

AMERICAN UNIVERSITY OF BEIRUT

DISASTER WASTE MANAGEMENT CHALLENGES AND  
ENABLING FACTORS FOR STRATEGIC PLANNING: CASE  
OF BEIRUT PORT EXPLOSION

by  
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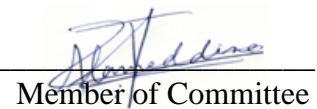
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# ABSTRACT OF THE THESIS OF

Lara Malek Al-Tawil

for

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Title: Disaster Waste Management Challenges and Enabling Factors for Strategic Planning:  
Case of the Beirut Port Explosion

Disasters occur in both developed and developing countries and tend to generate significant quantities of construction and demolition (C&D) wastes. Developed countries have previously developed and implemented adequate disaster waste management (DWM) strategies to facilitate their recovery processes. Lebanon, alike many developing countries, has struggled to overcome various technical, administrative, managerial, legal, institutional, and financial limiting factors, which hindered the development of adequate DWM action plans. In Beirut, the capital of Lebanon, a devastating explosion at the port resulted in the generation of around 800,000 tons of C&D wastes. Accordingly, the ultimate aim of this research is to develop a DWM action plan for Beirut and the specific objectives are to assess the DWM strategies currently implemented in Lebanon, to identify the prevailing challenges and comprehend the respective enabling factors, and to conduct a comparative assessment to compare the DWM plans between Lebanon and other selected countries. The developed DWM plan that is ready to be adopted and implemented in Lebanon can be contextualized in other developing countries.

The challenges Lebanon faced with the management of the construction and demolition wastes were assembled through conducting a well-developed in-depth interview guide. As such, interviewees were selected from both governmental and non-governmental organizations due to their knowledge, expertise, and involvement on the topic of DWM of the Beirut Port. The interviews were later transcribed, and thematically analyzed. The DWM challenges that should be tackled before developing DWM plans were tabulated in a comparative assessment table and were compared across different countries. These challenges were selected as they represent the most significant ones that negatively impacted the DWM development process in both developed and developing countries. Based on the literature review, no country was able to successfully implement a DWM plan without determining the enabling factors for these challenges that were tabulated, thereby qualifying them to be significant challenges worthy to be selected to conduct the comparative assessment. Each of the challenges presented in the table were scored and cumulative scores pertaining to each country gave an indication of its DWM performance. Scores were given to each challenge based on a set of criteria that should be available to overcome the challenge; all of which are presented in a rubric. Higher scores were given to countries who satisfied

the criteria under each challenge, which thereby indicated that the country is facing less challenges in developing and implementing its DWM plans. Lower scores were given to countries who failed to satisfy the criteria under each challenge, which indicated that the country is highly challenged in managing its DW.

The findings of the thematic analysis revealed that there are various technical, administrative, managerial, legal, institutional, and financial limiting factors that are challenging the DWM process in Lebanon. Interviewees believed that the absence of required technologies, infrastructure, expertise, and DWM guidelines are all technical challenges that hinder the management of disaster wastes. The absence of contingency, risk reduction, implementation, and stakeholder plans are considered administrative and managerial challenges worthy to be mentioned. Interviewees also stressed on the significant legal and institutional challenges faced as a result of the absence of a clear legal and institutional framework to govern the initiatives of DWM plans. It is not to underestimate the financial challenges faced due to the lack of adequate financial resources to support the management process.

The comparative assessment also portrayed the enabling factors that should be contextualized by Lebanon and other developing countries to succeed in DWM planning. It was proposed that inventories should be developed and they should include all the machines, expertise, and infrastructure needed. A DWM guideline could also enhance the decision making process regarding the best DW management methods. A proposed contingency, risk reduction, implementation, stakeholder mapping plans should be development before the occurrence of a disaster to facilitate coordination between stakeholders. As well, the development of a legal and institutional framework consisting of decrees to govern the initiatives regarding DWM should be well developed and implemented; that includes a budgeting strategy to the recovery process.

Hence, this research will have a great significance at the national level as it will assess the DWM challenges and enabling factors which will set the ground for the development of the elements of an action plan, one of which is a contingency plan, specific for Lebanon. These plans will guide stakeholders on what should be included in a plan; to ensure that it is well-developed and implemented. As such, the contingency plan must include a stakeholder mapping plan, waste characterization initiatives, developed inventories of technical, human, and financial expertise, infrastructure preparedness initiatives, waste treatment flow charts and decision trees, and finally closure and monitoring plans. This will help other developing countries draw resemblance between the Lebanese case and their own; to follow a similar process and develop their own DWM strategies that aim for a successful implementation. As well, this research is one of the few studies that will be available in the literature to help in the development of a DWM action plan that specifically manages C&D wastes instead of disasters as a whole. This will allow developing countries to differentiate between efforts implemented to manage their post- disaster wastes and those implemented to overcome the disaster generally.

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# CHAPTER 1

## INTRODUCTION

Globally, disasters generate significant amounts of debris that require urgent management strategies (OCHA, 2011). Countries tend to face man-made disasters such as intense explosions, short-term and/or protracted conflicts or natural disasters such as earthquakes, floods, tsunamis, hurricanes, and wildfires (Luther, 2017). The type of disaster that occurs and the nature of the impacted environment highly define the characteristics of the debris generated, upon which decision making is done to adequately manage the affected area (Brown et al., 2011). Natural or man-made disasters result in the generation of a variety of waste categories such as construction and demolition (C&D) wastes, organic wastes, electronic and white goods, marine wastes and sediments, vehicles and vessels wastes, personal property wastes, commercial or industrial hazardous wastes, and infectious wastes. Among the various types of wastes, C&D wastes represent the largest component of disaster debris (Luther, 2017). Generally, C&D wastes are constituted of damaged buildings debris such as glass, wood, tiles, gypsum boards, electric wirings and the remains of damaged public infrastructures (Luther, 2017).

The adequate management of disaster wastes is imperative due to their substantial public health and environmental impacts (Habib et al., 2019). The generated C&D wastes can expose people to safety hazards due to the increased risks of tripping and falling hazards resulting from the presence of damaged buildings and infrastructures (OSHA, 2020). Moreover, the presence of disaster wastes such as broken glass, metal, wood, gas tanks,

hazardous chemicals and damaged electric wirings all lead to safety hazards that could expose people to several physical injuries such as burns, electrocution, cuts, or death (OSHA, 2020). Hazards from exposure to asbestos embedded in walls of old buildings could also lead to respiratory diseases. People are also at high risk of secondary infections caused by the mismanagement of health-care debris in the affected area (OSHA, 2020). From an environmental perspective, disasters may generate large volumes of wastes that overwhelm the existing solid waste management system, resulting in inefficient waste sorting methods, open dumping, uncontrolled incineration, and decreasing the life expectancy of landfills. Consequently, this can increase the recovery time and associated cost of disaster areas (Brown et al., 2011).

Given the potential public health and environmental impact of disaster wastes, developed and developing countries must overcome several challenges at the technical, administrative, managerial, legal, institutional, and financial levels, to be able to develop adequate disaster waste management (DWM) strategies. Contingency, risk reduction, and implementation plans are fundamental to recover from disasters in the most time-efficient, environmentally responsive, and cost-effective manners (Yusof et al., 2016). Developed countries such as the US and Japan have previously developed and implemented such plans due to the high frequency and intensity of natural disasters and the absence of significant technical, managerial, institutional, and financial limiting factors that may hinder their work (Francesco et al., 2017). Both countries were able to develop strategies and tools that cover all the mentioned above limiting factors, thus allowing them to immediately respond and recover from disasters (Crowley, 2017). On the other hand, most developing countries

struggle to recover whenever a disaster occurs. They face several challenges in implementing effective and efficient strategies attributable to diverse technical, legal, institutional, and economic limiting factors (Zhang et al., 2019). The lack of the needed provisions and/or implementation of adequate management strategies often challenge such countries at the technical, administrative, managerial, legal, institutional, and financial levels (Asari et al., 2012). The most commonly adopted approach to manage disaster wastes is to accumulate them in piles without adequate collection, segregation, or disposal. This will unfortunately lead to the decomposition of unseparated organic material present in the piled waste stream (Poudel et al., 2019).

In the case of Lebanon, a devastating explosion took place on the 4<sup>th</sup> of August, 2020 which resulted in the generation of an estimated 800,000 tons of C&D wastes (Relief Web, 2020). Such a significant amount of generated wastes requires the presence and execution of adequate DWM strategies for the restoration and rehabilitation of the affected area. Accordingly, the challenges and enabling factors should be tackled to pave the way for DWM strategic planning initiatives.

### **1.1. Research Objectives**

The ultimate aim of this research is to develop a DWM action plan specific for the management of disaster wastes in Lebanon.

The specific objectives of this research are to:

1. Explore and evaluate the implemented strategies and measures for the management of the C&D wastes that resulted from the Beirut Port Explosion.
2. Identify the national barriers and enabling factors towards implementing current and future DWM strategies.
3. Conduct a comparative assessment of different DWM plans between Lebanon and other selected countries.

## **1.2. Research Significance**

It is clear that developed countries are ahead in developing and implementing their own DWM strategies. Their success has pushed several developing countries to adopt their guidelines. Yet, the major struggle that developing countries constantly face is in their ability to overcome technical, administrative, managerial, legal, institutional, and financial limiting factors to be able to develop and implement DWM contingency plans. Developing countries struggle to develop their own DWM strategies that are tailored to their local contexts (Karunasena et al., 2010). This research is expected to have a great significance at the national level, as it will assess the DWM challenges and comprehend the respective enabling factors that would successfully and prospectively improve the current DWM strategies in Lebanon. This will set the ground for the development of a well contextualized country specific contingency plan that would allow other developing countries to draw from the resemblance between the Lebanese case and their own; to be able to follow a similar process and develop their own DWM strategy that aims for a successful implementation. Most importantly, this research will provide the opportunity for developing countries to adopt,

contextualize, and successfully implement DWM plans from Lebanon, which is also a developing country who has faced challenges in DWM similar to the ones they are facing. This research will also set the ground for the development of a DWM action plan that tackles the management of disaster wastes specifically and not the disaster as a whole. To elaborate on this point, the body of literature covers various aspects related to disasters such as people evacuation strategies, provision of food and water resources, maintenance of social safety within a disaster impacted community, and in rare cases, it tackles the disaster waste management strategies implemented. This research, will only tackle the aspect related to the management of disaster wastes specifically, which gives this research its uniqueness.

## CHAPTER 2

### LITERATURE REVIEW

#### **2.1. Natural and Man- made Disasters and their impacts**

##### ***2.1.1. Nature of Disasters***

A disaster is a catastrophic and suddenly occurring event that is characterized by a defined spatial dimension, intensity, and frequency that tend to significantly disrupt human, material, and environmental resources (Greiving et al., 2016). In the past 70 years, both the frequency and severity of disasters have exponentially increased. The Emergency Event Database has recorded the occurrence of approximately 3,751 natural disasters between years 2008 and 2017 (Kotsireas et al., 2021). Natural disasters such as floods, hurricanes, volcanic eruptions, earthquakes, and tornadoes occur suddenly as they are beyond human control and leave behind significant impacts on humans and their environment (Marshall et al., 2020). On the contrary, man-made disasters such as explosions (chemical or nuclear), severe cases of pollution, toxic leakages, or fires may result from a wrongful human act or decision. Other man- made disasters such as national or international acts of war take place as a consequence of long-term political tensions (Marshall et al., 2020). Such disasters also account for a significant number of morbidities and mortalities, in addition to the significant amounts of generated disaster wastes (Tapp et al., 2008).

### ***2.1.2. Impacts of Disasters***

Natural and man-made disasters have various public health impacts as they increase the morbidity and human displacement rates, and psychologically traumatize and stigmatize impacted communities, which reduces human productivity. All of these impacts tend to develop various public health, economic, and global health security challenges within the affected country (Marshall et al., 2020; Halkos et al., 2015).

Most significantly, such disasters highly impact the physical environment of the spatially defined effected area thus leading to the generation of significant amounts of wastes. The characteristics of the generated wastes highly depend on the landscape of the impacted environment and the intensity of the disaster itself. For instance, an earthquake occurring on an island will leave behind a significant amount of marine and vegetative debris in comparison to one occurring in an urban area, which would leave behind mostly construction and demolition (C&D) wastes (Luther, 2017). Focusing on areas dominated by infrastructure, disasters in such landscapes lead to damages in buildings and infrastructure, which consequently increases the generation of C&D wastes. The 2011 Great East Japan earthquake and tsunami that took place north east the Japanese city of Sendai, generated around 16 million tons of C&D wastes, which was equivalent to 14 years of solid waste generation in the area under normal circumstances (Karunasena & Amaratunga, 2015). Accordingly, that natural disaster overwhelmed the preexisting waste management system and required the urgent implementation of disaster waste management (DWM) strategies.

Countries who fail to quickly and effectively respond to natural and man-made disasters may expose their communities to various psychosocial impacts. The

mismanagement of C&W wastes generated from hurricane Katrina continued to impact the health and the environment of the residing communities for up to 3 years post disaster (Karunasena et al., 2012). The 2004 Indian Ocean tsunami that impacted the South and Southeast Asia generated C&D wastes composed of damaged septic tanks and toilets that contaminated the soil and water of the surrounding environment. The environmental pollution caused by the damaged sewage pipes and sewers degraded the water quality of nearby water bodies (Karunasena & Amaratunga, 2015).

Additionally, failure to manage C&D wastes that result from man-made disasters also expose people to various psychosocial hazards as a result of the degraded and hazardous environment they are forced to live in. For instance, the war in Iraq generated significant amounts of C&D wastes, out of which concrete accounted for the greatest proportion of the wastes. The persistence of concrete in nature has led to several physical hazards that impacted the public and has hindered the reconstruction process. (Khatab et al., 2021).

## **2.2. Stages towards developing disaster waste management strategies**

In light of the increase in the global frequency of natural and man-made disasters, countries challenged by these unfortunate events have found urgency in effectively developing and implementing disaster waste management (DWM) strategies compatible with their own technical, managerial, institutional, and financial conditions (Karunasena & Amaratunga, 2016). Consequently, there is a need to shed the light on the phases required

to develop adequate disaster waste management strategies namely planning, response, and recovery (Karunasena et al., 2012).

### ***2.2.1. Planning***

There are two types of pre-disaster plans that should be developed for adequate DWM. These are the Risk Reduction Plans and the Contingency Plans.

#### **2.2.1.1 Risk Reduction plans**

When dealing with disaster prone areas, it is important to develop various risk reduction strategies that will help in limiting the amounts of disaster wastes generated post-disaster. In order to do that, one must have information about the quantity and the quality of the wastes that could be generated in the area of interest. This could be done through undergoing a field survey or referring to previous studies and technical reports that state the area's existing landscape, degree of urbanization, and existing facilities that could be affected by the disaster. It would also be helpful to refer to the recorded quantities and qualities of disaster wastes generated from previous disasters that occurred in that area. Enough data about the characteristics of disaster wastes will help in the development of waste reduction strategies and consequently allow specialists to develop successful disaster risk reduction measure to reduce the quantities of generated wastes and limit the contamination of the disaster waste stream by possible hazards (Denot, 2016).

There are different initiatives that could be developed before the disaster occurs to reduce the quantity of generated wastes post-disaster. On the other hand, there are some initiatives that could be developed to reduce the risks that people could be exposed to post-disaster (Denot, 2016). Table 2.1 demonstrates various risk reduction strategies that could be implemented both pre and post disaster.

**Table 2.1 – Disaster Waste Risk Reduction Initiatives**

(Tabata et al., 2019; Denot,2016).

	<i>Risk Reduction Initiatives</i>	<i>Benefits</i>
Pre-disaster Risk Reduction Initiatives	Adequate urban planning to limit the degree of urbanization	Reduces estimated quantity of disaster wastes
	Zoning the disaster-prone area	Speeds the management process since less waste quantity are managed in each zone
	Provide financial help to improve the stability of housing and infrastructure conditions  (earthquake resistant buildings and construction/renovation of flood prevention facilities, etc.)	Increases building stability which will reduce estimated quantity of disaster wastes
	Store material needed for post disaster outside the disaster-prone area	Enhances accessibility to needed machinery which can result in a quicker disaster response and

		prevents the accumulation of disaster wastes
Post-disaster risk reduction initiatives	Confine contaminated areas to prevent cross contamination of hazardous substance with recyclables	Reduces amounts of wastes to be landfilled  Minimizes potential risks on people and environment
	Limit the spread of disaster wastes through fast clean-up and collection procedures to previously designated temporary storage sites	Speeds the management of disaster wastes  Minimizes the potential post disaster psychosocial impacts on the residents and their environment

#### 2.2.1.2 Contingency Plans

Developing contingency plans has become a priority for disaster prone countries since these plans tend to state how a country should be managing its disaster wastes post-disaster. Developed countries have been working on this topic for a long-time as compared to developing countries, who are in the process of developing ones. Some countries have not even started prioritizing the development of such disaster waste management plans (Karunasena et al., 2012).

The development of contingency plans is usually handled by specialized disaster waste management stakeholders, who are eligible to develop them with the assistance of

various technical, administrative, legal, institutional, and financial expertise. As such, planning disaster waste strategies require more of an integrated approach to be developed and implemented successfully. However, these experts will not be able to develop such pre-disaster plans without identifying the DWM challenges their country is already facing or is at risk of facing. They should also be able to assess these challenges and comprehend the respective enabling factors that tackle technical, managerial, legal and institutional, and financial aspects (Karunasena et al., 2012).

Additionally, planning requires the availability of information tools that consist of data and literature on previously occurring disasters. This data-base should roughly include pre-anticipated estimations or predictions of the following:

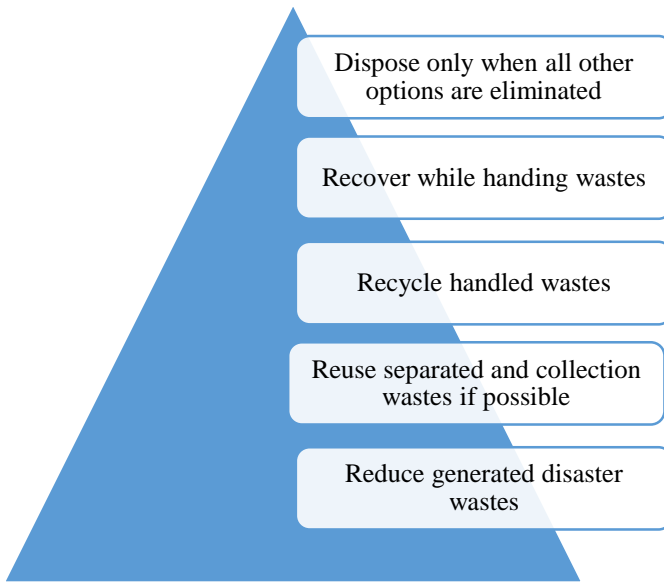
- Location, volume, and composition of the generated wastes
- Available disaster waste management and storage facilities and their estimated capacities
- Previously adopted means of recycling and other management strategies
- Guideline booklet / information tools (Technical, managerial, organizational, and financial aspects and challenges related to the DWM implementation process) (EPA, 2021)

This means that an extensive literature review on previous disasters should be done to gather enough background information and identify strengths and weaknesses of previously implemented DWM plans. Consequently, the reviewed historical case studies will

help in identifying the lessons learned to prepare for an adequate contingency plan that will be ready for implementation in future disasters (Gabrielli, 2018).

In regards to what a contingency plan should cover, an integrated disaster waste management flow charts should be included that would direct field workers on the steps they should take to sustainably manage the C&D wastes. As such, C& D wastes should be managed similarly to how solid wastes are treated and hereby should be managed through an integrated waste management approach.

While managing disaster wastes, the management process must be sustainable and as such should include various waste reducing, reusing, recycling, and recovery initiatives. The percentage of C&D wastes to be disposed should be greatly minimized in order to prolong the estimated lifespan of a landfill and conserve natural resources. The environmentally friendly management approaches are listed based on their preference in figure 2.1. As such, the reduction initiatives are mostly encouraged to be implemented, followed by reusing, recycling, and recovery initiatives and finally the disposal initiatives that should be only done in case the wastes are hazardous and should be landfilled.



**Figure 2.1 – DWM initiatives implemented towards sustainability**  
(Kandachar &Halme,2017)

### ***2.2.2. Response***

Response after the disaster occurs curtails managing the disaster debris quickly and efficiently and removes potential public health and safety risks that could impact the community and their environment. This requires the immediate provision of necessary resources, such as disaster waste collection equipment, technical expertise, transport and transfer equipment and vehicles, and financial resources. (Brown et al., 2011). Emergency response is an extremely important stage in the management of disaster wastes, since a faster clean-up will reduce the cost of the recovery and will limit the exposure of the communities and their environment to the potential disaster associated risks. EPA has clearly recognized the importance of developing adequate emergency response. This has motivated it to develop an “Emergency Response Program” that

responds to various small- or large-scale disasters through supporting areas that are subjected to disasters that exceeded their local response capabilities. As part of this program, EPA developed implementation plans that include coordination and role distribution initiatives to be able to respond to the disaster as quickly as possible (EPA, 2010).

### ***2.2.3. Recovery***

The recovery phase is one of the most important stages of disaster waste management because it is the stage where all the transportation and treatment of disaster wastes takes place. Yet, this stage is the most time consuming. For example, the recovery phase post Hurricane Katrina in New Orleans lasted up to 5 years to be completed (Brown et al., 2011). The recovery stage includes the transportation, treatment (reducing, reusing, recycling, and recovering wastes) and the final disposal of the remaining wastes. This stage will hereby require extensive decision making regarding the most efficient and cost-effective waste treatment method. For instance, in order to optimize the clean-up phase to reduce the clean-up cost, it is important to select the most adequate location of the temporary storage sites that are near the disaster impacted area, but a bit distant from nearby residential areas.

As such, successful recovery will require the availability of clear administrative decisions, technical expertise, advanced technologies, treatment infrastructure, and enough financial resources (Cheng et al., 2021).

### **2.3. Aspects and challenges related to the development of DWM strategies**

There are various technical, administrative, managerial, legal, institutional, and financial aspects to be considered when developing and implementing adequate DWM plans and strategies. These aspects could challenge the process and thus hinder the development of DWM plans as is happening in many developing countries. Consequently, these aspects and their challenges must be tackled to be able to develop DWM plans that are successfully implemented after the occurrence of a disaster.

#### ***2.3.1. Technical Aspects and their Challenges***

##### **2.3.1.1 Determining the Quantity and Quality of disaster wastes**

To begin with, a country should be able to identify the nature and estimate the severity of the disaster to be able to determine the quality and quantity of generated wastes (Zhang,2018). Knowing the quality and quantity of the generated wastes will help determine the technical capacity, technological resources, and infrastructure needed for the management of the disaster wastes.

Hereby, it is important to determine the severity of the disaster to determine the technical aspects needed in the management process However, it is important to note that the same disaster could potentially have different intensities and the greater the intensity, the more the impacts and damages will become. A series of earthquakes in the Philippines led to the damage of 9,775 houses, while a single more severe earthquake in China led to the

destruction of 40,000 house (Reliefwed, 2018). Other methods to identify the number of wastes could be through estimating the degree of urbanization within the impacted area (Gabrielli, 2018). This could be determined through using remote sensing technologies (Tabata et al., 2019). This could also be performed through a literature review on how much wastes were generated from previous disasters occurring in the same area to be able to estimate how much wastes will be generated from future disasters. It is important to note that the quantity may eventually turn out to be much more than the estimated quantity since the disaster may be more severe than the one planned for. In such a case, the management strategies should factor this variable while they determine the technical aspects needed for DWM planning initiatives (Brown et al., 2011).

Additionally, it is also important to predict the characteristics of the wastes that would also help in determining the technological resources and infrastructure needed for the management of the disaster wastes. For instance, if the disaster waste stream in a region is contaminated by asbestos, then expertise in managing asbestos-contaminated wastes should be ensured. Additionally, technologies and the infrastructure (hazardous landfill) to manage and dispose of hazardous wastes should be made available (OCHA, 2020).

#### 2.3.1.2 Technical Challenges faced by Developed Countries

There are limited technical challenges in developed countries since these challenges are tackled through the provision of the human and technological resources, and infrastructure needed for the management of disaster wastes.

### 2.3.1.3 Technical Challenges faced by Developing Countries

- *Absence of Technical Capacity*

Developing countries lack the ability to adequately decide on the best treatment method for DWM due to the absence of the human capacity, technical expertise, and the required infrastructure to optimize the decisions that the DWM plan proposes (Pradhananga et al., 2021). As well, in light of the economic conditions in many developing countries, the costs of DWM treatment methods often motivates developing countries towards open dumping or landfilling initiatives instead of enhancing recycling initiatives and pursuing more environmental friendly management methods (Pradhananga et al., 2021).

### ***2.3.2. Administrative and Managerial Aspects and their Challenges***

Managing disaster wastes have long been a lengthy process and has been carried out with little or no coordination whether it is a developed or developing country (Padilla et al., 2021). In the US, the Federal Emergency Management Agency (FEMA) has established disaster waste management roles; yet, there are no specific guidelines that state on whom the responsibility of managing disaster wastes lies. In some developed countries like Japan, disaster wastes generated from the Great Hanshin earthquake was managed by both the private and the public sector. In Turkey, no department was assigned the management of the disaster wastes post the Marmara earthquake. In other developing countries, the involvement of many local and international organizations and NGO's in DWM usually complicates

identifying whom the responsibility falls upon. Despite the availability of international assistance, developing countries still mismanage wastes when it comes to the implementation of inadequate treatment options (Padilla et al., 2021).

Moreover, communication in disaster waste management has long been a key aspect in the success of DWM plans. Pre and post disaster public communication through training programs have enhanced the public perception and involvement of impacted communities and stakeholders in preparing, planning, and managing disaster wastes (Brown et al., 2011).

Managerial aspects do not only cover the overall coordination and communication of the DWM process, but it also covers the development of DWM plans that include the disaster waste treatment process (clean-up, transfer and transport, storage, handling and treatment, disposal) (Brown et al., 2011).

#### 2.3.2.1 Administrative and Managerial Challenges faced by Developed Countries

- *Absence of Adequate Role Distribution Initiatives*

Due to the globally estimated increase in the frequency of disasters, developed countries were determined to manage disaster wastes efficiently to be able to speed their recovery process. Yet, the speed of response and recovery from the disaster is relatively slow due to the absence of guidelines that state on whom the responsibility of managing the wastes lies upon (Tabata et al., 2019). When no one is pre-assigned to take the responsibility of the clean-up phase, a longer clean-up duration will increase the management cost and extend the recovery period (Zawawi, 2016). There exists no one standard protocol that is appropriate

for all countries on how to distribute responsibilities to manage their C&D wastes. However, these countries can draft a detailed stakeholder mapping plan that would facilitate the managerial aspects and pave the way towards the development of suitable management strategies.

- *Absence of DWM tools in DWM Plans*

Even though developed countries have developed DWM plans and contingency and implementation plans, there exist various tools to manage disaster wastes that are not included within these plans. These tools such as the “Environmental Needs Assessment in Post Disaster Situations” and the “Flash Environmental Assessment Tool” can facilitate the management of disaster wastes if they are integrated in DWM plans – this being a managerial aspect that interferes with the success of future disaster waste management strategies (UNOCHA, 2011).

#### 2.3.2.2 Administrative and Managerial Challenges faced by Developing Countries

- *Absence of Adequate Role Distribution Initiatives*

Developing countries receive a lot of international assistance which complicates the process of assigning who is fully responsible to manage the generated disaster wastes. Additionally, the absence of stakeholder mapping plans makes it impossible for these countries to distribute the roles and responsibilities among the involved stakeholders (Asari et al., 2013).

- *Absence of DWM Plans*

Developing countries lack the incentive to prioritize developing DWM plans for pre and post disaster (Asari et al., 2013). Developing countries have the tendency to adopt DWM plans from developed countries. This process is often inefficient due to the presence of stark differences in the technical, managerial, institutional and financial contexts between developed and developing countries that will require developing countries to properly contextualize their DWM plans before implementing them (Asari et al., 2013).

- *Absence of Communicating and Coordination Initiatives*

One of the greatest limitations that hinders the successful implementation of disaster waste management strategies is the inability of developing countries to communicate their developed DWM plans with the assigned stakeholders and the public. From one side, stakeholders must be familiarized with the developed DWM contingency and implementation plans. On the other hand, the public must take the lead in managing their daily generation of municipal solid wastes, and must be involved in the management of disaster wastes (Menegaki & Damigos, 2018).

### ***2.3.3. Institutional and Legal Aspects and their Challenges***

A defined legally binding framework should be available in both developed and developing countries to govern the developed DWM plans and initiatives. However, it is important to have a not too relaxed and not too strict legislative framework. For instance, after Hurricane Katrina, US authorities decided to relax legislations pertaining to the clean-up standards of asbestos contaminated C&D wastes from 4 days to 1 day of clean-up. This

has resulted in the inefficient clean-up of the area which lead to the long term exposure of people to asbestos. On the contrary, after the 2009 L'Aquila earthquake in Italy, the government implemented strict environmental laws that prohibited the use of recycling and disposal sites until they were permitted after almost a year post-disaster (Brown et al., 2011).

Developed and developing countries both stand at two different scales when it comes to having the required institutional capacity that facilitate the management of disaster wastes. Developed countries like Japan have a strong institutional capacity that entails specific guidelines that state how the disaster wastes are to be managed (Asari et al., 2013). They also have a clear legal framework that tackles cases of emergencies and specify managerial aspects like ones pertaining to responsibility distribution. On the contrary, developing countries lack a legal framework specific for disaster waste management and if they potentially have one, they also lack the institutional capacity to enforce it.

#### 2.3.3.1 Institutional and Legal Challenges faced by Developed Countries

- *Absence of Specificity in DWM Guidelines*

One of the greatest challenges faced when managing disaster wastes is related to the absence of literature on country specific DWM guidelines. Moreover, the generality of these guidelines demonstrates minimal technical guidance, which makes them impossible to be used for optimizing the decision-making process regarding the best treatment method to be used. As such, due to the generality of the guidelines, the decisions made usually do not take into consideration the environmental and economic aspects of the decision. Even if some

decisions take into account the economic aspect of the treatment, it hereby disregards the environmental concerns of disaster waste management. This is a great weakness that decision making strategies face as this will impact the effectiveness and degree of optimization of the selected treatment processes (Tabata et al., 2019).

#### 2.3.3.2 Institutional and Legal Challenges faced by Developing Countries

- *Absence of Institutional/Legal Framework*

Various developing countries globally do not have legal frameworks that govern DWM plans. These countries also lack institutional capacity to enforce these DWM guidelines. This issue is a great challenge that is caused by the inability of developing countries to contextualize the DWM frameworks developed by various developed countries (Pradhananga et al., 2021; Asari et al., 2013).

#### **2.3.4. Financial Aspects and their Challenges**

Both direct and indirect costs of the management process are required to be able to estimate the total cost of disaster waste management. Direct costs mainly consist of the costs of collection, transportation, handling, treatment, and disposal of wastes. However, the costs usually vary based on the nature of the disaster and the respective quality and quantity of generated disaster wastes. (Brown et al., 2011).

On the other hand, the indirect costs are even harder to estimate and usually include the cost of impacts on different industries like tourism, delays in the reconstruction process, damages of critical infrastructure like sewage pipes and water distribution systems, costs of public health impacts, environmental remediation, decreases in life expectancy of landfills, and increases in resource depletion (caused by the decline in the resource recovery rates) (Brown et al., 2011).

Yet, there are some initiatives that could reduce the cumulative cost of DWM. For example, optimizing decision making regarding the most cost effective and efficient disaster waste management process would reduce the direct costs of waste management (Askarizadeh et al., 2015).

As such, whether it is a direct or an indirect cost, both developed and developing countries should be able to cover the expenses through developing a financial committee that has the capacity to finance the management of disaster wastes.

#### 2.3.4.1 Financial challenges faced by Developed Countries

Developed countries adequately fund the management of their disaster wastes. For instance, regardless the costs imposed on the country, the US Federal Emergency Management Agency (FEMA) is the one responsible for providing funds to the government upon the request of those in need, by which the state will distribute these funds to other state agencies, local governments or NGO's (Asari,2013). Another developed country which is Japan has also managed to assign a financial committee that is capable of funding the

management and recovery process from any potential disaster. This will help developed countries speed their recovery since they will not be forced to spend time searching for potential funds as the case of many developing countries globally (Ministry of Japan, 2018).

#### 2.3.4.2 Financial Challenges faced by Developing Countries

- *Absence of Funding Initiatives for DWM*

Developing countries lack the financial capacities that would allow them to develop and implement DWM plans and guidelines. Such countries depend on international assistance (Padilla et al., 2021).

**Table 2.2 - Summary of the Aspects and challenges related to the development of DWM strategies**

Aspects potentially hindering the development of DWM strategies	Description of the Aspect	Challenges faced by developed countries	Challenges faced by developing countries
<b>Technical Aspects</b>	<ul style="list-style-type: none"> <li>• Determining the Quality and the Quantity of disaster wastes</li> </ul>	<ul style="list-style-type: none"> <li>• Minimal technical challenges faced</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of Technical Capacity</li> </ul>
<b>Administrative and Managerial Aspects</b>	<ul style="list-style-type: none"> <li>• Guidelines that distribute the responsibility of DWM</li> <li>• Communication between stakeholders to manage disaster wastes</li> <li>• Development of DWM plans</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of adequate role distribution initiatives</li> <li>• Absence of DWM tools in DWM plans</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of adequate role distribution initiatives</li> <li>• Absence of DWM plans</li> <li>• Absence of communication and coordination initiatives</li> </ul>
<b>Institutional and Legal Aspects</b>	<ul style="list-style-type: none"> <li>• Legal and institutional</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of specificity in DWM guidelines</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of Institutional/ Legal Framework</li> </ul>

	<ul style="list-style-type: none"> <li>framework specific for DWM</li> <li>• DWM guidelines for adequate DWM</li> </ul>		
<b>Financial Aspects</b>	<ul style="list-style-type: none"> <li>• Funding committee to cover direct and indirect costs of DWM</li> </ul>	<ul style="list-style-type: none"> <li>• Availability of funding committee</li> <li>• Availability of financial capacity to find DWM plans</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of financial capacity to develop and implement DWM plans</li> </ul>

It is also important to note that some developed countries like the US has earlier faced several of the mentioned above challenges. For instance, after the 9/11 bombing that took place New York year 2011, there were several gaps that emerged between the team coordinating the incident on site and the leadership team who was responsible to develop DWM plans to guide the teams on-site. In other words, there was no clear agency that held the responsibility to ensure the environmental safety of the workers and take the leadership in the clean-up process. As well, they faced challenges in helping the residents preserve their health and safety, in light of all the scattered C& D wastes. However, positively, the process of removing the debris was relatively smooth, fast, and well executed, even though challenges where faced when it came to covering and wetting the debris to ensure the smooth transportation of the wastes. Inventories of equipment, expertise, and needed infrastructure was pre-developed and directly implemented. As well, enough data was gathered on the environmental impacts that effected the nearby drinking water sources; which further limited the potential public health impacts on the citizens. Eventually, US, being a developed country, has learned from the incident after it determined the challenges they faced earlier. They recommended that a task force should always be ready to respond to any potential emerging disaster; as they should be responsible to secure the area and implement the safety

standards for the on-site workers. As well, additional funding must be dedicated to speed up the recovery process that should include the establishment of a health registry for all the residents and workers residing in the impacted area. It is important to note that a separate unit should be developed and should be held responsible to assess the response after the disaster (Nordgren et al., 2002).

## CHAPTER 3

# METHODOLOGY

### 3.1. Research Setting

On the 4<sup>th</sup> of August, 2020, a devastating explosion at the Port of Beirut resulted in more than 200 casualties, 6,000 cases of injuries and more than 170,000 residents being displaced from their homes. It also caused significant damages to buildings and infrastructure within an area with a radius of 20 kilometers from the port. The blast impacted more than 47,000 apartments, at least 20 primary health care centers and 6 hospitals, in addition to more than 120 schools in the area. Consequently, it led to the generation of around 800,000 tons of C&D wastes (ReliefWeb, 2020). It was also noted that there were many hazardous chemicals stored in the port that can increase public health and environmental risks.

Given that the Lebanese waste management system is already overwhelmed ever since the waste crisis that started in 2015, inadequate solid waste treatment strategies were already in existence. Adding on to the challenges, Lebanon was struggling from a severe economic crisis. Taking into consideration that the clean-up cost of the environmental degradation resulting from the explosion was estimated to be over \$100M (UN, 2020).

It is worthwhile mentioning that this country has faced similar challenges when it came to the management of the disaster wastes post 2006 war that Lebanon witnessed. Lebanon was not ready to accommodate significant quantities of disaster wastes; especially

in light of the absence of disaster preparedness and response plans. Initiatives were diverted towards developing alternatives recovery strategies that withhold less impacts on the environment (Nasr et al., 2009). As such, management of disaster wastes was and still is considered a burden on Lebanon, leaving behind a country still struggling to manage disaster wastes instead of learning from previous experiences and progressing to better manage future disasters.

It can be concluded that the Lebanese experience unfortunately is reflected in several other developing countries that struggle to manage their disaster wastes such as Nepal and Malaysia. Accordingly, there is a need to understand the various challenges that hinder proper DWM and the enabling factors required to develop effective management strategies (Brown et al., 2011).

### **3.2. Study Design**

Objectives 1 and 2 which circulate around exploring and evaluating the implemented C&D waste strategies in Lebanon and second identifying the national barriers and enabling factors towards implementing current and future DWM strategies; were achieved using a qualitative research method, specifically, in-depth interviews were conducted to build a comprehensive and thorough understanding of the various factors influencing the implementation of a DWM plan in Lebanon. The points of view of experts and governmental bodies were recorded. A qualitative approach provided the opportunity to develop and conduct a well-structured interview guide that consists of open-ended questions, which allowed respondents to take their time in elaborating their answers freely without any

constraints. This also allowed the interviewer to investigate and explore questions that are significant for the achievement of the study's objectives.

Objective 3 was achieved by conducting a desk review comparative analysis of documents including different DWM plans from developing and developed countries. Decision matrices were developed to compare various DWM practices used in Lebanon with those adopted in other countries.

This work sets the ground for the development of a DWM action plan which is the ultimate aim of this research.

It is also important to mention that this study got the approval of the Institutional Review Board at the American University of Beirut.

### **3.3. Data Collection**

A semi-structured, in-depth interview guide was developed in the aim to collect qualitative data. This guide included several open-ended questions corresponding to the objectives set forth and that were tackled in this research. Open-ended questions were chosen over close-ended questions in order to avoid restricting the respondents with limited or misleading answers that would not clearly reflect the opinions of the interviewees about some complex concepts. The greater objective of the interview was to attain a deeper understanding of the interviewees' perspectives on significant themes that would enhance the interviewers' conceptualization of the problem that was tackled within the study. The semi structured interview guide was designed with the aim to tackle the following issues/ themes: the currently implemented strategies and measures for the management of disaster wastes resulting from the Port's explosion, the respective DWM challenges, and the corresponding

enabling factors and determinants that would improve the current waste management strategies. Consequently, 18 interviews were conducted with professionals involved in the DWM of the port, working at various governmental and non-governmental levels, and have a high level of knowledge and expertise on the topic. These professionals were chosen due to their knowledge and expertise on the topic and their involvement in the DWM of the Beirut Port.

A summary of the interview questions linked to the first 2 objectives of this research study available in the appendix demonstrates the interview questions corresponding to the research objectives. The qualitative data gathered were treated confidentially without stating the names of the expertise interviewed, as such, the responses were not linked to individual respondents.

As well, a comparative assessment was conducted in the aim to tackle the 3<sup>rd</sup> objective, which entails analyzing the major differences in DWM between Lebanon and selected countries. The countries selected were similar in the amount of wastes generated and the respective environmental impacts, regardless whether the disasters are natural or man-made. These countries were also selected because the availability of publications that specifically cover how these countries managed their disaster wastes, what challenges they faced, and what were the enabling factors that were most convenient to them. On the contrary, other countries either have minimal publications on this topic or covered topics related to the management of disasters in general instead of topics related to the management of wastes specifically. As such, the comparative assessment was done through conducting a desk review analysis of documents that included DWM plans pertaining to different developed and developing countries. Case studies were also reviewed to compare the challenges and the

enabling factors that were faced when developing DWM strategies in these countries. As a result of the comparative assessment, decision matrices were developed to compare various DWM practices used in Lebanon with those adopted in other countries, and the respective challenges and enablers that were tackled throughout the development of these DWM strategies. This comparative assessment facilitated the development of a comprehensive approach and strategy to be able to develop and implement DWM strategies in the Lebanese context.

### **3.4. Recruitment of in-depth interviews participants**

Professionals were selected according to their knowledge and expertise on the topic and their involvement in the DWM of the Beirut Port. A summary of the potential governmental and non-governmental environmental professionals to be interviewed is presented in Table 3.1.

**Table 3.1 - List of potential research participants**

<b>Participants positions in governmental/non-governmental organizations</b>
<b>Interviewees representing the government</b>
Representatives from Beirut’s Municipality
Representatives from OMSAR (Office of the Minister of State for Administrative Reform)
Representatives from the Ministry of Environment
Representatives from the Ministry of Interior and Municipalities
Representatives from the Ministry of Transport and Public Works
Representatives from the Lebanese Army Force
Representatives from the Ministry of Health
Representatives from the Ministry of Economy
Representatives from CDR (Council for Development and Reconstruction)
Representatives from the Higher council for Relief

<b>Interviewees representing international organizations</b>
Representatives from UN Environment/OCHA Joint Unit (JEU)
Representatives from the EU
Representatives from Human Rights Watch
<b>Interviewees representing the private sector</b>
Representatives from Arcanciel
Representatives from RAMCO, private company who is involved in DWM
Representatives from the impacted hospitals in the area (AUBMC)
Representatives from Khaddit Beirut
Representatives from Lebanese Red Cross

### **3.5. Data Analysis:**

Thematic analysis was employed when analyzing the data in order to analyze, interpret, and evaluate the transcripts so as to build a comprehensive understanding of their opinions that tackle the research objectives (Castleberry, 2018). The responses of the interviews were organized based on the mentioned overarching broad themes (barriers and enabling factors) in order to facilitate the analysis of the qualitative data. The data was studied and the transcripts were compared to identify the trends and patterns as well as the similarities and the differences between the interviewees’ perspectives. Consequently, the organized data was further sorted and accumulated under its corresponding theme for a complete review. Direct quotes from the interviewees were used to support the identified common themes. This was done by hand through the use of tables that demonstrated what each of the interviewees representing the public sector, international organizations, and private sector; believe are the challenges and the solutions to adequately manage disaster wastes in the Lebanese context.

After reviewing the literature to establish a comparative assessment between Lebanon and other countries, decision matrices were developed to compare various DWM practices

used in Lebanon with those adopted in other countries, and the respective challenges and enablers that were tackled throughout the development of these DWM strategies. The qualitative data sorted and organized in matrices has set the floor for the establishment of adequate comparison between Lebanon's DWM practices to other countries.

As such, two developed and two developing countries were selected to be compared against Lebanon. The US and Japan were selected to represent the developed countries since they are highly advanced in the development of their DWM strategies at the planning and implementation levels. For the developing countries, Malaysia and Nepal, were chosen as they represented the Lebanese case in terms of the challenges they faced in developing and implementing their DWM plans. As well, these developing countries were struggling to tackle the technical, managerial, institutional, and financial limitations that were certainly well overpassed in the US and Japan. With respect to solutions of the persisting challenges, these developed countries represented the enabling factors that should be adopted by Malaysia, Nepal, and most certainly Lebanon, which further justifies why they were selected to be compared against Lebanon.

In order to assess the challenges faced by each of the selected countries, a scoring mechanism was developed for each. The significant technical, managerial, institutional, and financial limiting factors that are challenging for each country were scored. Each of the challenges presented in the table were scored and the cumulative scores pertaining to each country gave an indication of its DWM performance. Scores were given to each challenge based on a set of criteria that should be available to overcome the challenge. The criteria are presented in the form of a rubrics in the appendix section. The scores ranged from one to four, one indicating that the country did not develop nor implement the aspect that would

permit adequate DWM. A score of 2 means that the country is progressing in the development of the initiatives and has not yet implemented any aspect that would facilitate DWM. A score of 3 indicates that the country has finalized the development of its initiatives, but has not yet implemented them. Lastly, a score of 4 means that the country has successfully developed and implemented. It is important to note that the challenges scored were given equal weights in terms of their importance. After giving each challenge a score, a cumulative score for each country was obtained which gave an insight of the standing of each country as shown in the Table 3.3. Higher scores were given to countries who satisfied the criteria under each challenge which thereby indicated that the country is facing less challenges in developing and implementing its DWM plans. On the contrary, lower scores were given to countries who failed to satisfy the criteria under each challenge which indicated that the country is highly challenged in managing its disaster wastes. Consequently, the standing of countries depends on how much they are challenged by the limiting factors that exist at the level of their DWM. A rubric for the scoring mechanism will be available in table 3.2.

**Table 3.2 - Comparative Assessment Rubric**

Category (Weight%)		4 (Developed and implemented)	3 (Developed but not implementation)	2 (Development in Progress)	1 (Not developed or implemented)
Technical Aspects (25%)	Inventory of necessary resources	Developed inventories that fully secure the availability of required machines, expertise and needed infrastructure	Developed inventories that secure the basic resources needed	Inventories are in progress/ incomplete and secure inefficient amounts of machines, expertise, and infrastructure	No inventories are developed, the necessary machines, expertise, and infrastructure are not present
	DWM Guidelines	Well developed and implemented Guidelines	Well-developed guidelines but they are not yet implemented	Guidelines are in progress	Guidelines are neither developed nor implemented

	Data Collection Mechanisms	Data collection mechanism are well developed and implemented successfully	Data collection mechanisms are developed but not yet implemented	The development of data collection mechanisms is in progress	No developed data collection mechanisms to be implemented
<b>Managerial and Administrative Aspects (25%)</b>	Development of DWM Action Plan	Contingency, risk reduction, and implementation plans are fully developed and implemented	Contingency, risk reduction, and implementation plans are developed but not implemented	Contingency, risk reduction, and implementation plans are in progress	Contingency, risk reduction, and implementation plans are not developed nor implemented
	Development of Stakeholder Mapping Plan	Stakeholder plans are fully developed and implemented	Stakeholder plans are developed but not implemented	Stakeholder plans are in progress	Stakeholder plans are not developed nor implemented
	Plans to eliminate bureaucratic Intrusions	Plans to eliminate bureaucratic Intrusions are fully developed and implemented	Plans to eliminate bureaucratic Intrusions are developed but not implemented	Plans to eliminate bureaucratic Intrusions are in progress	Plans to eliminate bureaucratic Intrusions are not developed nor implemented
<b>Legal and Institutional Aspects (25%)</b>	Legal and institutional framework	Legal and institutional framework is fully developed and implemented	Legal and institutional framework is developed but not implemented	Legal and institutional framework is in progress	Legal and institutional framework is neither developed nor implemented
<b>Financial Aspects (25%)</b>	Plans to secure financial resources	Plans to secure financial resources are fully developed and implemented	Plans to secure financial resources are developed but not implemented	Plans to secure financial resources are in progress	Plans to secure financial resources are neither developed nor implemented

**Table 3.3 – Scoring Criteria**

	Scores	Scores Description
Individual Scores	1	Not developed nor implemented
	2	Development in Progress
	3	Development but not yet implemented
	4	Well-developed and implemented
Cumulative Scores	1-5	Critical Need for Change
	6-10	Needs Improvement
	11-15	Good Standing

	16 and above	Excellent Standing
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Once the comparative assessment was conducted, the challenges and respective enabling factors became evident. The comparative assessment has set the ground for the development of an adequate DWM action plan that includes a contingency plan, risk reduction plan, and implementation plan. One of the most important components of a contingency plan is a stakeholder mapping plan which has been developed to propose possible distributions of initiatives among potential stakeholders. This stakeholder mapping plan was developed in the form of a figure, available in the appendix section, which was able to assign the initiatives that should be present to adequately manage the disaster wastes to stakeholders pertaining to the public sector, private sectors, and international organizations. To further facilitate the development of a proper DWM contingency plan, a set of guidelines were developed. Most importantly, a decision tree was developed to guide stakeholders towards optimizing their decision-making process in regards to the selection of the best DWM treatment method.

## CHAPTER 4

### RESULTS AND DISCUSSION

#### **4.1. Perspective of interviewees on DWM in Lebanon**

Up till this moment, the wastes are still accumulated in a land next to the port of Beirut. This land was selected randomly by the government since it did not undergo an EIA to make sure that the land is suitable to be used as a temporary storage site.

Waste characterization initiatives were completed by private international organizations and it was concluded that the disaster waste stream was contaminated by asbestos. Unfortunately, a great portion of the asbestos contaminated wastes were randomly dumped in that land without undergoing any treatment or capsulation initiatives. According to a participant representing the government:

“The greater problem is that even if the government wants to manage these asbestos contaminated wastes, we do not have a hazardous landfill in this country that would allow us to properly dispose these hazardous wastes in”

As such, in light of the absence of hazardous landfills in Lebanon, other initiatives are being developed to manage these wastes. Asbestos contaminated wastes were going to be crushed by the recently imported crushers and later transported to a selected quarry where they will be properly lined above each other. The objective behind this initiative, which is known by the “rubble to mountain initiative”, is to rehabilitate the damaged quarry. A great limitation that challenges this initiative is the fact that no EIA has been done to select the quarry assigned to be rehabilitated.

It is important to note that only a small percentage of the generated waste was dumped in the temporary storage site located next to the port of Beirut. This is because the majority of the asbestos contaminated wastes, collected from all regions across Beirut and its suburbs, were randomly transported through unspecialized collection trucks to open dump sites all across the country. Interviewees were highly concerned about the disadvantages that accompany the open-dumping initiatives since the quantities of wastes transported outside Beirut and the location of these dumpsites remain unknown and unidentified till this moment. One of the interviewees from the government said:

“I was going back to my home outside Beirut when I saw huge construction trucks moving C&D wastes from Beirut towards rural areas that are not prepared to accommodate such wastes. These rural areas do not have any facilities that could treat the C&D wastes, which means that tons of disaster wastes were being randomly dumped in valleys.”

The interviewees’ description of the current situation portrays the degree of mismanagement of C&D wastes by the responsible authorities. This condition persists due to the prevalent national challenges that hinder the development and implementation of adequate DWM strategies.

## **4.2. Interviewees’ opinions on the National factors that challenge the implementation of DWM strategies**

### ***4.2.1. Technical Challenges***

There were contradicting opinions on whether the technical capacity is available in Lebanon or not. Some participants expressed their concern that this country does not have

the adequate expertise needed to make decisions regarding the best DWM strategy. A representative from the government clearly stated that:

“we don’t have a company that has the experience to manage disaster wastes properly”.

Another representative from international organizations believed that:

“only 3-4 people in the Ministry of Environment work on both solid wastes and disaster waste management which is for sure not enough”.

Other interviewees contradict what the representatives previously stated since they believe that this country has a sufficient number of technical expertise that are eligible to select the most economical and efficient DWM treatment methods in light of the current economic crisis. The expertise that are present in Lebanon are also capable of motivating their developing country towards adopting recycling initiatives and other proper management methods instead of open dumping and landfilling.

A major constraint is that even with the presence of the advanced technical capacity and capacity building initiatives in the country, Lebanese citizens lacked the sense of responsibility and awareness that would push them to properly manage the generated disaster wastes. For instance, after the explosion happened, a very small percentage of residents were motivated to sort their wastes as per the recommendations of expertise involved in this topic. Consequently, the mismanagement to wastes has led to the generation of a highly intermingled pile of C&D wastes, characterized by an increased management cost and degraded quality.

However, it is important to note that the citizens should not be responsible to sort the wastes that were generated post-disaster. Moreover, the ideology of sorting was never implemented within the Lebanese society as a whole, which further limits the willingness and motivation of the population to sort their municipal solid wastes, nevertheless to start sorting their disaster wastes. As such, the mismanagement of the intermingled piles of C&D wastes is not the fault of the citizen, but the DWM unit and all stakeholders assigned to be involved in DWM as a whole.

Another technical challenge faced when managing disaster wastes is related to the absence of suitable technologies needed to manage the C&D wastes. Lebanon had to get a donor to fund and import a glass crusher for the crushing of sorted glass and other C&D material. Lebanon also has only 2 mechanical biological treatment facilities (MBT), both located in areas next to Beirut. The facilities could be used to manage compostable material that could be separated from the C&D waste stream. The one present nearby the port was completely destroyed and the other was already overwhelmed and has reached its capacity long before the explosion. As per one of the interviews done with a government representative:

“Lebanon does not have an MBT plants or any other technology to manage its C&D wastes. As well, this country does not have a landfill for solid wastes nevertheless to have one for hazardous wastes. As such, it would be best to conclude that we are dealing with a great technical challenge here!”

Thus the respondents made it clear that Lebanon does not have the necessary infrastructure to manage its disaster wastes efficiently. This challenge is also faced by many

other developing countries. (Brown et al., 2011). Yet, this topic was also debated by a government representative who stated that:

“We do have all the required machines to recycle wood and other recyclables if we coordinate with the private sector. The glass and other C&D wastes can be crushed and transported to be used for the rubble to mountain initiative. As for the hazardous wastes, we can export them outside the country to be managed. This means that we can manage approximately 95% of the C&D waste quantities.”

Additionally, the absence of historical data that shows the strengths and weaknesses of developed and implemented DWM plans is one of the major technical factors that should be tackled. In the case of Lebanon, this country has minimal data pertaining to the previous man-made disasters that occurred in Lebanon. The absence of enough data that reveals the strengths and weakness of the implemented DWM strategies will consequently weaken DWS plans developed in the future. This case is similar to the one in Malaysia since this country also faced challenges at the level of data availability (Yusof et al., 2016).

#### ***4.2.2. Administrative and Managerial Challenges***

There were several managerial challenges hindering the management of C&D wastes in Lebanon. One commonly recognized among all participants is the absence of DWM preparedness and response plans. A unit representing the governmental body has developed disaster risk reduction plans that are disaster specific. As such, they have plans to reduce the risks and manage disasters like fires, tsunamis, earthquakes and others. However, they do not have plans ready to manage a man- made disaster similar to the one that happened at the port.

This is a challenge faced in the two other developing countries, Malaysia and Nepal (LEAD Nepal, 2015) (Zawawi et al., 2016). A representative of a governmental unit clearly stated that:

“No planning specific to the management of disaster wastes was developed since no one could have predicted the occurrence of such an explosion in the middle of a city. Not a single country will be ready for a disaster of such a scale. Yet, we are now working on a DWM plan that is specific for such man-made disasters.”

This opinion was very much common among many interviewees as they believed that even if a plan was previously developed, no one could have implemented it because expertise could not have predicted to plan for such a disaster. As such, any plan could have easily failed due to the scale of the crisis.

Yet, it is still important to stress on the reality that a preparedness plan could have facilitated a quicker response and recovery from the disaster compared to what happened on the ground. The absence of plans weakened the cooperation and coordination between responsible authorities and this partially goes back to the even greater managerial challenge which is related to the absence of role distribution initiatives. Unfortunately, this challenge is present in most of the developing countries globally (Brown et al., 2011). What happened in the field is that no plan stated who should be carrying the activities to manage disaster wastes which led to a chaotic situation. A disaster management committee was absent, which means that there was no one available to distribute the roles and responsibilities of managing disaster wastes. According to an international organization representative:

“Even though the army was in charge of the operations, many institutions were involved in DWM which automatically slowed down the disaster response and recovery processes.”

Private initiatives started their work immediately without any coordination or communication of efforts, which has led to the duplication of initiatives or even the dedication of human resources in the wrong realm. The mix between the centralization and decentralization of the management of such C&D wastes also added to the chaos of whom should be responsible to manage such types of wastes.

Challenges at the level of the bureaucracy were manifested in the absence of transparency and accountability in the governmental body. Also, corruption at the bureaucratic level directed DWM towards initiatives that focus on gaining profits from the extensive charges caused by inadequately managing disaster wastes, this being a challenge faced by most developing countries (Brown et al., 2011). According to one representative of the public sector, the price of the management of one ton of wastes, from collection all the way to landfilling, is very expensive since Lebanon does not sort at source. This is because the degraded waste quality obtained after their costly management does not permit these wastes to be put into service and used in any way possible. This has created a very high margin of profit for the Lebanese politicians to benefit from. As such, the bureaucratic corruption highly defines how disaster wastes are managed. According to one of the interviews representing the private sector, he summed up the situation in Lebanon by stating that:

“We are a failed state full of corruption since no institution is working properly and everything is highly subjected to clientelism. As such, there exist only a small percentage of people working in the realm they are qualified to work in.”

#### ***4.2.3. Legal and Institutional Challenges***

It was clear from all the interviews that Lebanon lacks any institutional guidelines for DWM that are bound by law in any way possible. There is no legal framework that consists of clear and simplified mandates specific for the management of disaster wastes aside from the management of solid waste generally. As such, the case of Lebanon is similar to that of Nepal (LEAD Nepal,2015). According to an international organization representative, this framework should assign the roles and responsibilities to limit the persisting ambiguity and the presence of many actors in DWM. Such a framework should even explicitly define the definition of C&D wastes and who owns the wastes. According to one of the private sector interviewees, it was stated that

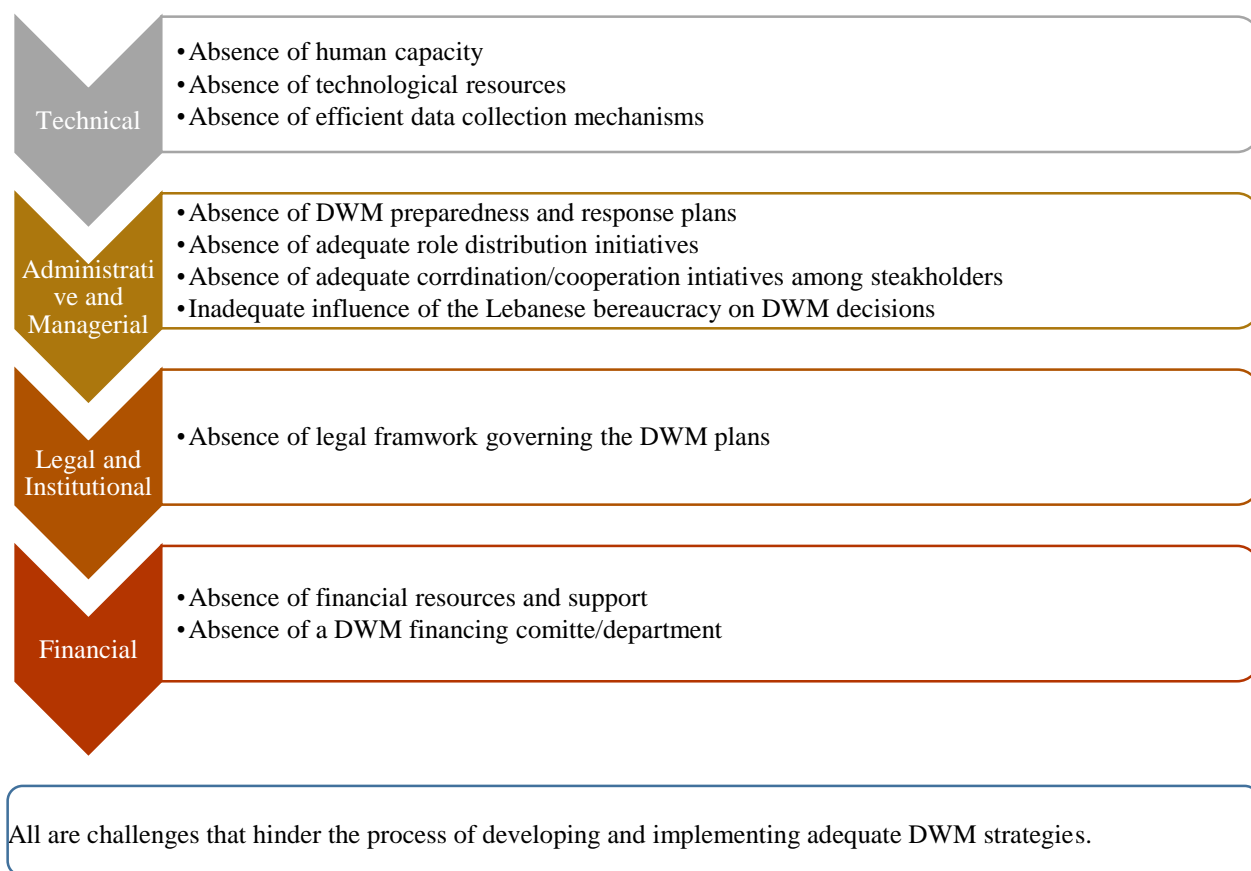
“Lebanon has only one decree related to DWM which is the one for hazardous wastes management; known as decree 5606/2019. Yet, this decree is neither enforced not implemented.”

#### ***4.2.4. Financial Challenges***

One of the main challenges that was common and stressed upon by all interviews without any exclusivity was the absence of financial resources to support the development and implementation of DWM strategies and plans. Management of disaster wastes after such a crisis will require a significant budget that was unavailable in the case of Beirut. As such,

Lebanon's only source to fund such projects were through the provision of funds from international donors.

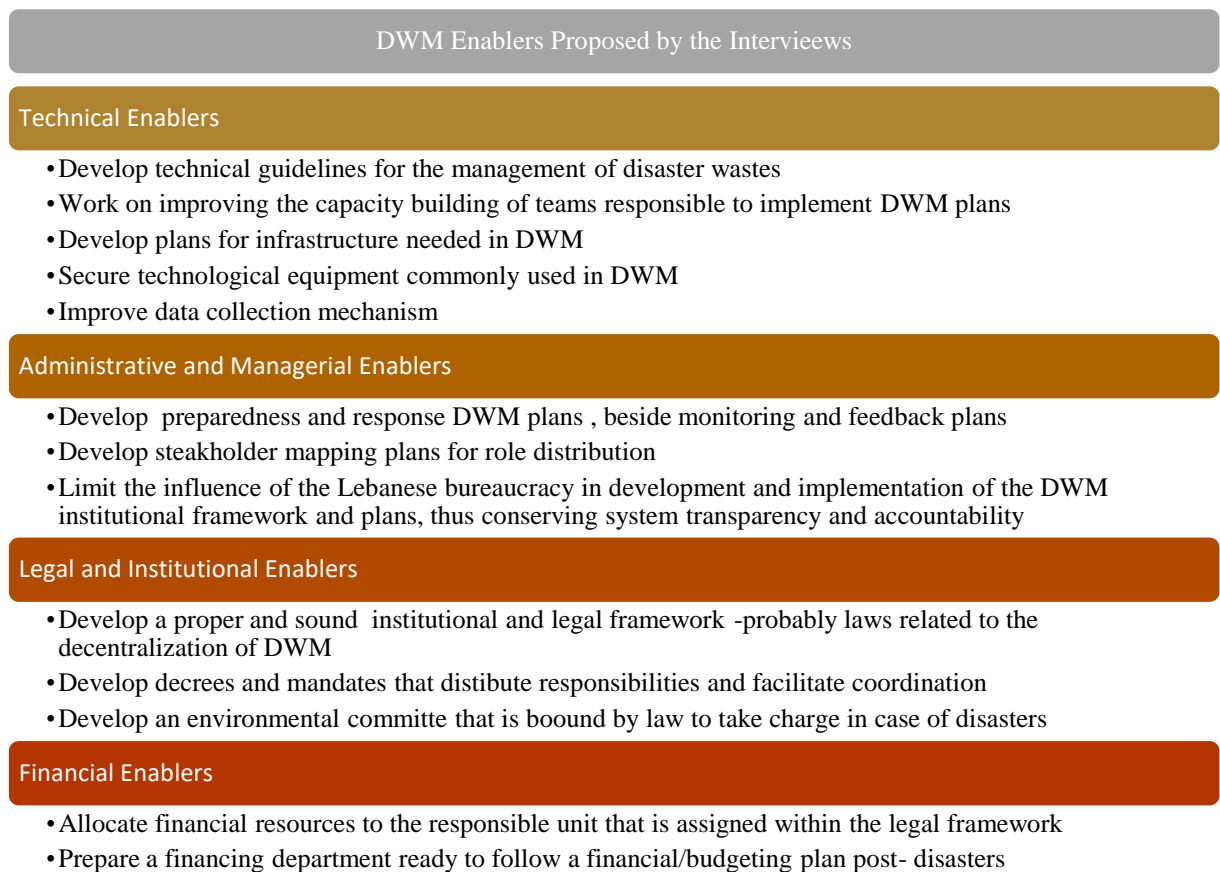
Figure 4.1 clearly summarizes the technical, administrative, managerial, legal, institutional, and financial challenges that hinder the development and implementation of DWM strategies at the national level.



**Figure 4.1- Summary of Interviewees' perspective on the Lebanese National Challenges in implementing DWM Strategies**

### 4.3. Proposed National Enabling factors towards developing and implementing DWM strategies

In order to implement adequate disaster waste management strategies, the technical, managerial, institutional and financial challenges should be tackled. As such, a legal framework should be developed that consists of all the decrees and mandates that would help in tackling all the challenges mentioned previously in figure 4.1. Figure 4.2 clearly demonstrates the initiative that were suggested by interviewees that could set the grounds for a successful development and implementation of adequate DWM strategies.



**Figure 4.2- Summary of the Enabling factors proposed by the interviewees towards successful DWM strategic planning**

#### **4.4.Comparative assessment of different DWM plans**

Both developed and developing countries have been facing an increase in the frequency and intensity of disasters, regardless of whether they are natural or man- made. Such incidents are respectively leading to the generation of significant quantities of disaster wastes, which requires urgent management strategies to be redeveloped and effective to be used as a quick response post-disaster (Brown et al., 2011).

Developed countries like the US and Japan have successfully worked on enhancing their response to disasters since they have tackled various technical, administrative, managerial, legal, institutional, and financial aspects that allowed them to implement adequate DWM strategies as shown in Table 4.1. For instance, both US and Japan have developed technical guidelines for the management of disaster wastes. Japan developed the “Disaster Waste Management Guideline for Asia and the Pacific” that consists of all the necessary guidelines. They have also developed inventories that consist of all the infrastructure and technologies needed for the management of their disaster wastes (Ministry of Environment, in Japan, 2018). These countries developed preparedness, contingency, and implementation plans to enhance their readiness for possible disasters that may occur. This for sure facilitated their response and respectively shortened their recovery period, which reduced the public health impacts on the community and their environment. Through these plans, they were able to distribute the roles and responsibilities of each of the authorities and respectively limit the influence of bureaucracy on DWM. Through distributing the roles, they were also able to designate a financing department and plan their funding strategies. For instance, the US has designated their Federal Emergency Management Agency to finance the management of disaster wastes post-disasters (Luther, 2008). Most importantly, these

developed countries were able to set a legal framework for DWM specifically, that consists of all technical managerial, legal, and financial aspects related to the DWM strategies that are going to be implemented after the disaster (Brown et al., 2011).

On the contrary, developing countries like Malaysia, Nepal, and Lebanon are still in the early stages of progress in DWM. These countries are facing technical challenges since they have not yet developed guidelines for the management of their disaster wastes, nor have they prepared inventories to secure their technological capacities and infrastructure that should be ready once a disaster occurs (Zawawi et al., 2016). Some countries like Lebanon have enough technical expertise to adequately manage the DW; yet, they do not have the technologies nor temporary storage sites, treatment and processing facilities, or even hazardous landfills to properly manage the disaster wastes, especially since their generated wastes is contaminated by asbestos. Such developing countries also suffer from various managerial and administrative challenges since they either have not yet fully developed their preparedness, contingency, and implementation plans, or they did not start developing them at all (LEAD Nepal, 2015). The fact that these countries deprioritized working on preparedness plans has led to chaos at the level of role distribution, which resulted in duplication of efforts and the implementation of inadequate DWM strategies (Yusof et al., 2016). This issue is significant as it has permitted the influence of bureaucracy on DWM and has resulted in the absence of a party to hold the responsibility of managing these disaster wastes. Yet, one great factor that also re-enforced the managerial challenges is the absence of a legal and institutional framework that consists of decrees and mandates to tackle all of the technical, managerial and even the financial challenges (Zawawi et al., 2016). Nevertheless, such a framework should assign a committee that would hold the responsibility

and the role of allocating financial resources to be able to manage disaster wastes specifically (Yusof et al.,2016). Yet, since these initiatives are not present in developing countries, funding for adequate DWM strategies is not available, as shown in Table 4.1 below

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As evident from Table 4.1, the countries with the highest scores are Japan and the US which indicates that they have an excellent standing in terms of their implemented DWM strategies. They are not facing evident challenges that could hinder their DWM process, even though they may for sure face challenges at all the technical, managerial, legal and financial levels when it comes to managing significant amounts of wastes. This all depends on the extent of the disaster and how significant the impacts were.

In contrast, developing countries have scored low at the level of various aspects which has resulted in a low cumulative score. This indicates that these countries are in a critical need to address their technical, managerial, institutional, and financial challenges to be able to adequately develop and implement their DWM plans. Most significantly, Lebanon's score is the lowest among the developing countries, since the disaster that occurred has resulted in the generation of a significant quantity of C&D wastes, that is impossible to manage, due to the absence of DWM response and management initiatives.

#### **4.5. A proposed DWM Action Plan for the generated C&D wastes in Lebanon**

##### ***4.5.1. Components of a proposed DWM Action Plan***

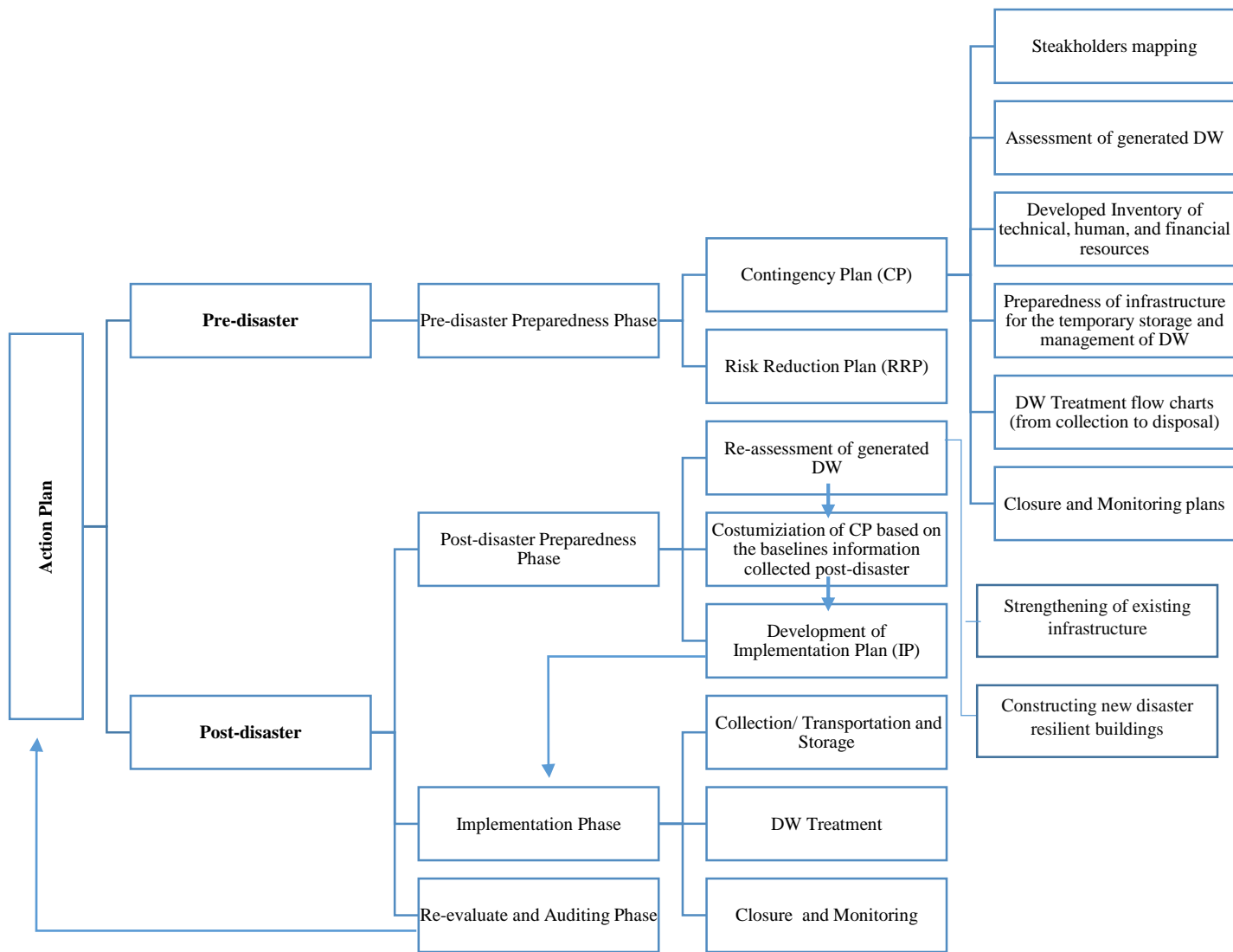
After the occurrence of the port explosion, Lebanon clearly did not have a developed DWM action plan to be implemented. As such, it was of a great importance to develop one in this paper, since this action plan will be the first developed across Lebanon. It aims to guide stakeholders towards the most adequate DWM management process, that once

implemented successfully, will allow Lebanon to properly and quickly recover from its disaster.

The management of significant quantities of disaster wastes require the development and implementation of a cohesive action plan that takes into consideration the technical, administrative, managerial, legal, institutional, and financial aspects that may be challenging the country's ability to manage disaster wastes. As evident by the cases demonstrated in developing countries, the absence of an action plan has led these countries to mismanage their disaster wastes, which consequently withholds significant public health and environmental impacts on the citizens and their environment. As such, these developing countries need to tackle the challenges they encounter when managing their disaster wastes through a well-structured action plan (Yusof et al., 2016).

As such, it is important to categorize the initiatives that are developed within an action plan into several phases that take place before and after the occurrence of the disaster. The phases are:

- Pre-disaster Preparedness Phase
- Post-disaster Preparedness Phase
- Implementation Phase
- Re-evaluation and Auditing Phase



**Figure 4.3 – Proposed Elements of a well-structured Action Plan**

#### ***4.5.2. Pre-disaster***

According to figure 4.3, and as part of the pre-disaster preparedness phase, a country should have developed its contingency plan (CP) specific for DWM. This plan should mainly distribute the roles and responsibilities across the stakeholders through the development of a stakeholder map. DW assessment should also be done to determine the quality and the quantity of generated wastes. Additionally, an inventory consisting of all the technical, human, and financial resources that are needed in DWM could also speed up the implementation of DWM plans and reduce the potential chaos resulting from delays in importing the necessary equipment, searching for funders, and finding the knowledgeable expertise to respond and implement the DWM plans (Ministry of Environment in Japan, 2018). It is not to mention that a CP must consist of a list of all the needed infrastructure that are available, functional, and capable of accommodating significant quantities of wastes at any time. A CP should also consist of DW treatment flow charts which will facilitate the management of these wastes starting from the cleaning and collection phase to the final disposal phase. It is also significant to mention the importance of developing closure and monitoring plans for the infrastructure that were used in DWM such as the temporary storage site.

As such, in the aim to prepare for the disaster before its occurrence, a DWM contingency plan must be well developed to be properly implemented. This will require the availability of a set of guidelines that will enable stakeholders to adequately implement the constituents of CP. For example, people responsible to conduct stakeholder mapping should follow a model such as the “Design Thinking Stakeholder Mapping” model that would allow

them to distribute the roles and thereby designate stakeholders to each of the phases of the action plan. As well, guidelines would help stakeholders assess the generated disaster waste stream through determining an estimation of the quantity and quality of the generated DW. Seismic surveys could determine the amount of generated disaster wastes while understanding the waste composition will require the collection of samples from the wastes stream. Another component of a CP is the development of an inventory for the technical, human, and financial resources which could be done through tabulating the machinery needed, suppliers that could provide the necessary equipment, the expertise needed and the specific budget to be spent in each of the phases of the action plan. It is important to mention that having the necessary infrastructure is one of the basic elements needed for the management of DW. This will require a set of selection criteria that would help stakeholders in determining the land to be used for DWM. A decision tree for the treatment of DW can also facilitate and optimize decision making in regards to the best treatment method to be implemented to manage the DW. Once the management of wastes is completed, it is important to develop plans for the closure and monitoring of the infrastructure. This can be done through a set of guidelines that state how the used infrastructure will be emptied, cleaned, and monitored through sampling strategies to ensure that the site is safe and ready to be used. Table 4.2 summarizes the guidelines developed towards adequate implementation of the CP.

**Table 4.2- Proposed guidelines developed for the adequate implementation of a DWM Contingency plan**

<i>Constituents of a CP</i>	<i>Guidelines</i>
Stakeholder Mapping	<ul style="list-style-type: none"> <li>• The “Design Thinking Stakeholder Mapping: will help in the distribution of stakeholders among the different phases of DWM, as it constitutes of rings located in one another.</li> <li>• Each ring within the center circle may represent a phase from the ones presented in the appendix section and is color coded. The core of the circle may represent the pre-disaster preparedness phase, followed by the greater ring which may represent the post-disaster preparedness phase, then the Implementation phase, and lastly the monitoring and auditing phase. Each of the rings then consist of the initiatives that fall under each of the phases. The core circle may include the initiatives related to the development of a risk reduction plan and a contingency plan. The second ring may include the initiatives related to the assessment of generated DW, customization of CP based on the baseline information collected post-disaster, and development of IP. The third greater ring may include the initiatives that fall under the implementation phase that include the collection/treatment and storage of DW, DW treatment, and Closure and Monitoring. Lastly, the greatest ring may include re-evaluation and auditing initiatives.</li> <li>• Under each initiative, there could be a list of the possible stakeholders that could be involved in each.</li> </ul>
Assessment of generated DW	<ul style="list-style-type: none"> <li>• The assessment of the generated DW will enable the identification of the quantity and the quality of wastes generated.</li> <li>• The quantity of DW will determine the extent of damage the disaster has caused and will help stakeholders decide on the most efficient management strategies and infrastructure to be prepared for use.</li> <li>• An estimation of the quantity can be estimated through a GIS map, seismic surveys, or through referral to previous disasters of similar nature. (EU, 2020).</li> <li>• To determine the quality of DW, collecting samples and testing the wastes will allow the identification of the waste composition. This step will also help in obtaining an estimation of the percentage of hazardous wastes, and others that can be recycled or landfilled (EU, 2020).</li> </ul>
Development of an Inventory of technical, human, and financial resources used in DWM	<ul style="list-style-type: none"> <li>• The country should have an inventory of suppliers to provide DWM machinery (bulldozers, collection vehicles, handbarrows, shovels, etc. (Ministry of Environment in Japan, 2018; UNOCHA,2011).</li> <li>• This inventory can be developed in the form of a table that constitute of the different DWM phases, the respective machines used, the suppliers providing these machines and the expertise needed. The inventory also constitutes the detailed budgets spent on each of the DWM phases (UNOCHA,2011).</li> </ul>

<p>Preparedness of infrastructure for the temporary storage and management of DW</p>	<ul style="list-style-type: none"> <li>• All infrastructure (sorting/ recycling/ incineration/ storage/ landfills) must be available and ready to be used</li> <li>• Criteria for temporary storage sites: <ul style="list-style-type: none"> <li>- accommodate significant quantities of DW appropriate to the scale of the disaster</li> <li>- far away from wells, rivers, streams, wetlands, lakes, drainage systems, flood susceptible lands, agricultural areas, residential areas, power lines and pipelines</li> <li>- flat instead of a steep land to avoid storm water runoffs</li> </ul> </li> </ul> <p>(UNOCHA,2011)</p>
<p>DW Management and Treatment (Collection to Disposal)</p>	<ul style="list-style-type: none"> <li>• Disaster wastes must be properly managed from the sorting/ recycling phase to the disposal. However, if the disaster waste stream consist of hazardous wastes, it must be managed separately through different treatment methods. As such, it is important to develop a decision tree to be able to make informed decisions based on the quality of disaster wastes generated.</li> </ul>
<p>Closure and Monitoring of infrastructure</p>	<ul style="list-style-type: none"> <li>• Temporary storage sites should not be used for more 12 months after the transportation of wastes to the site to avoid public health and environmental impacts (Hayes et al., 2021).</li> <li>• Since the storage site will be empty after the management of wastes, the site will be closed once the onsite equipment and machines, and the left over debris are removed followed by deep cleaning of the site.</li> <li>• Develop an environmental monitoring plan for the site to collect soil samples at different times and locations. This should be done to ensure that the site is safe to be used for future potential projects (parking, recreational, or construction site).</li> </ul> <p>(UNOCHA,2011).</p>

A Risk Reduction Plan is also one that should be developed and implemented as part of the pre-disaster preparedness phase, since it consists of a set of country specific initiatives, that if implemented, could reduce the cumulative quantities of disaster wastes generated post-disaster (Ministry of Environment in Japan, 2018). For instance, if the infrastructural stability of old buildings is constantly monitored in Lebanon, this could significantly reduce the risk of collapse of such buildings and therefore reduce from the quantity of C&D wastes generated post-disaster. As such, initiatives could be directed either towards strengthening existing infrastructure or towards setting criteria for the construction of new buildings that are disaster resilient (UNOCHA, 2011).

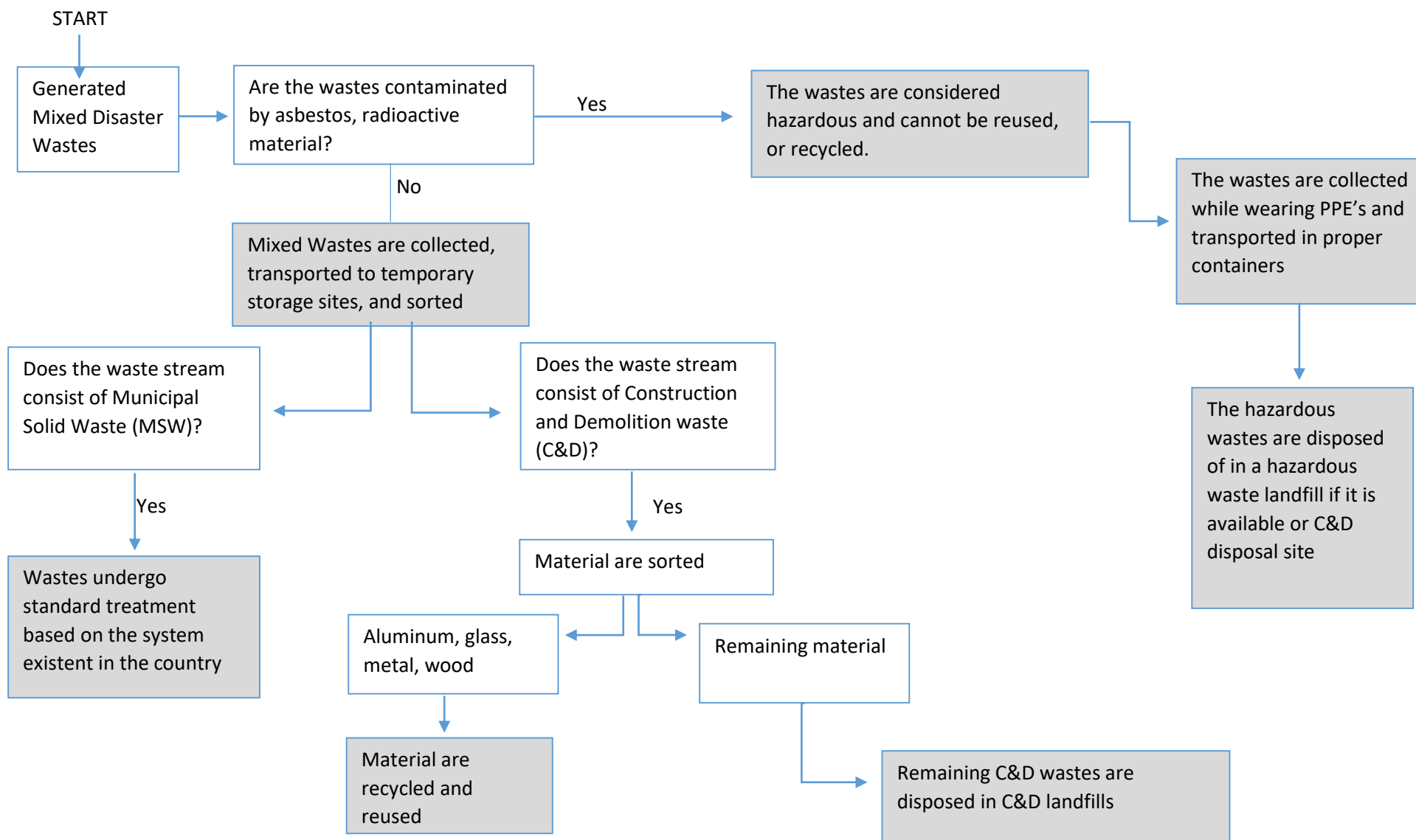
#### ***4.5.3. Post- Disaster***

After the occurrence of a disaster and as part of the post-disaster preparedness phase, the stakeholders should first start by re-assessing the generated DW. As visible in figure 4.3, this initiative should even happen before collection to be able to identify potential hazards that could cause health and safety risks. This step will also provide baseline information that is enough for the stakeholders to know the potential quantity, quality, and waste composition of the DW stream. Consequently, this will allow them to customize the CP to become more disaster specific rather than theoretical, and thereby develop an implementation plan (IP) to adequately manage DW.

Since the country has developed its IP in the post-disaster preparedness phase, stakeholders should be able to implement it in the implementation phase. As such, they

should be able to collect and transport the wastes into the temporary storage sites that were pre-assigned in the CP and reassured upon in the IP.

Afterwards, the most efficient DW treatment method, stated in the IP, should be implemented following a decision tree that will help in deciding on the best treatment flow diagram that is specific and effective to the waste stream they are dealing with. The decision tree related to DW treatment is summarized on Figure 4.4.



**Figure 4.4- Proposed decision tree for DW Management**

Following DW treatment, the facilities used should be ready for closure to go back to their normal operations, even though some such as sanitary and hazardous landfills should be monitored for the long term to ensure the health and safety of the communities.

Additionally, the re-evaluation and auditing phase is the last phase that should be completed following the implementation of the DWM plans (RRP, CP, and IP). Re-evaluation processes will allow stakeholders to determine the challenges faced in managing DW, think of the enabling factors for these challenges, and correct their pre-existing plans. This will improve the development and implementation of DWM plans which will reflect on the efficiency of future DWM strategies.

#### **4.6. Legal Framework governing DWM Action Plan**

The DWM Action Plan presented in figure 4.3 cannot be implemented without it being bound to a legal framework consisting of policies that govern its initiatives. As made clear by the comparative assessment, developing countries face challenges at the legal and institutional level due to the absence of legally bound frameworks, laws, decrees, or policies that are specific to the management of disaster wastes. In Lebanon, there exist no legislations related to the management of C&D wastes post-disaster. There exist only laws related to solid waste management in addition to the presence of a decision known by number 41 done by the head of the parliament that states that a “Disaster Risk Management” unit should be formed for the management of disasters and national crisis. Mostly, the laws in Lebanon are not specific, nor are they enforced. For this reason, Lebanon, like all developing countries must overcome its legal challenges to be able to develop and implement an effective DWM action plan, since without a legal framework, DWM plans cannot be implemented.

#### **4.7. Contextualization of DWM Action Plans**

It is important to note that the DWM action plan outline presented in figure 4.3 can be contextualized by stakeholders in any developing country other than Lebanon, since it tackles all the components that developing countries are challenged in.

## CHAPTER 5

### CONCLUSIONS

The Beirut port explosion that took place in the capital of Lebanon on August 4<sup>th</sup> 2020 has generated a significant quantity of disaster wastes. However, the response to the disaster was very slow, uncoordinated, and no one took the responsibility of DWM. This is due to the absence of DWM plans, which also resulted in the mismanagement of the wastes and the development of open dumps.

After processing the in-depth interviews, the results revealed that the management strategies that were implemented post-disaster were challenged by various technical, administrative, managerial, legal, institutional, and financial factors. For instance, the interviewees made it clear that the absence of required technologies, infrastructure, and expertise after the occurrence; in addition to the absence of adequate DWM guidelines that would enhance the decision making process, are all technical challenges that hinder the management of disaster wastes. The absence of contingency, risk reduction, implementation, and stakeholder mapping plans could also be considered administrative and managerial challenges worthy to be mentioned, as they greatly slow down the recovery process and allow bureaucracy to influence the DWM decision-making process. All of the interviewees also stressed on the fact that the absence of a clear legal and institutional framework to govern the initiatives set forth by the DWM plans could greatly lead to the failure of the implementation of these plans. Lastly, the absence of adequate financial resources to support the post-disaster management process could also hinder

and delay the implementation of the previously developed DWM initiatives. As such, taking into consideration that these challenges previously existed in light of the persisting solid waste crisis that Lebanon is suffering from, the disaster has added pressure on the waste sector and amplified the existing challenges. All the challenges mentioned are limiting the ability of the country to develop DWM plans and strategies.

After completing the thematic analysis, the results showed that the absence of necessary technologies, infrastructure, and expertise has forced Lebanon to face some technical challenges when it comes to managing their wastes. The absence of role distribution and coordination initiatives, and preparedness and response plans, in addition to the intrusion of bureaucracy in DWM decision making all lead to the emergence of administrative and managerial challenges. On the other hand, the absence of legal frameworks and financial resources specific for DWM lead to the development of legal, institutional, and financial challenges respectively.

After conducting the comparative assessment, the results concluded that these challenges faced by Lebanon are very much similar to the ones faced by other developing countries. Nevertheless, developed countries tackled their challenges and have an excellent standing in terms of their implementation to DWM strategies. This is because these countries have developed Risk Reduction Plan (RRP) and Contingency plans (CP) for pre-disaster preparedness and Implementation plans (IP) for post-disaster preparedness.

In the aim to tackle these challenges, the interviews clearly portrayed the enabling factors at the technical, administrative, managerial, legal, institutional, and financial

levels. As such, it was proposed that inventories should be developed. They should primarily include all the machines, expertise, and infrastructure needed to adequately manage the technical challenges that could hinder adequate DWM. A DWM guideline could also enhance the decision making process regarding the best methods to be used to manage disaster wastes. It was also suggested that a contingency, risk reduction, implementation, stakeholder mapping plans should be development before the occurrence of a disaster. It was believed that such plans could speed the recovery process and strengthen the level of coordination between stakeholders, all in the aim to minimize the costs imposed on the government. These interviewees have stressed on the fact that these plans will eliminate possible yet expected bureaucratic influence on DWM. As well, the development of a legal and institutional framework consisting of decrees to govern the initiatives regarding DWM should be well developed and implemented. It is also worthy to mention that the needed financial resources should be made available by a well-developed financial committee to be able to better support the recovery process. All of these enablers must be tackled within a well-structured and cohesive action plan, as revealed by the results of both the interviews and the comparative assessment.

After referring to various countries within the comparative assessment and interviewing the participants, the outcomes reported that the action plan must tackle pre-disaster and post-disaster preparedness phases followed by an implementation phase then a re-evaluation and auditing phase. A contingency plan is developed in the pre-disaster preparedness phase which will include initiatives for the development of a stakeholder mapping plan, initiatives for the assessment of generated DW, an inventory that includes

the human, technical, and financial resources, initiatives for the preparedness of needed infrastructure and temporary storage sites, developed DW treatment flow charts (included in decision making trees), and closure and monitoring plans. Furthermore, the constituents of a contingency plan should be well customized based on the results of the DW assessment since the CP must reflect the extent and magnitude of the disaster. This will help develop an IP, ready to be implemented in the implementation phase.

# APPENDIX 1

## STAKEHOLDER MAPPING PLAN

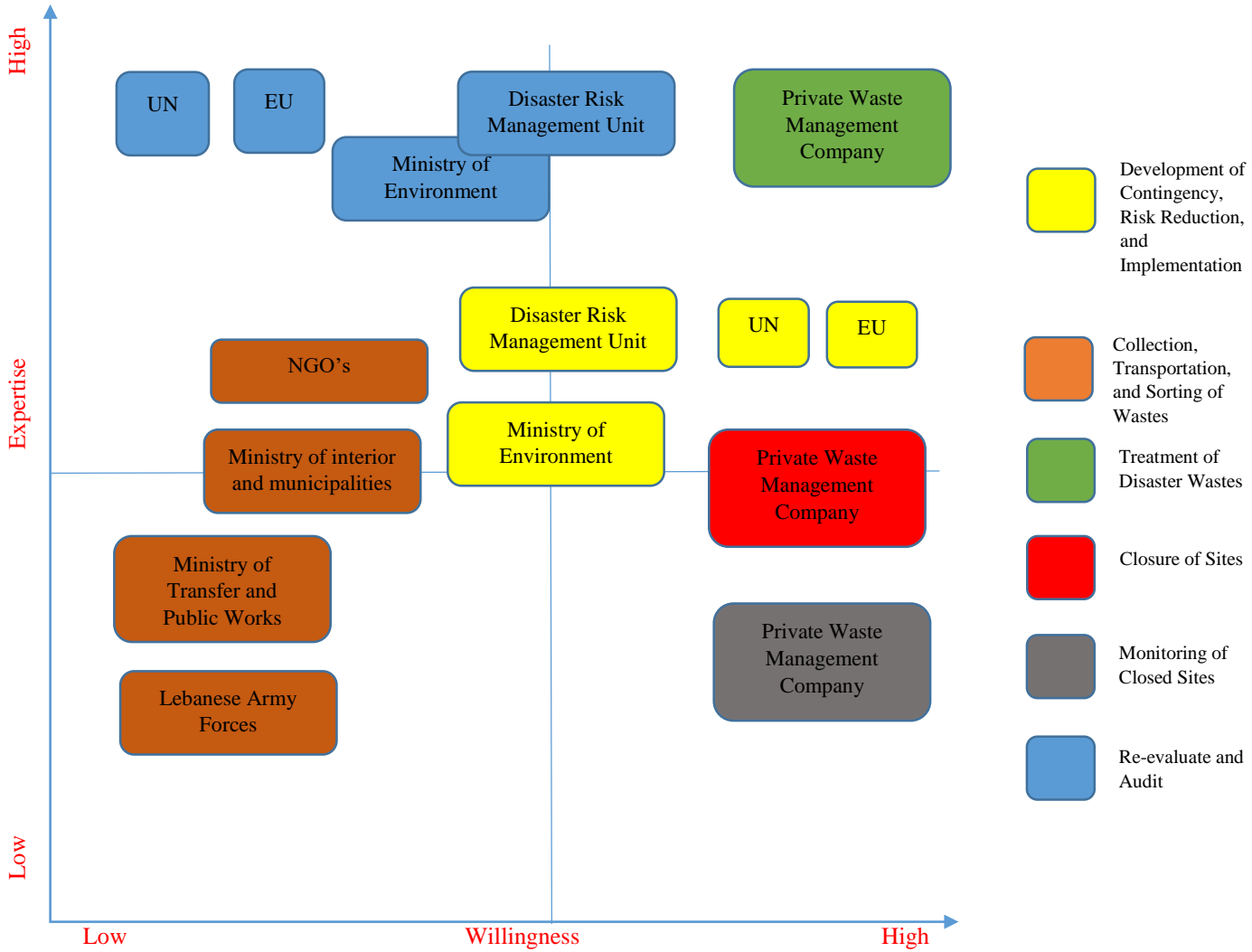


Figure 1- Proposed Stakeholder Mapping Plan for adequate DWM

## APPENDIX 2

### INTERVIEW GUIDE

**Table 1 - Summary of the interview questions linked to the first 2 objectives of this research study.**

<i>Objectives</i>	<i>Questions</i>
<b>Explore and evaluate the implemented strategies and measures for the management of the C&amp;D wastes that resulted from the Beirut Port Explosion.</b>	<ol style="list-style-type: none"><li>1. What were the measures adopted to manage the generated 800,000 tons of post- disaster wastes?</li><li>2. What actually happened to the generated DWM?</li><li>3. What were the guidelines followed in the management of the waste?</li><li>4. Were these measures capable of effectively managing disaster wastes?</li><li>5. Who are the institutions that were involved in the DWM?</li></ol>
<b>Identify the national barriers and enabling factors towards implementing current and future DWM strategies.</b>	<ol style="list-style-type: none"><li>1. What were the technical, managerial, institutional and financial limitations that challenged the management of DWM?</li><li>2. What are the underlying factors that forced Lebanon to suffer from the challenges set forth by these limiting factors?</li><li>3. What are the enabling factors that should be developed/implemented at the technical, managerial, institutional and financial levels to facilitate the management of the current disaster wastes?</li><li>4. What are the essential key factors that should be tackled to facilitate the development of a contingency plan for the DWM of future disasters?</li></ol>

## APPENDIX 3

### DETAILED COMPARATIVE ASSESSMENT

**Table 2 –A Detailed Comparative Assessment of DWM aspects across USA, Malaysia, Japan, Nepal and Lebanon**  
 (Asari et al., 2013), (EPA,2008), (Homeland Security, 2008), (LEAD Nepal, 2015), (Luther, 2008), (Ministry of Environment in Japan, 2018), (Yusof et al., 2016), (Zawawi et al, 2016)

Aspects tackled for proper DWM	Technical Aspects			Managerial Aspects			Institutional Aspects	Financial Aspects
	Inventories of necessary resources	DWM guidelines	Data Collection Mechanism	Development of DWM Action Plan	Development of Stakeholder Mapping Plans	Plans to eliminate Bureaucratic Intrusions	Legal and institutional framework	Plans to secure financial resources
<b>USA</b>	<ul style="list-style-type: none"> <li>• Provision of required machinery</li> <li>• Provision of expertise</li> <li>• Provision of needed infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Provision of tools that help in the decision making process regarding the most adequate DWM method</li> </ul>	<ul style="list-style-type: none"> <li>• Presence and implementation of DWM Data Collection Mechanism</li> </ul>	<ul style="list-style-type: none"> <li>• Availability of RRP, CP, and IP</li> </ul>	<ul style="list-style-type: none"> <li>• FEMA, EPA, members of the Congress, local Chiefs (all stated chronologically) are governed by a NRP developed by HS</li> <li>• Adequate coordination between stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>• Present</li> </ul>	<ul style="list-style-type: none"> <li>• Presence of legal framework with bounding laws on DWM</li> </ul>	<ul style="list-style-type: none"> <li>• Availability of financial resources through FEMA</li> </ul>

<b>Malaysia</b>	<ul style="list-style-type: none"> <li>Absence of required machinery</li> <li>Availability of an inadequate number of expertise</li> <li>Absence of infrastructure needed for DWM</li> </ul>	<ul style="list-style-type: none"> <li>Absence of decision making tools that guide towards the selection of the most adequate DWM practices</li> </ul>	<ul style="list-style-type: none"> <li>Improved Data Collection Mechanism</li> </ul>	<ul style="list-style-type: none"> <li>Absence of clear RRP, CP, IP</li> </ul>	<ul style="list-style-type: none"> <li>Directive No. 20 distributes roles and responsibilities</li> <li>No coordination between stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>Absent</li> </ul>	<ul style="list-style-type: none"> <li>Absence of a cohesive legal framework specific for DWM</li> </ul>	<ul style="list-style-type: none"> <li>Mostly absent, however, when funds are available, loans are delayed which consequently delays the use of the fund for management purposes</li> </ul>
<b>Japan</b>	<ul style="list-style-type: none"> <li>Provision of required machinery</li> <li>Provision of expertise</li> <li>Provision of needed infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>Availability of DWM guidelines (JSMCWM) that help in the selection of adequate DWM strategies</li> </ul>	<ul style="list-style-type: none"> <li>Presence and implementation of DWM Data Collection Mechanism</li> </ul>	<ul style="list-style-type: none"> <li>Availability of RRP, CP, IP</li> </ul>	<ul style="list-style-type: none"> <li>Availability of “Task team on DWM and Reconstruction”</li> <li>Adequate coordination mechanism between stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>Present</li> </ul>	<ul style="list-style-type: none"> <li>Presence of legal framework with bounding laws on DWM</li> </ul>	<ul style="list-style-type: none"> <li>Availability of financial resources</li> </ul>
<b>Nepal</b>	<ul style="list-style-type: none"> <li>Current Initiatives developed for the provision of required machinery</li> <li>Provision of expertise</li> </ul>	<ul style="list-style-type: none"> <li>Efforts dedicated towards developing guidelines for DWM</li> </ul>	<ul style="list-style-type: none"> <li>Improved Data Collection Mechanism</li> </ul>	<ul style="list-style-type: none"> <li>Progressing in the development of RRP, CP, and IP</li> </ul>	<ul style="list-style-type: none"> <li>Proposed framework includes potential roles distributed across authorities</li> <li>Proposed framework specifies a coordination</li> </ul>	<ul style="list-style-type: none"> <li>Absent</li> </ul>	<ul style="list-style-type: none"> <li>Proposed legal framework specific for DWM (National Strategy for Disaster Risk Management) (NSDRM), but it is not yet approved to be implemented</li> </ul>	<ul style="list-style-type: none"> <li>Proposed financial plan for the allocation of financial resources to manage DW</li> </ul>

	<ul style="list-style-type: none"> <li>• Provision of needed infrastructure</li> </ul>				mechanism between authorities			
Lebanon	<ul style="list-style-type: none"> <li>• Absence of required machinery</li> <li>• Absence adequate number of expertise</li> <li>• Absence of infrastructure needed for DWM</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of DWM guidelines</li> </ul>	<ul style="list-style-type: none"> <li>• Absence/Non Cohesive/Random Data Collection Mechanism</li> </ul>	<ul style="list-style-type: none"> <li>• Unavailability of RRP, CP, IP</li> </ul>	<ul style="list-style-type: none"> <li>• No distribution of roles and responsibilities</li> <li>• No coordination between stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>• Absent</li> </ul>	<ul style="list-style-type: none"> <li>• Unavailability of a legal framework specific for DWM</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of financial resources allocated for DWM</li> </ul>

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