, the Syrian construction industry should work feverishly to improve in terms of education, new product development and the creation of new sustainable building methods.

6.3 Risk response and mitigation measures

This section answers the second objective of this research with the results being gathered in Table 5.

The 5-points Likert scale was adopted for measuring the effectiveness of the response, where 1 reflected "very low", 2 "low", 3 "moderate", 4 "high", and 5 a "very high" response effectiveness. As shown in Table 5, the economic risk responses (Well-prepared bidding requirements) with a score of 4.27 has the highest rating followed by (Make pressure on decisions being made on time) at 4.07. This reflects the need to avoid failure to comply with PRRP sustainability contractual requirements. These response measures contribute to less design errors/omissions/delays attributed to the designers. It is also important to respond to PRRP cost overruns and green technology changes which are common risks associated with contractors.

Table 5 shows the environmental risk response that has the highest ranking (Improved energy efficiency) with a score of 4.06. The social risk responses that have the highest ranking are: (Highlighting all potential risks through meetings and training programs that upgrade workers' skills) at 3.93 followed by (Transferring risks to the project team) with 3.9.

Table 5 shows that the response categories weightings are 44%, 31%, 25% for economic, environmental and social responses, respectively. Whereas, in Table 4, the sustainability risk categories weightings were 38%, 24%, 39% for economic, environmental and social risks, respectively. This mismatch indicates that respondents are more willing to accept social sustainability risks since they are not contractual or legal related compared to economic and environmental types of risks. Drastically, most responses appear to deal with negative sustainability risks in a "mitigate" approach in order to minimize these risks during construction phase through remedial actions. This ranking of the risk response measures facilitates SRM plans (preventive measures, corrective actions, risk budget, etc.). This is explained further in the following section that elaborates on the interviews key findings.

Table 5 Damascus PRRP sustainability risk responses

Category weighting	Code	Risk response and mitigation	Response Type	Mean
Economic (44%)	RMM1	Allowing for PRRP contingency funds	Mitigate	3.34
	RMM2	Making sure that PRRP contractor has enough knowledge and resources	Avoid	3.708
	RMM3	Devoting adequate resources to planning and research	Mitigate	3.615
	RMM4	Being active in PRRP process to take an action when any risk occurs	Mitigate	3.719
	RMM5	Transferring risk by involving consultants/experts in PRRP process	Transfer	3.298
	RMM6	Well prepared bidding requirements	Mitigate	**4.271**
	RMM7	Decisions being made on time	Mitigate	**4.066**
Enviro. (31%)	RMM8	Highlighting all potential risks on workshops or meetings	Mitigate	**3.935**
	RMM9	Making adjustments in the project's environmental targets	Mitigate	3.547
	RMM10	Implementing passive design	Mitigate	3.283
	RMM11	Improving PRRP energy efficiency	Mitigate	**4.063**
	RMM12	Efficient use of resources and waste management	Mitigate	**3.699**
Social (25%)	RMM13	Changing management that comprises different design and social aspects	Mitigate	3.333
	RMM14	Enhancing communication and improving coordination among PRRP stakeholders	Mitigate	3.802
	RMM15	Training programs that upgrade workers' skills	Mitigate	**3.896**
	RMM16	Transferring risks to the PRRP project team	Transfer	**3.925**

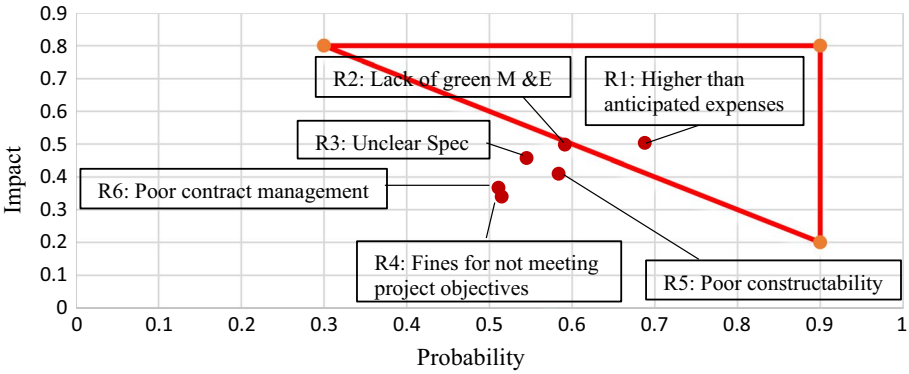


Fig. 11 Economic risks matrix

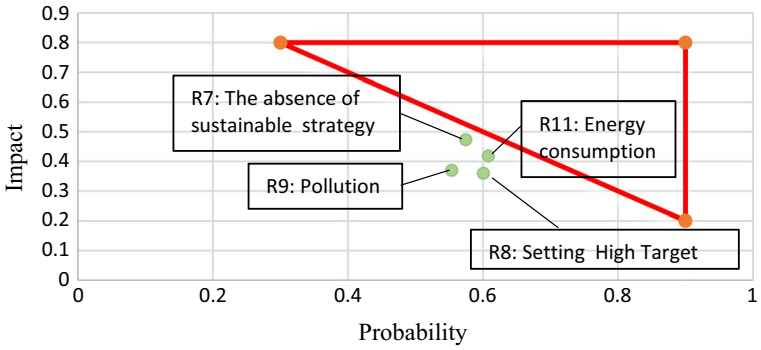


Fig. 12 Environmental risks matrix

7 Discussion and analysis

The second step in developing multi-criteria SRM framework for Damascus PRRP is based on the qualitative understanding of the PRRP SRM boundaries through the interviewees' comments on the survey findings.

The interviewees agreed on the severity rankings revealed by the survey and provided some insightful comments on the SRM boundaries. The survey results indicate a moderate severity for (The absence of RM consideration) with a score of 0.24. The reason, as the interviewees opined, is the existence of some unstructured forms of RM driven by the increased demand for more sustainable PRRP, new government mandates long term cost savings and an increased sensitivity to BBB.

Interviewees were asked to classify the selected responses into one of the three risk allocation strategies (avoid, mitigate or transfer). Table 5 demonstrates that "mitigate" is the dominant risk response strategy while the "avoid" approach is viewed to be effective at the early stages of the PRRP life. The "mitigate" approach aims at risk minimization during construction. The followings include interviewees' comments on the survey results of economic, environmental and social risk matrixes, Figs. 11, 12 and 13.

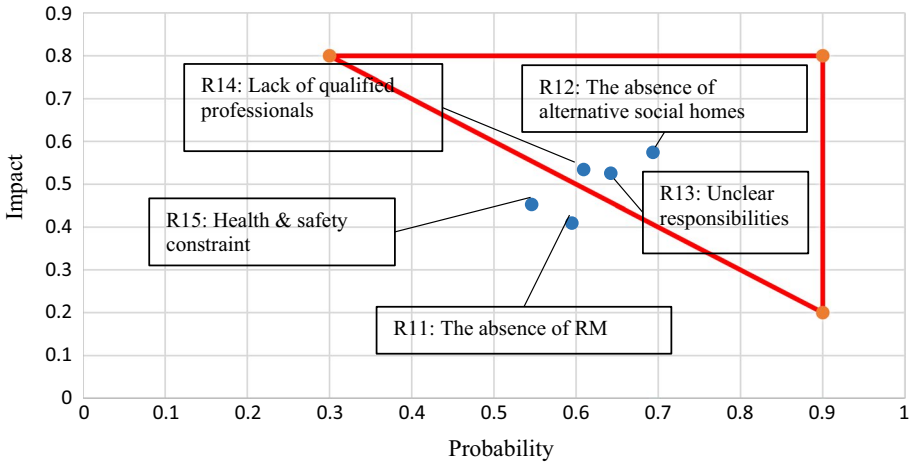


Fig. 13 Social risk matrix

7.1 Economic sustainability

From the economic risk matrix, Fig. 11, the economic risks marked in the triangle in the upper right corner are the risks with the greatest negative impact on PRRP performance.

As for R1 (the higher than anticipated expenses), the result obtained is in agreement with the prior research that found this factor among the top critical factors leading to construction time and cost overruns (Zou and Couani 2012; Xia et al., 2018). Moreover, one of the interviewees declared that "it is mainly due to the low price provided for the implementation of PRRP as some tenders were priced 20% less than its actual reasonable cost estimate. Although PRRP higher cost of sustainability standards is related to long-term savings with integrated design, this cost is perceived as the risk having the highest severity in Damascus' PRRP. All interviewees agreed that this is a critical risk as it is related to the project's liability.

R2 (the lack of sustainable building materials and technology) recognized by all interviewees as the shortage of green material and equipment is risking the success of PRRP. Drastically, more sustainable PRRP require technologies that minimize resource consumption and the environmental impact of the built environment. In Damascus, the need to manufacture, develop and test green building materials and equipment for PRRP is not well established yet. Therefore, the majority of construction equipment, materials and even plants designated for PRRP need to be imported, which normally requires a complicated procedure and a long period to be delivered on site. Nowadays this is even impossible due to the sanctions imposed on Syria by the U.S.A. (Hassan & Beshara, 2019). Another research conducted by Hwang et al. (2017) on Singapore green buildings demonstrated that the most significant risks seem to be related to green material and equipment (e.g., inflation, currency and interest rate volatility due to importing green materials, quality of local green materials, and shortage of green materials and equipment). This is because the country has limited green materials and such projects require these materials and equipment to be imported. Other possible economic risk subcategories' measures gathered from interviews are: energy bills, inflation, currency exchange

rate fluctuation, equipment rental, workers' salaries and volume of PRRP material diverted from landfill in Tons in light of the post-war demotion and reconstruction.

Justifiably, the interviewees agreed that most of the PRRP contractors tend to "transfer" the consequences of the economic risks procedure back to the "owner/client". For that, Design and Build (D&B) is recommended as an integrated delivery method for Damascus PRRP. Also, prior related research recommended improving contract structures to share the risk burden (El-Sayegh et al., 2018). D&B is a viable solution to improve communication and minimize alienating any stakeholder base (Kibert, 2016). This is because D&B allows early discipline integration (Xia et al., 2018). This approach is seen as necessary for multi-criteria SRM as various stakeholders' concerns can be considered.

7.2 Environmental sustainability

Table 4 shows that the environmental sustainability risks with 24% has the least weighting compared to the social and economic risk categories. Simultaneously, Fig. 12 does not indicate any critical environmental risk mainly due to the post-war situation shifting urgent priority to the social and economic risks. The environmental response category weighting at 31% supersedes the social response weighting at 25% as shown in Table 5. This indicates that respondents tend to respond to environmental risks when it is contractual or legal-related. As shown in Table 5, the environmental risk response RMM11 (Improved energy efficiency) with a score of 0.71 has the highest severity followed by RMM12 (the efficient use of resources and waste management) at 0.7.

The highest environmental response score of RMM11 indicates the difficult situation of the Syrian energy sector since the beginning of the current conflict. Oil and natural gas production has decreased dramatically mainly due to the sanctions imposed by the US, the war damages to energy sector infrastructure and the government losing control of many oilfields (Hassan & Beshara, 2019). Therefore, more sustainable PRRP are also challenged by technical and economic risk sub-categories associated with adapting energy efficient new techniques. According to the interviewees, this category includes: on-site electricity, gasoline and diesel consumption, resources and related transportation.

As for the environmental response of RMM12, it indicates that mitigating the PRRP environmental risks demands better resources and waste management. This fits in with the increase recorded in sales of cement, which, as of April 2011, amounted to 480,000 tonnes, had gone up by 115% compared to the figure for March 2015. This falls in line with increases in the prices of construction materials and labour (Clerc, 2015). The interviewees declared that present practice of demolition consists of turning projects into landfilled rubble. The interviewees have rising concerns associated with the landfills including soil, water and air pollution, release of harmful gases and landscape blight. Thus, the new Decree3 (2018) tackles the issue of rubbles removal and recycling. Salvaged materials from (non-structural and structural) deconstruction must be recovered. One interviewee (project manager) provided an example that the spent gypsum ceiling tiles can be used as raw materials in the manufacturing of new gypsum tiles, thereby; replacing the raw gypsum. Another interviewed project manager mentioned that concrete blocks are being crushed to produce aggregate for concrete mix or for backfill. The environmental risks subcategories have been identified, by interviewees to include generating waste, air, water and soil pollution and reduction of non-renewable energy.

7.3 Social sustainability

Social risks are related to the risk of PRRP on society (on local stakeholders and on the people involved and their acceptance of PRRP). This research study tackles the PRRP social risks from the perspective of construction professionals as the risk of causing an impact on local groups arises when the inhabitants of an area are a source of risk due to not being managed correctly. Interviewees explained that the construction of public PRRP lagged behind private construction. Many PRRP remained unfinished mainly because they did not address existing demands of low-income households as they were planned as long-term investments for an upmarket clientele.

As shown in Fig. 13, the social risk R12 (absence of alternative social homes) with a score of 0.40 has the highest severity followed by R13 (unclear responsibilities) at 0.34 and lastly R14 (lack of qualified professionals) with 0.33.

As for R12, the interviewees agreed on the severity of this risk and indicated the government delays in the limited compensations provided to the war victims who had to leave their homes for safety. This resulted in slowing down reconstruction work, disabling residents from returning to their original homes, dramatically increasing apartment's rental prices in Damascus and many other environmental, economic and social problems. The government justifies the delay with allocating fund to other priorities such as deportation rubble and securing infrastructure. These issues were viewed as critical by respondents who suggested feedback from the local community and residents through including them in the planning process rather than a purely top-down planning approach.

R13 indicates preventing PRRP owners from providing sufficient specifications to designers and contractors resulting in misinterpretation or misunderstanding of the owner' real purposes. This risk is being addressed by all interviewees who pointed out the government role through cautious transfer to decentralization the post-war re-construction process.

When being questioned about R14, the interviewees agreed that PRRP are challenged by lack of qualified professionals and insufficient workforce unless some control mechanisms are adapted to regulate training and provide appropriate certificates.

The differences in the results between this research and prior ones highlight the importance of this study showing that the Syrian PRRP has different critical risks compared to other countries. The feasibility of the elimination of all PRRP risks is unlikely. The best that can be achieved is developing a multi-criteria SRM framework to allocate risks to various stakeholders.

The interviewees further declared that the "transfer" response is the contractors' prevalent response to "client" and "consultant"-related risks, while the "mitigate" option is the principal response pattern linked to "contractor" and "exogenous" group-related risk factors. Interviewees also agreed that PRRP contractors mitigate risks that are contractual and legal related only. The dominant perception of the interviewees is that the crucial sustainable risks are related to clients and consultants suggesting that these two parties have an essential role in controlling the negative risks.

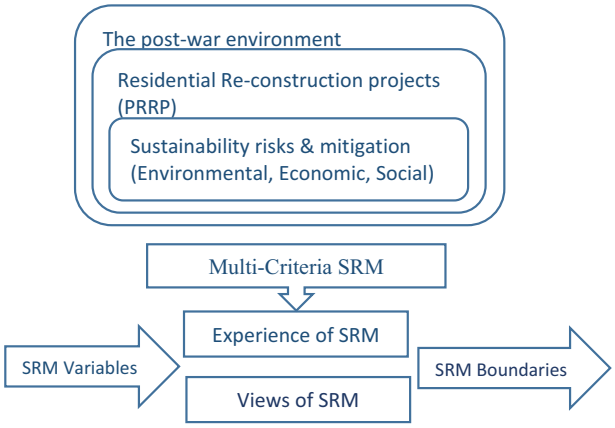


Fig. 14 Semi-structured interviews levels of analysis

8 Conceptual SRM framework

This section uses the survey and the interviews' findings to develop a multi-criteria SRM framework for Damascus PRRP. The interviewees agreed on the importance of SRM for PRRP with attention paid to sustainability risks expected due to: (1) local construction companies lack of experience in more sustainable PRRP, (2) post-war (economic, political and legal) circumstances, (3) construction resources and methods (manually or mechanically) and (4) strictness of contract specifications and conditions.

The identification of the sustainability risks itself is a challenge. Figure 14 represents the interviews levels of analysis. The three levels are: post-war environment (legal, political, economic and security situation), the PRRP progress (on the corporate and project levels) and the SRM (risk identification, indicators, level of impact and response types). This analysis is essential for the identification of sustainability risks PRRP face. PRRP sustainability risk drivers arise from the three levels including what must be built and how will it be built, construction companies' capabilities, contractual parameters and the effect of the various post-war circumstances. Representation of these elements can be gained from the concept of profiling which can be the most ideal way to elaborate the components that form a part of PRRP risks in terms of standards and valid characteristics.

To this point, the framework profiles different aspects of PRRP and its related risk in order to estimate the probability of occurrences and the impact if the risk actually happens. Syrian construction entities have been dealing with sustainability risks in an unstructured manner, operating in a developing country under post-war sanctions with little money to invest and a few experts in sustainable buildings. The interviewees indicated that although unstructured RM is considered an integral task for PRRP delivery, construction industry practitioners may experience challenges in its structured implementation especially with respect to sustainability risks identification and response selection to individual risks. As a solution, this study multi-criteria framework provides a structured process for sustainability risk assessment which can be explicit with the implicit risks being common hence making way for unpredictability and non-optimal decisions. These findings were evident in data from the semi-structured interviews.

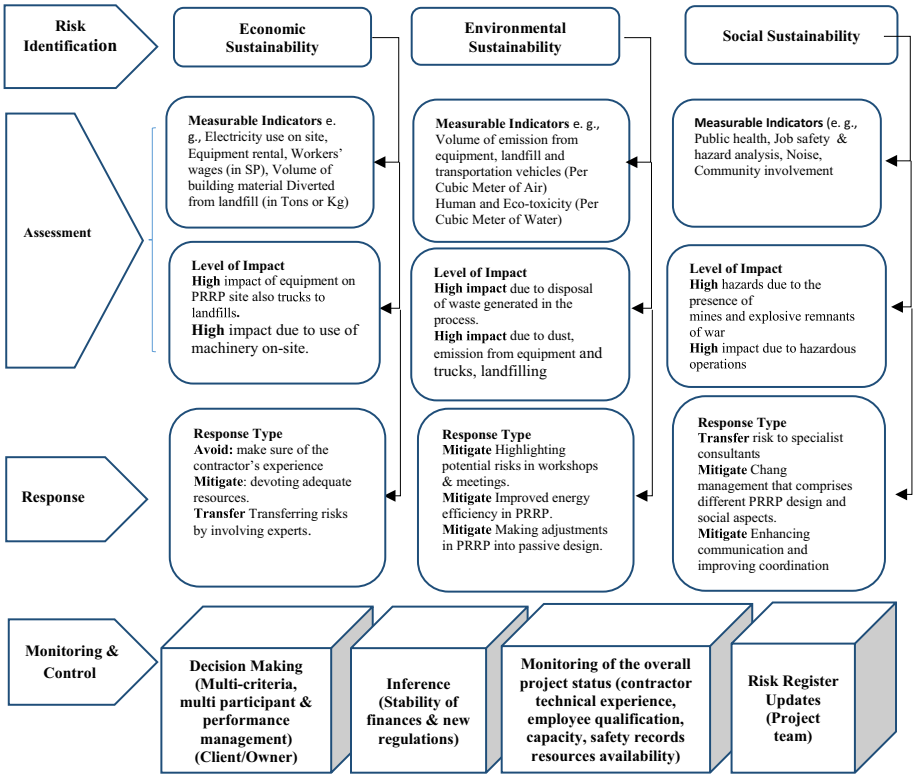


Fig. 15 Multi criteria SRM framework for Damascus PRRP

This study's framework reflects the interaction of sustainability assessment (economical, environmental, and social) and its associated risk impacts in Damascus PRRP. This is to establish MCDM context based on: (1) unique synthesis criterion approach through sustainability's three pillars, (2) ranking synthesis approach through RM process as to provide the preference to decision-makers and (3) interactive local judgment approach proposes alternate steps with multi sustainability objective to get successive compromising decisions.

As can be seen in Fig. 15, the framework is constructed in three dimensions: sustainability assessment to building systems and components as one dimension (x-axis), risk management process as the other (y-axis), and MCDM as the third dimension (z-axis; presented in the 3D boxes at the bottom of the figure). Other attempts from previous similar research have proposed frameworks constructed in two dimensions only: sustainability assessment and MCDM (Si et al., 2016), MCDM and sustainability three pillars (Hosseini et al., 2016) or risk management and stakeholder management (Xia et al., 2018). Figure 15 illustrates the procedural SRM for PRRP decision screening process: (1) Preliminary review on environmental, economic, and social risks, (2) Assessment of the risk impact level on the economic, environmental and social sustainability, (3) Allocation of weight values, (4) Synthesizing the alternative ranks, (5) Response type and responsible party, (6) Decision and (7) Monitoring and risk register updates.

In this sense the framework four levels have the following roles: (1) Risk identification could start form the Pre-design phase to assist the owner, planner and others involved at the planning (pre-design) stage of the project. (2) Risk assessment offers a self-assessment check system that allows architects and engineers to raise PRRP sustainability under consideration during its design process. Assessments here is based on the design specification and the anticipated performance. It has two main roles: (1) To assist in grasping measurable indicators such as the basic environmental impact of the project and selecting a suitable site. (2) To evaluate the level of impact of the project at the Pre-design stage. (3) The response level is based on risk records for selecting the appropriate response type. (4) Monitoring is the tool for decision Making (by Client/Owner). Monitoring of the overall PRRP status (by contractor) and building risk register updates (by project team), Fig. 15.

According to the interviewees, some construction firms had simple procedures or used checklists to eliminate risks while others chose to transfer risk management to engineering consultants. The framework was seen applicable by the interviewees with a few suggestions e.g., supporting the framework with a simple manual that includes basic theoretical information and ready-to use guidance. Once the risk assessment is conducted, suitable risk responses can be implemented in the form of transfer, avoid, or mitigate.

These findings were evident in data from the semi-structured interviewees, the subject matter experts. To determine the extent of each interviwee had contributed to the identified dimentions, an assessment and response metrics was created with columns for dimention of importance (benefits, practices vs implemenation gap and recommendations) and rows in which sustainability assessment, risk management and decision-making categories were categorized, Table 6. The interviewees were provided with the study main findings. Then the experts were asked to respond to the statement categorised in Table 5. Five interviewees (with the percentage of 71.43%) included that there are other stakeholders' managerial risks e.g. unclear contract conditions for dispute resolution. Whereas six interviewees (with the percentage of 85.71%) indicated the risk of complex planning approval and permit procedures of Damascus PRRP. One expert responded in a manner that required a subjective evaluation to transform the expert's opinion into the requested categories. This is because this interviewee referred to the fluctuation in exchange rates affecting the import of green building materials and technologies. The main responses are presented in Table 6.

Figure 15 presents the final developed approach. The framework proposed specific steps which are essential to solve a multi-criteria SRM decision-making problems in Damascus PRRP. Decision-makers first identify risk factors, which have an essential influence on PRRP performance. After that, all feasible alternatives to the problem solution are defined. The stakeholders should identify PRRP goals and a set of criteria. The assessment response matrix and weighting are essential for the framework development. Mitigation and response are then selected to ensure the risk tolerance and interests of all PRRP actors. Thus, SRM is negatively affected by the post-war circumstances. The framework proposes a scheme toward improving SRM through compensation and motivation in construction process, which will enhance sustainability within PRRP process and performance.

9 Research contribution and limitation

In line with the empirical evidence and theoretical opinion presented in this study, it is expected that more sustainable PRRP will buffer the relationships among the environmental, social and economic risk reduction measures. In other words, SRM will be stronger

Table 6 Multi-criteria SRM assessment and response metrics

	Existing provisions	Benefits of the framework	Implementation issue	Recommendations
Sustainability Assessment	-Fragmented voluntary initiatives (85.71%). -Unclear contract conditions (85.71%). -Unclear detailed design or specifications (85.71%).	-Setting economic, environmental and social sustainability risks, indicators (100%). -Weighting and responding (85.71%).	-Inference (stability of finances & new regulations) (85.71%).	-Sustainability standard method, tests for evaluation and certification (100%). -Promoting renewable energy systems (100%). R&D on LC analysis (57.14%).
Risk Management	-Unstructured RM (100%). -Other stakeholders' contractual, material and equipment considerations: Design errors and changes during construction (71.43%). -Insufficient quality control leading to material quality problems (71.43%).	-Reducing negative events and uncertainties (100%). -Improving ability to deal with them (100%). -Providing risk assessment tool for designers with sustainable consideration (100%).	Other stakeholders' managerial considerations: -Unclear contract conditions for dispute resolution (71.43%). -Complex planning approval and permit procedures (85.71%).	-Risk Register Updates (by project team) (100%). -Better quality control (57.14%). -Better communication among stakeholders (71.43%). -Better control over subcontractors (71.43%).
Multi-criteria Decision Making	-Undocumented rational process (100%). -Poor communication among stakeholders (85.71%).	-Achieving PRRP objectives (85.71%). -Scoring alternatives (100%). -Synthesizing the final results (85.71%).	-Decision making: multi-criteria, multi participant & performance management) (Client/Owner) (85.71%).	-Monitoring of the overall project status (contractor technical experience, employee qualification, capacity, safety records resources availability) (85.71%). -The availability of capital required (100%). -Smaller size economic PRRP (28.57%).

(more positive) for Syrian construction companies that implement the proposed multi-criteria framework than those without. The framework enables construction companies combining the effects of all the mentioned risk factors as no single factor is enough to make a decision but sometimes a single factor could be enough to make a severe risky decision.

There is more insight obtained in this research study from using mixed method research. The combination of quantitative and qualitative methods offers an expanded understanding of research problem (Creswell & Creswell, 2017). This is seen essential for this research study that incorporates the need both to explore and explain SRM in PRRP. The developed multi-dimensional conceptual model aims to assess decision making for more sustainable PRRP e.g., technology selection.

The study's multi-criteria framework offers practitioners a novel approach to customize their own list of sustainability risks. The main benefit of this framework is the logic, in which SRM output assessment can be done in an improved manner, resulting in a shift in the SRM control from input oriented to a more output oriented one. Therefore, the prime motive for construction companies to implement the study framework is to be equipped with a short-term reactive approach for managing sustainability risk.

The study basic approach to multi-criteria SRM for Damascus new PRRP is based on the following rules, with the aim of achieving widespread use of SRM: 1) this framework provides a positive risk assessment tool for designs with sustainable consideration, rather than simply a negative checker, to motivate designers, clients and other partitioners to be more interested in using it; 2) it should be a general-purpose framework, able to evaluate PRRP sustainability with wide-ranging types and sizes; with the framework assessment system (measurable indicators and impact level) kept as simple and comprehensible as possible and 3) to ensure widespread use of SRM, this framework assessment criteria have a flexible structure able to enhance sustainability initiatives taken by local construction companies based on their organizational circumstances. Therefore, mitigating sustainability risks in the three previous rules requires all PRRP stakeholders' cooperation, innovative thinking and continuous learning.

As SRM is a multi-criteria and multi participant procedure, it is necessary to concentrate on the most neglected areas of advocacy; funding and knowledge concerning PRRP risk reduction measures. The interviewees' comments on the applicability of the presented framework (identification, assessment, response and monitoring process) were gathered. The framework applicability depends on: (1) reputation of the PRRP owners, (2) financial capability of the PRRP owners, (3) PRRP Size, (4) fulfilling contract conditions and standards, and (5) the availability of capital required. Smaller size economic PRRP were recommended for the time being by two of the research interviewees.

The research validity is ensured as the researcher checks the accuracy of the findings by employing certain valid procedures while reliability indicates that the researchers' approach is consistent. The research objectives were achieved despite limitations to the conclusions that may be drawn from the results. Validity is one of the strengths of mixed research (Creswell & Creswell, 2017). Thus, many RM studies depended on subjective judgments and experience (Hwang et al., 2017; Yang et al., 2016). This study different data sources of the survey and the semi-structured interviews were used to build the multi-criteria framework coherent justification. Since the framework themes are established based on converging several sources of data from participants, then this process can be claimed as adding to the validity of the study.

Simultaneously, the accuracy of the semi-structured interviews findings was double checked through sharing major findings, analysis and the framework with participants. Follow up emails were sent to the interviewees to determine whether they feel that they are accurate. This procedure provided an opportunity for them to comment on the findings. An assessment and response metrics was provided in Table 6. The intent of this study is not to generalize findings outside the case of Damascus PRRP. The findings were well interpreted in the context of Damascus PRRP which may be different from the context of other countries. Nonetheless, this study provides an in-depth understanding of sustainability risks and responses in Damascus PRRP. In fact, the value of this research lies in the particular description and themes developed in context of Damascus PRRP.

As the severity of sustainability risk is related to post-war complexity, the project team should not focus only on managing the identified risks, but also be prepared for new expected negative risks. Therefore, this research framework offers identifying, assessing and controlling more possible risk elements. The benefit here is to enable construction companies from performing a significant part rating PRRP execution against achieving projects sustainability objectives.

Finally, as the success of any PRRP is determined by how sustainability risks associated with each project are managed throughout the entire project lifecycle, further research would be necessary to conduct a stakeholders' approach throughout PRRP lifecycle phases. The application of SRM equips project team members with the ability to develop a formal process of systematically identifying, assessing and formulating an effective SRM. Relying on findings from this study, construction companies in other post-disaster cities can improve their understanding of sustainability risks in PRRP, adopt SRM framework for their projects and originate other potential risk effective responses.

10 Summary

This research contributes to empirical knowledge by introducing a multi- criteria SRM set for Damascus PRRP based on the overview of the literature, survey and experts' judgement. A checklist of (31) key potential sustainability risk factors in PRRP was firstly identified. Beside, sustainability risk matrixes in terms of economic, social and environmental sustainability were developed to evaluate the relative priority of all previous risks and determine the high—priority risks for more effective planning and successful response actions. The study used a survey and semi-structured interviews to develop a multi-criteria SRM framework as a decision-support methodology for Damascus PRRP.

The top five risks found are: higher than anticipated expenses, absence of sustainable technology, delays in planning for alternative social homes, unclear allocation of responsibilities and lack of qualified professionals. The highest three severity risks are caused by political, economic and legal circumstances associated with the post-war situation. Such risks have no structured method to be identified, predicted or controlled by the Syrian construction companies in the post-war context. Hence, this study proposes key effective risk responses through procurement changes toward D&B, design changes that improve energy efficiency, minimizing resources, improving waste management and policy changes to enforce decisions being made on time based on multi-criteria SRM. Also, SRM can be

improved through workshops, meetings and training programs to improve staffs' skills on sustainable construction technologies.

While projects sustainability objectives are set by different international standards, sustainability risks vary from one project to another with numerous conditions. SRM contributes to a better view of PRRP consequences resulting from unmanaged sustainability risks leading to negative impact on PRRP process and performance. The main advantage is an increased level of control over PRRP and efficient problem solving process at PRRPs' early design stages.

Appendices

Appendix A: The Translated Questionnaire

Section 1: Background Information of Respondent

1. Please select the type of your company
   - Consultancy
   - Contracting
   - Construction management
   - Regional planning
   - Engineering academic
   - Other engineering body----------

2. Please identify your job title
   - Project Manager
   - Architect
   - Engineer
   - Quantity Surveyor
   - Consultant
   - Regional planner
   - Developer
   - Quantity surveyor
   - Other----------

3. Please identify your years of experience in traditional residential building construction projects
   - Less than 5 year
   - 5 to 10 years
   - 10 to 20 years
   - More than 20 years

4. Please identify your years of experience in sustainable residential building construction projects
   - Less than one year
   - 1 to 3 years
   - 3 to 4 years
   - 4 to 5 years
   - More than 5 years

Section 2: Assessment of Sustainability Risks in Damascus Post-war Residential Projects

Based on your experience in sustainable post-war residential projects, please assess each risk below regarding its probability and impact, using rating scales (one being very low and five being very high)
Probability: 1–Very unlikely; 2–Unlikely; 3–Fairly likely; 4–Likely; 5–Very likely.
Impact: 1–Very insignificant; 2–Insignificant; 3–Fairly significant; 4–Significant; 5–Very significant.

Category	Code	Identified Risk	Probability					Impact				
			1	2	3	4	5	1	2	3	4	5
Economic	R1	Higher than anticipated expenses & shortage of funds										
	R2	Lack of availability of green materials and equipment										
	R3	Unclear contracts' technical specifications and conditions										
	R4	Being fined for failing to meet the project objectives										
	R5	Poor constructability[1]										
	R6	Delays due to poor contract management										
	Other Please specify											
Envirn.	R7	The absence of sustainable reconstruction strategy and policies										
	R8	Setting High Target for Green Mark Rating[2]										
	R9	Pollution										
	R10	Energy Consumption										
	Other Please specify											
Social	R11	The absence of Risk Management consideration										
	R12	The absence of alternative social homes										
	R13	Unclear allocation of roles and responsibilities										
	R14	Lack of qualified professionals and poor workmanship										
	R15	Health and safety constraint										
	Other Please specify											

[1] Constructability is the optimal use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. It defines the ease and efficiency with which structures can be built. Constructability is in part a reflection of the quality of the design documents; that is, if the design documents are difficult to understand and interpret, the project will be difficult to build.
[2] Green mark rating: is the Green Mark points assigned based on the degree of compliance with the applicable criteria initiative as PRRP must fulfil their respective pre-requisite requirements to attain the respective Green Mark rating.

Section 3: Assessment of Sustainability Risk Mitigation Measures in Damascus Post-war Residential Building Projects

Based on your experience in more sustainable post-war residential projects, please assess the following risk mitigation measures in terms of their effectiveness, using rating scale: with numbers ranging from one to five (one indicates very low response effectiveness and five indicates very high response effectiveness).
1–Totally ineffective; 2–Ineffective; 3–Neutral; 4–Effective; 5–Very effective.

Category weighting	Code	Risk response and mitigation	Response effectiveness				
			1	2	3	4	5
Economic	RMM1	Allowing for PRRP contingency funds					
	RMM2	Making sure that PRRP contractor has enough knowledge and resources					
	RMM3	Devoting adequate resources to planning and research					
	RMM4	Being active in PRRP process to take an action when any risk occurs					
	RMM5	Transferring risk by involving consultants/experts in PRRP process					
	RMM6	Well prepared bidding requirements					
	RMM7	Decisions being made on time					
	Other Please specify						
Enviro.	RMM8	Highlighting all potential risks on workshops or meetings					
	RMM9	Making adjustments in the project's environmental targets					
	RMM10	Implementing passive design					
	RMM11	Improving PRRP energy efficiency					
	RMM12	Efficient use of resources and waste management					
	Other Please specify						
Social	RMM13	Changing management that comprises different design and social aspects					
	RMM14	Enhancing communication and improving coordination among PRRP stakeholders					
	RMM15	Training programs that upgrade workers' skills					
	RMM16	Transferring risks to the PRRP project team					
	Other Please specify						

Interest in further semi-structured interview

Semi-structured interviews will be conducted as part of this research study to investigate how sustainability risk management is perceived and experienced by construction professionals in Damascus. As an experienced construction professional you are in an ideal position to give us valuable first-hand information from your own perspective.

The interview will take around 30 minutes. The main objective of these interviews are to gain an overall understanding of how the perceived PRRP sustainability risks affects construction companies' decision making in practice. Certain open-ended questions will be asked in the same order. Your responses to the questions will be kept confidential. There is no compensation for participating in this study. However, your participation will be invaluable addition to our research and findings could lead to greater awareness of sustainability risk management in Damascus post-war reconstruction residential projects.

If you are willing to participate please provide your contact details and suggest a day and time that suits you.
Please do not hesitate to contact me for any further information.
Thanks
Regards

Appendix B: The supplementary semi-structured interviews protocol

Interview protocol

Interview Protocol **Project title: Multi-Criteria Sustainability Risk Management for Post-war Residential Re-construction**		
Time of the interview: Place: Date: Interviewer: Interviewee: Interviewee position: Brief description of current PRRP:		
Main themes questions	Follow-up (Why and How)	Main outcomes
1- What are the key sustainability risks you have faced while completing the PRRP?	Risk Identification: -Economic -Social: -Environmental:	
2- How will PRRP contractors respond to sustainability risks, identified in Table (4) and classified in; -figure (11): economic sustainability, -figure (12): environmental sustainability -figure (13): social sustainability.	Measuring indicators & level of impact: -Economic: -Social: -Environmental:	
3- In your judgment, were the responses in table (5), classified as avoid, mitigate or transfer strategy type?	Response Type: -Avoid: -Mitigate: -Transfer:	
4- How will construction companies could benefit from this research multi-criteria SRM framework, figure (15)?	Filling the gap between: -Existing provisions -Implementation issues	
5- Do you suggest any other requirement for the proposed framework?	Recommendation	
Closed-ended questions were found to be ideal gateways to open-ended probing. For example, after asking, "In your judgment, were the responses, in table (5), avoid, mitigate, or transfer strategy type?" the researcher could follow up by asking, "Why is that?" or "Why do you feel that way?" and continue with additional probing as needed. Each interview/meeting took about 60 minutes.		
Thank the subject expert for participating in this interview. Assure him of confidentiality of responses.		

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Declarations

Conflict of interest There are no conflicts of interests to declare.

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