DEMOLITION WASTE ASSESSMENT

OUTSIDE THE PORT OF BEIRUT

Acknowledgements

Thanks are due to:

- Frontline Engineers for undertaking this invaluable initiative after the tragic event.
- UN Habitat for sharing their rapid damage assessment data for debris quantification.
- Elie Mansour (UN-HABITAT) for his analysis and review of this report.
- Martin Bjerregaard (EU Expert for Debris Management) for providing technical support on site assessment and quantification of debris.

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1. Background

Introduction

The Beirut blast that took place on the 4th of August 2020, has left 202 deaths and injured thousands of people. The tragedy happened in a country that is already suffering from a severe financial crisis in addition to the COVID-19 pandemic. Within the port area, the explosion destroyed a section of the shoreline, and left a crater that is 124 m (407ft) in diameter and 43 m (141ft) in depth. The city's dense residential and commercial areas were also severely damaged within two to five kilometers from the explosion's site.

While humanitarian actors and local NGOs including volunteers continue to address immediate humanitarian needs across the affected areas, the effort towards a long-term recovery process has already started to take place backed up by adequate assessments and planning efforts. For environmental repercussions to the blast and the recovery process therein, we must ensure that the disaster waste (rubble and other specific waste streams) resulting from the explosion and upcoming demolition and rehabilitation works, must be treated in an environmentally sound manner including sorting, recycling and final disposal. Even though a few damage assessments of buildings have been conducted, detailed information is not available of the type and quantity of the disaster waste from the explosion.

UNDP's Response

In order to develop and implement an environmentally sound and efficient waste management plan, we first needed to assess and estimate the type and amount of disaster waste through a detailed site survey. Over and above the effort we have done ourselves on the ground in collecting this type of information, the results of publicly available damage assessments such as the Disaster Management Sector Beirut Port Explosion Response Assessment Results by Lebanese Red Cross (LRC), the Building Damage Assessment by Order of Engineers and Architects (OEA), and the Beirut Rapid Damage Assessment by UN-Habitat and Beirut Municipality were taken into consideration in terms of validation and cross-referencing the debris quantification to the best possible extent (see section on **Comparative Analysis**).

Furthermore, the results of this assessment will be integrated into the Construction and Demolition Waste Management Plans under development by the European Union (EU) group of experts and the options for treatment will consider the analysis herewith in consultation with stakeholders and national partners, notably the Ministry of Environment.

2. Objectives

The main objective of this assessment is to support the design of an environmentally sound and cost-effective waste management plan by identification and quantification of the disaster waste from the Beirut Blast. From past experience, the volume of disaster waste is expected to increase over time due to the waste from construction and demolition during recovery and reconstruction activities (**Figure 1**).

The assessment aims at estimating the volume of Construction and Demolition Waste (CDW) from the demolition in Beirut and glass waste as a result of the blast as well as the identification of specific disaster waste streams such as hazardous waste, e-waste, and vehicles, which requires specific treatment. This assessment only covers the area damaged by the explosion that is surrounding (outside) the Port of Beirut.

It should be noted that although this study took into consideration building damage, the results should only be used for debris management and recovery planning; not for recommendation on demolition, evacuation or refurbishment of buildings. The building damage assessment for such a purpose is being done by OEA and the Municipality of Beirut. However, their assessment does not intend to identify or quantify the type and amount of C&D waste, glass wastes as well as other disaster waste.

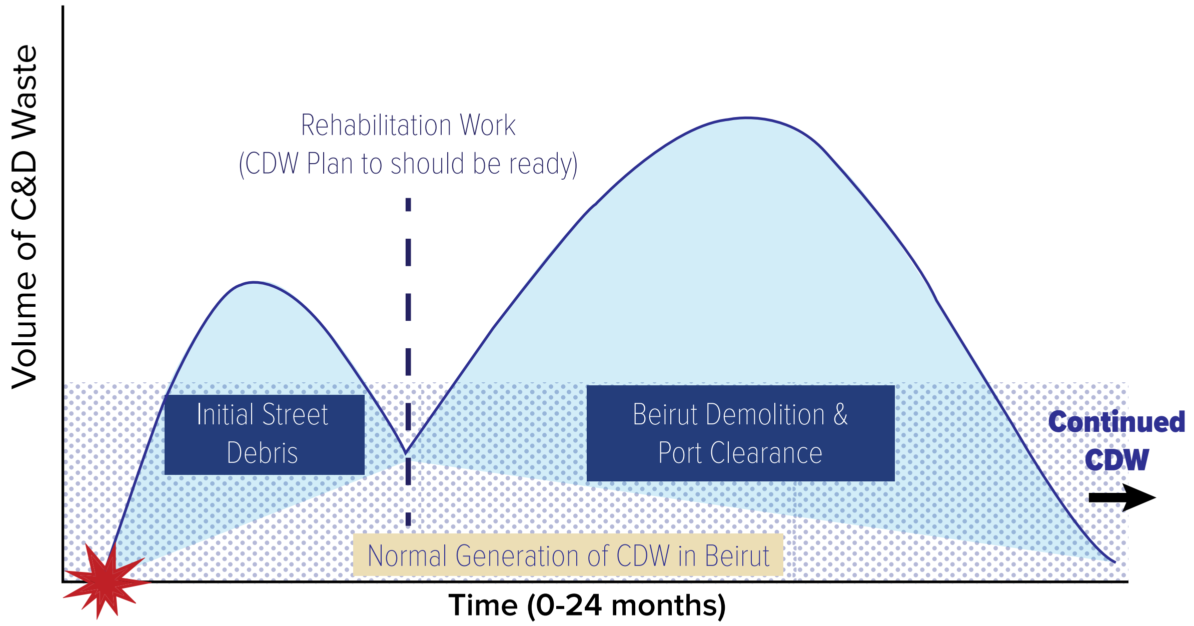


Figure 1. Amount of Construction and Demolition Waste Over Time

3. Methodology of the Survey and Assessment

Survey Questionnaires

The survey questionnaires were designed based on the UNDP's Household and Building Damage Assessment (HBDA) toolkit[1], which has been used by UNDP in many countries in response to similar situations. The questionnaires of HBDA were adjusted by the UNDP Lebanon team, UNDP Crisis Bureau, Frontline Engineers and the waste experts from the EU and the Ministry of Environment to integrate the specificities of this disaster and the general Lebanese context.

The full list of adopted questionnaires can be found in **Annex 1**. The questionnaire is divided into the following 6 themes covering various types of information related to the location of the damage buildings, the type, the size, the type of material, degree of building damage and the type and amount of disaster waste present at the site:

A. Building Base Data (GPS coordination, accessibility to the building)
B. Building Use and Household Information
C. Building Size
D. Building Materials
E. Building Damage and Repairs
F. Building Services and Debris

Data Collection and Zoning of Affected Areas

Data collection on site-level was led and executed by the Frontline Engineers, a group of engineers who volunteered to undertake the technical assessments including the one of UNDP. UNDP initiated the discussion with Frontline Engineers immediately after the blast and agreed on undertaking the assessment in partnership. Frontline Engineers mobilized more than 75 volunteer engineers and UNDP, with support from EU waste expert, trained the volunteers on the survey questionnaire, data collection approaches and the data collection mobile app. UNDP provided the engineers with personal protective equipment (PPEs) to ensure their safety on site. This included safety helmets, gloves, N95 masks, etc. In addition, measuring equipment and practical tools such as laser-measuring tapes, stationery and other small items were provided. Five tents were installed on site, where a group of nurses (also volunteers) were available to address any emergency needs in terms of health and safety on site. Additionally, a receptionist for each tent was made available to manage new volunteers and the PPE distribution and inventory.

The survey was initiated on 15 August 2020. The damaged areas in Beirut and Mount Lebanon were divided into 139 zones based on the delineation set by the Lebanese Armed Forces (LAF) and commonly used among the humanitarian and international agencies in the response[2]. 36 zones located within an approximate 2 km radius of ground zero of the Beirut blast were considered to be the "Red Zone" for this assessment based on the initial observation of the building damage in Beirut (**Figure 2**)[3]. In line with this observation, the subsequent assessment by UN-HABITAT (see section for Comparative Analysis) revealed that there were only minor and no structural damage to buildings outside of the Red Zone, even though windows and doors were damaged in the broader area. Thus, it was assumed that the quantification of construction and demolition waste (CDW) within the Red Zone would provide a reasonable estimation of the potential volume of overall CDW from the blast. More details can be found in the **Annex 2**.

By the end of September, over 700 buildings in the red zone were inspected by the engineers to assess damages on site, and collect the information related to the waste quantities and types. This data was collected using a questionnaire developed and tracked by the Information Management team (IM) at UNDP. The application was deployed on the mobile phones of the engineers through the *Survey123 for ArcGIS* application tool.

1- UNDP, HBDA Toolkit (https://www.undp.org/content/buildingdamageassessment/en/home.html)
2- UNOCHA (2020), Beirut Port Explosion: Operational Zones References as of 20 August 2020.
3- Operation Zone Numbers for the zones included in Red Zone analysis: 1-3, 7, 8, 10-40. (See also Annex 2)

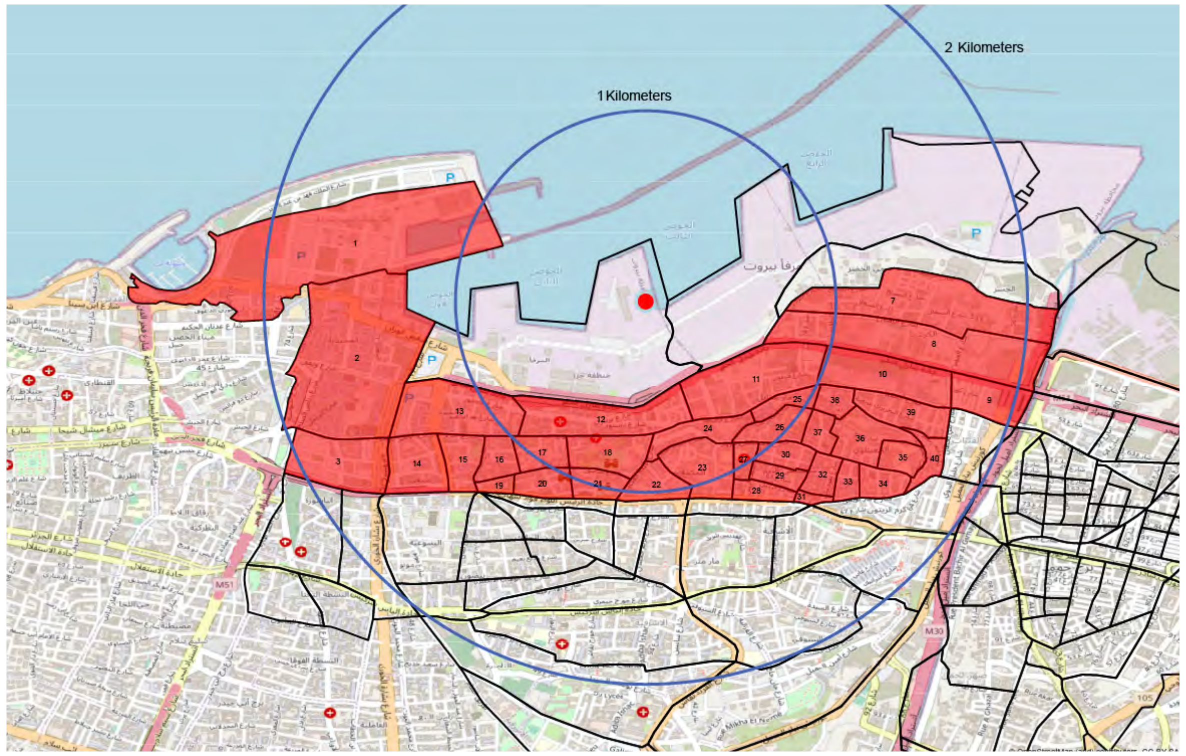


Figure 2. Map of Red Zone in Beirut.

Mobile Data Collection Tool

After the Beirut Blast, the UN Disaster Assessment and Coordination (UNDAC) and OCHA established the Assessment Cell to manage the data flow of all activities regarding the blast response. The Lebanese Red Cross (LRC) led in data management at the inter-agency level and coordinated with the LAF at the governmental level. The UNDAC agreed to work under one information management platform administrated by LRC and LAF. Data was accordingly collected and hosted on LRC's geographic information system (GIS) platform called *Survey123 for ArcGIS* in coordination with the LAF.

Survey123 for ArcGIS is a GIS data collection tool developed by ESRI. It is compatible with both Apple and Android devices and allows for map-based consolidation of observational quantitative data. Before deploying the survey in bulk, a pre-test was conducted on site with a small group of engineers for feedback and optimization of both the content of the form and the mechanics of the survey. Following the amendments, each engineer was given access to an ESRI account provided by LRC through the UNDP IM officer. Following this, the volunteers downloaded the questionnaire on their mobile to start the data collection on site. Once the data was inserted, the engineers were able to submit their information directly to the IM department who had access to a live map showing real-time progress of submissions and their respective locations. UNDP IM team also developed the training manual (**Annex 3**) for the data collection tool.

All data collected from the field was automatically uploaded into a geodatabase from which maps and georeferenced datasets were extracted by the UNDP team and communicated to a technical team for results analysis.

Assessment Methodology

In order to estimate the volume of CDW as well as glass waste, the buildings within the red zone were inspected by the engineers, taking into consideration the following dimensions:

1. Type (residential/commercial/ industrious) of buildings
2. Size (square meter, m^3) of buildings
3. Category of structural damage to the building wall (completely destroyed, severe damage, moderate damage, minor damage, no damage)
4. Surface area of the gap created by the blast (m^2) (where windows/doors seemed to be blown off)

CDW:

Based on experiences from a number of demolition sites across the world, the amount of demolition waste depends on the type of building. As a rule of thumb, to estimate the CDW from the building volume (m^3), the below ranges are used for the various buildings' types as per data No.1 above – these are called the maximum CDW potential:

- CDW from completely destroyed warehouses and industrial buildings with few or no internal walls constitute 5-15% of the building volume (based on data No. 2 above);
- CDW from completely destroyed schools, commercial buildings such as offices and banks, and other buildings with high and large rooms constitute 15-20% of the building volume;
- CDW from completely destroyed residential houses constitute 25-35% of building volume, depending on thickness of walls and size of rooms.

For this assessment, the maximum ratio of demolition waste for each type of building was applied for all the building type (15% for warehouses/industrial buildings, 20% for commercial buildings and schools, 35% for residential houses).

Each category of structural damage building was given an adjustment factor which describes the proportion of CDW with respect to the maximum CDW potential had the building been completely destroyed.

- 100% for Completely Destroyed (>75% of the structure damaged; at least three walls collapsed, mostly destroyed aside from foundations)
- 35% for Severe Damages (50-74% of the structure damaged; some walls collapsed, all doors and windows affected, not structurally sound and not liveable)
- 15% for Moderate Damages (25-49% of the structure damaged; cracks in the walls, all windows and doors affected, structurally sound and liveable)
- 5% for Minor Damages (0-24% of the structure damaged; doors and windows affected)
- 0% for No Damages

Based on the above, the equation to calculate CDW (m^3) from a building is:

Max CDW potential (based on data No.1 – type) (%) * volume of the building (based on data No.2 – size) (m^3) * adjustment factor (based on data No.3 – category of damage)

Out of a total of 2,550 buildings in the Red Zone, 796 buildings were inspected for this assessment, which accounts for 31% of the buildings in the Red Zone. The average ratio of CDW volume per building from the surveyed buildings (i.e. total/796 buildings) was then used to project the total amount of CDW by multiplying it with the total number of buildings in the Red Zone. A linear regression methodology was used based on the number of the buildings, and not the area because there is empty area in Red Zone which would have resulted in an overestimation of the CDW). This is based on the assumption that the surveyed area/buildings and its distribution in terms of type, size and damage represents the overall situation in the Red Zone. The linear regression based on the area was not used.

It should be noted that this extrapolation based on the number of buildings is indicative but may include inaccuracies because the dimension, type, engineering of the buildings and the degree of damage from the blast are not consistent across the whole Red Zone. More accurate numbers can be obtained by collecting the relevant data from all of the buildings in Red Zone or affected area in Beirut. Given such an exhaustive information is not available, the comparative analysis was undertaken to consider the information from the other assessments that covered more areas but does not contain all the indicators needed for this estimation (see section on **Comparative Analysis**).

Glass Waste:

The estimation of volume of glass waste was based on the surface area (m^2) of the gaps (data No.4) along with the glass thickness (see below), i.e. area multiplied by thickness and calculated accordingly. The same linear regression methodology was used for the estimation of glass and the debris present at the site (not from upcoming potential demolition activity).

Disaster Waste Directly Generated from the Blast:

The surveyors visually inspected the amount and type of disaster waste present on site and estimated their total volume in m^3.

4. Results and Analysis

Key Results

The key results of the assessment for disaster waste management planning are as follows:

A. Estimated amount of CDW

B. Estimated amount of glass waste

C. Estimated Amount of disaster waste directly generated from the blast (e.g. e-waste, hazardous waste, and vehicles) within the Red Zone

A. Estimated amount of CDW

The amount of CDW from the blast itself and from the potential demolition activities in Beirut (excluding the Beirut Port clearance) was estimated based on the above methodology. The estimated figures for CDW volume and weight are as follows:

- **Total CDW Volume in Red Zone: 657,386 m^3**
- **Total CDW Weight in Red Zone: 1,051,818 tonnes**

B. Estimated amount of glass waste

The same methodology (estimation based on linear regression with the number of buildings) was applied in order to calculate the total volume of glass. To estimate the volume of glass waste, the surface area (m^2) of the gaps (where windows/doors seemed to be blown off) in the building were visually inspected and estimated by the engineers.

As a general observation, the glass thickness in Beirut houses has varied over the years. In the last few decades, houses used wooden windows with a glass thickness of 4 mm. Afterwards, people opted for aluminum window frames with a single glass of 6 mm thickness. In modern times, people started using double glazed windows with a varying thickness between 12mm to 16mm as a replacement to single glazed windows. Taking into consideration the variations, it was assumed that the thickness of glass is 10 mm and the weight of glass to estimate volume and weight of glass waste is 10 mm and 2.5 tonne/m3 respectively.

The total area where windows/doors seemed to be blown off is **573,135 m^2** in the Red Zone. Assuming that this space was filled with glass before the blast, the density of glass is 2.5 tonne/m^3 and the thickness is 0.01 m, the estimated amount of glass waste from the blast in Red Zone is approximately **14,328 tonnes**. However, given that the affected area with the damage of glass and window seems to be much larger than Red Zone, the estimation in all likelihood underestimates the amount of overall glass waste in Beirut (see section on **Comparative Analysis**).

C. Estimated amount of disaster waste directly generated from the blast (e.g. e-waste, hazardous waste, and vehicles)

As detailed in **Table 4** and **Table 5**, there were different types of disaster waste generated by the blast and present on site during the survey. The surveyors visually inspected the amount of such disaster waste present on site and the total volume was estimated to be approximately **204,633 m^3**, which is calculated by the same methodology above. They include not only CDW but also glass, scrap metal, e-waste, and destroyed vehicles. Based on the observation from the ground, it is likely that part of the waste was already cleaned and transferred to the Karantina's temporary site (or other). Notably, most of the debris on the street was already cleaned up by volunteers and NGOs a few weeks after the explosion (see section **Ongoing Waste Collection and Plans**).

Comparative Analysis

There have been several damage assessments undertaken by different institutions after the blast. The below is a comparative analysis of the results of the UNDP survey along with other assessments.

a. Beirut Municipality Rapid Damage Assessment by UN-Habitat and Municipality of Beirut

UN HABITAT and Beirut Municipality conducted an exhaustive rapid damage assessment in order to identify buildings that have collapsed, those that were severely affected, or had minor impact within the administrative zone of Beirut. The field survey was conducted by volunteers supervised by municipal engineers and private engineering companies. Asdepicted through **Figure 3**, the severely damaged and destroyed buildings are largely located in close proximity to ground zero, within the Red Zone. Thus, the estimation of CDW only within the Red Zone is expected to generate realistic value.

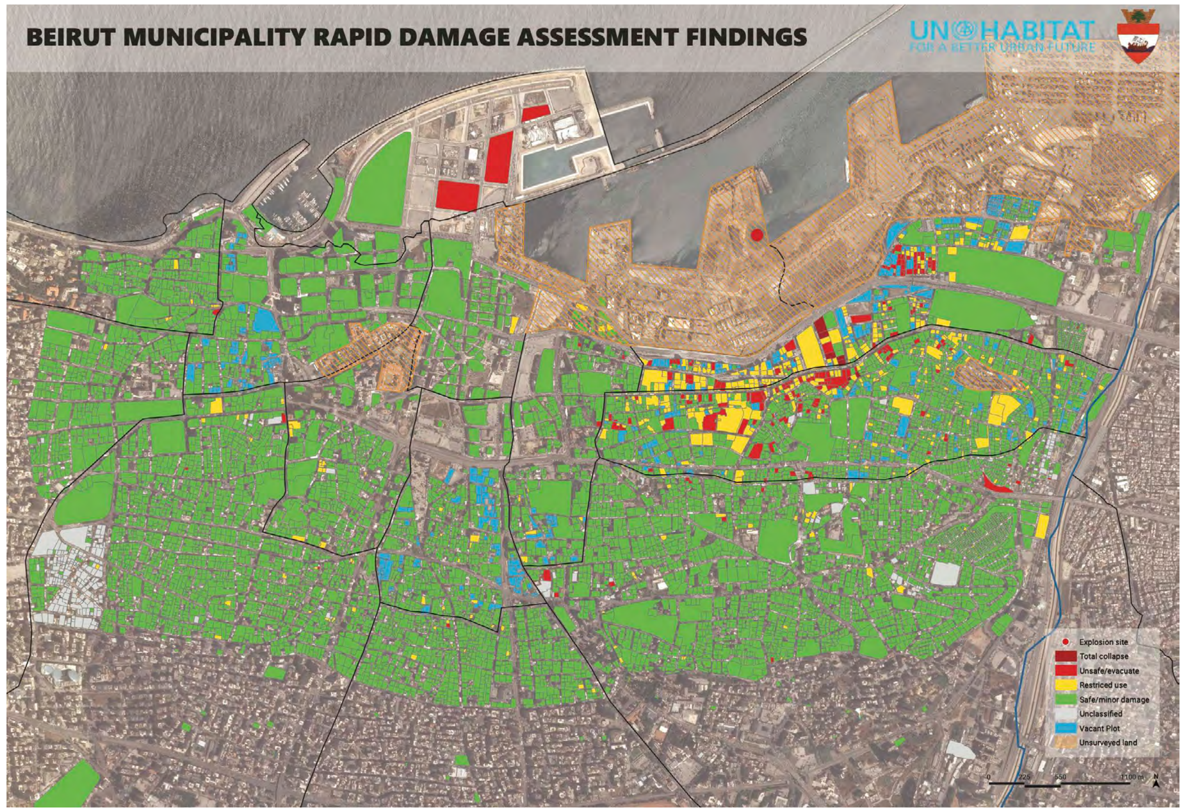


Figure 3. Rapid Damages Assessment by UN-HABITAT and Beirut Municipality.

Amount of CDW

UN-HABITAT's assessment also implied that several zones within the Red Zone might not have significant damage (total collapse, unsafe/evacuate category, but could have minor damage) as shown in green in **Figure 2**. Taking this into account the estimation with linear regression was carried out by removing buildings within these zones from calculation for the sake of comparative analysis (**Figure 4**)[4]. Using the same linear regression, the estimated amount of CDW based on this assumption is as follows:

- Total CDW Volume in Red Zone: 318,735 m^3
- Total CDW Weight in Red Zone: 509,977 Tonnes

Since this assumption does not take into account the CDW from removed zones, which have minor damage as well as severe damage to a lesser extent, this estimation clearly underestimates the amount of CDW.

4- The zones that were identified as mostly safe/minor damage in the assessment by UN-Habitat & Beirut Municipality: 2, 3, 10, 13, 14, 19, 27-34, 36, 37, 39, 40.

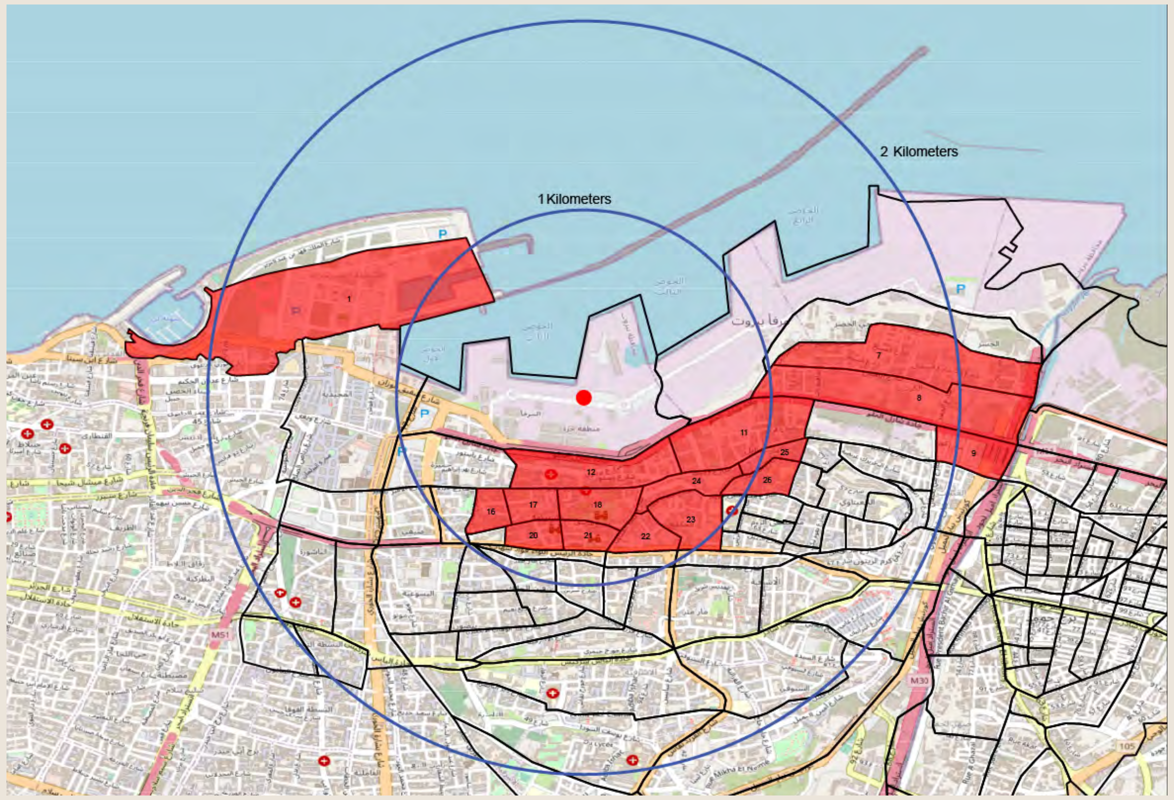


Figure 4. Modified Red Zone for Comparative Analysis based on UN-Habitat's Assessment

Amount of Glass Waste

While UNDP's survey only covered the Red Zone (36 zones out of 139 zones in Beirut), other assessments and reports suggest that there were broken glasses and windows by the blast outside of this zone. UN-Habitat's assessment for instance, estimated the blown off surface area beyond the Red Zone. In their assessment, surveyors (engineers) also visually estimated the areas in square meter of the following components on the building's external envelope:

Damaged Glass: 421,416 m^2

Damaged Aluminum Windows (assumption: 40% aluminum and 60% glass for volume): 560,000 m^2 (aluminum: 224,000 m^2, glass: 336,000 m^2)

Damaged Aluminum Sliding Doors (assumption: 40% aluminum and 60% glass for volume): 63,150 m^2 (aluminum: 25,260 m^2, glass: 37,890 m^2)

Applying the same assumptions as the above (density 2.5 tonne/m^3 for glass, 2.7 tonne/m^3 for aluminum, thickness 0.01 m), the total weight of glass and aluminum was estimated as follows:

Glass waste from the blast: 795,306 m^2, 19,883 tonne.

Aluminium waste from the blast: 249,260 m^2, 6,739 tonne.

a. Building Damage Assessment by Order of Engineers and Architects

The Order of Engineers and Architects (OEA) undertook a building damage assessment in order to produce recommendations for buildings that needed isolation for weather proofing, those that needed to be evacuated, as well as those that needed structural strengthening, whether immediate or onsite. As depicted by **Figure 5,** the OEA divided the affected area in Beirut into three zones (Zone A, B and C). The OEA's assessment does not measure the size of buildings since their objective was not to estimate the amount of CDW from demolition. Zones A and B nearly overlap with the Red Zone of UNDP's assessment.

By 31 August 2020, the OEA had surveyed 2,083 lots in total; out of which 30% of buildings are found in Zone A and 86% are found in Zone B. From the lots surveyed by OEA, 176 lots were classified as needing evacuation and 403 lots were considered as requiring structural strengthening, and 103 lots were classified in need of "isolation". Due to the lack of dimensional data of the buildings and different damage categorization, the quantification of CDW from OEA's assessment was not possible.

b. Multi-Sector Needs Assessment (MSNA) by Lebanese Red Cross (LRC)/UNHCR[6]

This assessment was based on the immediate household surveys conducted by LRC volunteers and other partner's enumerators in the impacted areas. While the assessment focused more on socio-economic aspects, the assessment also monitored the shelter (building) damage and generated an interactive map[7]. The building damage assessment was based on observation and Key Informant Interviews (KIIs) of respondents' homes in relation to damage to structure (columns, beams, ceiling/roof/slab, balcony), doors and windows. However, this assessment does not provide a credible data on the CDW in terms of its quantification because survey questions only addressed whether the structure was collapsed/damaged or not damaged, and did not consider the extent of damage, which is necessary for quantification of the potential CDW.

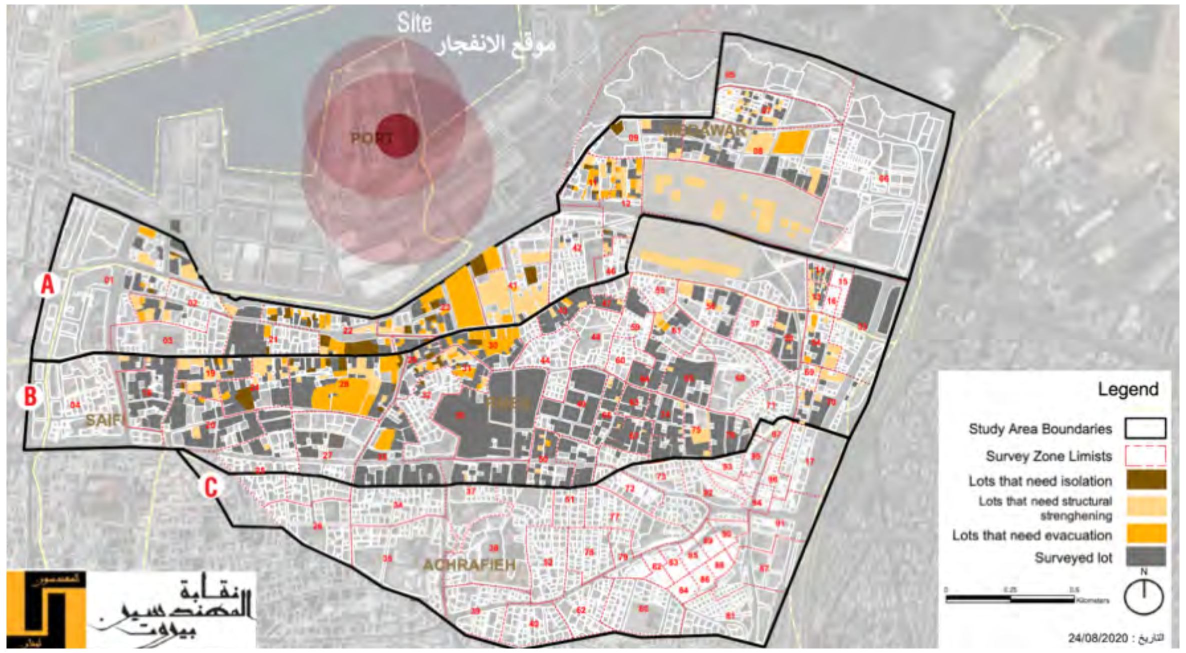


Figure 5. Building Assessment and Survey Zoning by OEA[5].

5- OEA (2020), Building Assessment Weekly Report (August 24, 2020).
6- LRC (Aug 24, 2020), MSNA and DANA.
7- LRC & UNHCR (2020), Beirut Blast Shelter Damage (Interactive Map, checked in Sep 17 ,2020).

Detailed Results

The type of buildings inspected were residential/dwelling (51%), residential and commercial (29%), commercial/business (17%), public (1.5%) and other (1.5%).

Building damage was assessed for walls, roof, ceiling, floor and foundations respectively. The distribution of the damaged buildings in the Red Zone is shown in **Table 2**. The assessment has shown that the (i) complete destruction and (ii) severe structural damage are relatively minor even within the most affected area (Red Zone) in Beirut: (i) < 3.2% and (ii) < 8.4% respectively for inspected buildings.

Table 1. Structural Damage to Buildings by the Blast

	Walls	Roof	Ceiling	Floor	Foundations
Completely destroyed (>75% of the structure damaged) (at least three walls collapsed, mostly destroyed aside from foundations)	1.7%	3.2%	2.9%	0.3%	0.2%
Severe damage (50-74%) (some walls collapsed, all doors and windows affected, not structurally sound and not liveable)	8.4%	4.0%	6.3%	2.4%	0.8%
Moderate damage (25-49%) (cracks in the walls, all windows and doors affected, structurally sound and liveable)	26.0%	7.9%	13.0%	5.9%	1.4%
Minor damage (0-24%) (doors and windows affected)	49.8%	51.4%	43.3%	42.4%	8.3%
No damage	13.3%	27.6%	30.8%	45.5%	61.6%
Not possible to assess/others	0.8%	5.9%	3.7%	3.5%	27.7%

In terms of the material for the building, concrete is the most commonly used for building frame, wall, roof, ceiling and floor (including tiles on concrete). Note that several materials are sometime used for the same building. The commonly found materials for wall, building frame and roof is as follows:

Table 2. Common Materials Used for Building Structure

Material	Building Frame	Material	Wall	Material	Room
Concrete (column/beam)	83.2%	Concrete block	79.4%	Concrete	92.1%
Stone	15.2%	Rendered wall	10.6%	Clay tile	4.9%
Concrete block	10.3%	Glass/curtain walls	9.7%	Corrugated metal	3.0%
Steel (column/beam)	4.6%	Lath and plaster	6.7%	Wood	3.0%
Timber	4.4%	Timber	4.8%	Galvanize sheeting	2.1

Regarding the damage to utility services (electricity and water) by the blast, the damage to public network seems to be minor even though there are few buildings that had internal networks damage (**Table 4**). As per the preliminary assessment of the Rapid Damage and Needs Assessment (RDNA) by the World Bank[8], the damages to the electricity sector are mainly related to transmission (the high-voltage Achrafieh substation and the National Control Centre – NCC); distribution (substations, distribution lines, and a data centre for the billing system); administrative assets of the state-owned power utility Electricité du Liban (EDL – headquarters, meter laboratory, vehicles and warehouses); and the headquarters of the Ministry of Energy and Water (MoEW). These results of RDNA validate UNDP's assessment given that it also shows that the damage to public network is not widespread in the Red Zone.

8- WB, EU and UN (2020), Beirut Rapid Damage and Needs Assessment.

Regarding the water sector, the World Bank's RDNA states that the water supply and sanitation facilities in Beirut and Greater Beirut are functional despite being impacted by the blast. The RDNA also suggests that the damage to water supply network at household-level is limited which is also reflected in the UNDP's assessment.

Table 3. Damage to Utility System

	Electricity system	Water supply system
Damage to internal and public network	2.5%	0.2%
Damage of public network	3.5%	0.3%
Damage of internal network	12.5%	7.9%
No damage	70.2%	78.4%
Not possible to assess/others	11.3%	13.2%

The survey also identified several types of disaster wastes that were present on site at the time of the site survey which needed be collected and removed. Such disaster wastes were present at 46% of the inspected buildings (337 buildings out of 730 buildings). The following types of disaster wastes were found at the various sites (**Table 5**).

Table 4. Type of Disaster Waste Present at Site

Type of disaster waste	% of buildings with disaster waste	# of building with disaster waste
Construction and demolition waste (concrete, bricks, asphalt, plaster, hollow stone blocks)	33.4%	244
Scrap metal (rebar, structural steel, water and fuel tanks, aluminium roof sheets, etc.)	26.2%	191
Construction wood, painted, treated or untreated (natural materials (soil, rocks, mud, plant matter including trees, etc.)	0%	0
Electrical and electronic waste (E-waste) including white wares, cooling systems, air conditioning, etc.	22.9%	167
Hazardous waste such as generator fuel, explosive/flammable materials, chemicals, hazardous raw materials used in commercial or industrial enterprises, hospital (university/school labs, etc. – to be specified,	0.4%	3
Destroyed vehicles (trucks, cars, motorcycles, etc.)	6.4%	47
Health care waste including pharmaceutical and infectious waste, sharps and needles etc., and others, including containers/ with unknown contents	0.1%	1
Other	1.5%	11

A category of waste stream which this report classifies as "special waste streams" includes waste such as e-waste and damaged vehicles which require special treatment/management. The following types of wastes were identified within the "special waste streams" category as follows (**Table 5**).

Table 5. Type of Special Waste Streams

Type of Special Waste Streams	% of buildings with disaster waste	No. of buildings with disaster waste
Vehicles	8.9%	65
Refrigerators	15.3%	112
Air Conditioners (ACs)	23.2%	169
Heating systems	2.5%	18
Electricity systems	4.2%	31
Transformers	16.0%	117
Capacitors	11.0%	80

The engineers also checked if hazardous and health care waste was present at the site (**Table 6**). It should be noted that specialists should verify and propose disposal methods for such a hazardous waste. The following findings should be considered as indicative.

Table 6. Type of Hazardous Waste

Type of Hazardous Waste	% of buildings with hazardous waste	No. of buildings with hazardous waste
Asbestos panels	0.7%	5
Medical and Healthcare waste	0.1%	1
Pharmaceutical waste	0.1%	1
Explosive and Flammable materials (e.g. liquid gas bottles)	1.5%	11

5. Conclusions

Debris Quantification

The UNDP's assessment estimated potential Construction and Demolition Waste (CDW) in Beirut (excluding port clearance) to be approximately 1,052,000 tonnes. Considering the result of UN-HABITAT's damage assessment, the average of two estimations (Red Zones and modified Red Zones) would give an approximate value for the lower limit of the potential amount of CDW outside of the port, which is 780,898 tonnes.

In conclusion, the CDW from Beirut demolitions (excluding the port clearance) would therefore be in the range of **800,000 – 1,000,000 tonnes.** This amount would be higher if significant demolition activities take place outside the 139 operational zones, and if CDW resulting from building rehabilitation and restoration are accounted for.

As for glass waste, UNDP's assessment estimated the amount to be 14,328 tonnes of glass waste within Red Zone while the estimate goes up to 19,883 tonnes of glass waste if the additional zones[8] considered within UN-HABITAT's assessment are taken into account.

Given the widespread damage to windows/ doors compared to the structural damage to buildings, it is estimated that **at least 20,000 tonnes** of glass waste were generated from the blast or possibly more if considering other areas such as Bourj Hammoud, Achrafieh and Hamra districts.

Additionally, it should be noted that during the first few weeks after the explosion, part of the CDW waste, mainly of households outside the Red Zone, was mixed with municipal waste stream due to individual household cleaning done by citizens. Such quantities are relatively minimal and, based on preliminary data, do not exceed 2% of the overall estimated quantities of CDW generated from the blast.

Finally, based on visual inspection at site, it was estimated that approximately 204,000 m^3 of disaster waste (including CDW, e-waste, vehicles, glasses etc.) still remain scattered around the Red Zone that were directly generated from the blast and should be transferred to the designed temporary storage site in Karantina.

The summary of these key results is shown in the below **Table 7.**

Table 7. Summary of Key Results

Key Outputs	Value (rounded)
Estimated potential amount of CDW from demolition of damaged buildings in Beirut (excluding port clearance)	**800,000 - 1,000,000 tonnes**
Estimated amount of glass waste from the blast in Beirut	**20,000 tonnes**
Amount of disaster waste directly generated from the blast in Red Zone	**200,000 m^3**

Specific Waste Streams and Hazardous Wastes

The assessment confirmed that 23% of inspected buildings had e-waste and 6% of those had destroyed vehicles in and around their vicinity. Even though some of this waste could be repaired and then reused, there is a critical need to properly manage e-waste and vehicle waste given that these are considered as hazardous waste streams.

Even though no significant amount of chemicals, explosive or medical material was found in the assessment, the assessment concluded however the presence of asbestos in the buildings. Specific site inspections also confirmed the predominance of asbestos in certain damaged structures and in the rubble piles. One of the common uses of asbestos around Beirut is in corrugated cement roofs and rain pipes although it may be found elsewhere. Since asbestos has a carcinogen risk if airborne fibers are inhaled, suspected asbestos containing materials such as CDW should not be disturbed without control. Given that increasing number of buildings will be rehabilitated in the coming months, the proper treatment and the safety measures for people working on CDW must be ensured. Efforts on mainstreaming such protective measures into the NGOs' activities are ongoing through ground-level coordination.

Ongoing Waste Management Initiatives by Civil Society

In the hours after the port blast, Lebanese volunteers rushed to help people and support in the recovery activities. Several organisations and individual volunteers participated in the cleaning activities after the blast.

UNDP, with the support of the Accelerator Lab, has mapped all the identified interventions related to disaster wastes removal by NGOs and has identified the different temporary disposal sites used. More than 30 group of local activist/ NGOs were found to be involved in the debris collection, waste upcycling and recycling initiatives for different types of waste (more detail in **Annex 4**). This list is continuously changing and is only a snapshot of the information collection to date. So far, the collected and sorted materials by NGOs are mainly glass, metal and wood. Environmentally sound and economically viable treatment and disposal should be ensured for these waste through the ground level information sharing.

Despite these efforts, several incidents of overlap between initiatives have been identified on more than one occasion and occasionally absence of synergy and of complementary activities has been noted.

Current Status of Disposal of Construction and Demolition Waste (CDW)

Unfortunately, given the state of emergency and the lack of a clear national strategy related to construction and demolition waste even before the blast, debris and rubble were mixed with glass and other waste, including hazardous material such as asbestos. The segregation and reuse/ recycling processes became difficult to undertake at some point since the waste was mixed although not impossible to do. Most of the CDW and other disaster waste are currently being transferred to the site assigned by the Municipality of Beirut in Karantina for temporary storage, while smaller piles of waste have been identified around the Karantina area and in other places around the Beirut. These sites need to be inspected and the waste should be eventually removed.

The disposal site and plan for CDW treatment has not been determined yet. It should be noted that there will be significant amount of CDW generated again once the major demolition and rehabilitation works starts in Beirut and potentially at the Port of Beirut as well. The EU is currently designing more detailed management plans for the waste and the results of this report will feed into these plans. Any waste management plan should also take into account the normal generation of CDW in Beirut and its vicinity so that the treatment plan of CDW can serve and benefit the country for the long term and be more sustainable.

Unofficial reports indicate that the CDW waste in Karantina is approximately 120,000 tonnes which is significantly less than the amount of waste estimated from the damaged buildings. There are several reasons for this discrepancy which needs to be considered in more detail at a later stage given that this is outside the scope of this current report.

It is important however to note the following observations for the sake of more informed policy recommendations:

- The amount of waste temporarily stored in Karantina has not been confirmed by experts yet and this should be done before any treatment works commence so that the proper disposal or use options can be determined accordingly.
- The waste that is located in smaller piles around Karantina and Beirut need to be quantified and transported to the main site as well or directly treated.
- It is presumed that large quantities of construction waste that could have any financial value (resale value) was removed from the waste before it reached the Karantina site. This includes waste such as metals, electronic appliances or other material. The same applies to other debris that could have been reused or resold such as furniture.
- Some of the CDW waste may have also been removed and illegally dumped in locations outside the designed temporary storage site.

6. Lessons Learnt and Way Forward

Given the magnitude of potential amount of debris from demolition linked to the recovery phase, a proper debris management plan must be developed as soon as possible. Environmentally sound management options that include the full cycle of the debris waste treatment, any recycling potential and final disposal sites, as well as cost allocation needs to be put in place before any works on the ground starts; otherwise, there is a risk of improper handling of the waste, doing more harm than good in this case.

It is important to note that the initial handling of the debris can have a significant impact on the options available for the debris management[9]. If the debris is mixed with general waste, then the opportunities to recycle are considerably reduced since pre- sorting of the debris/waste is required to enable reuse and recycling. This is especially true for hazardous wastes such as asbestos which should be strictly prohibited at the recycling sites, these being disposed of in a controlled manner at the local landfill/dump site. Health and safety of personnel working on debris management must be ensured. Thus, clear and consistent communication and information sharing with all the stakeholders is also essential given active participation of a number of different organizations.

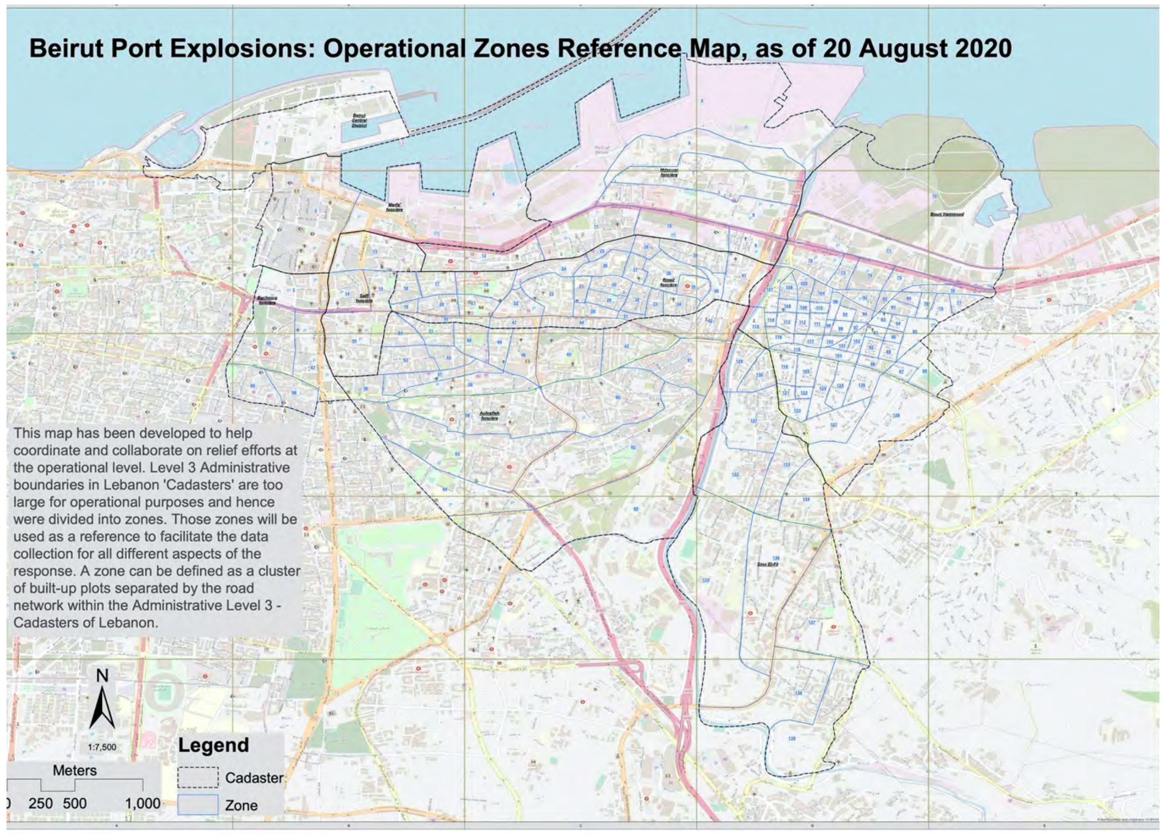
In terms of swift execution of the necessary assessment in a crisis situation, a key lesson learnt was to engage local actors and initiatives for the assessment. It turned out that many different assessments and surveys were conducted by different actors including international and national NGOs, the municipalities and other stakeholders. It was also agreed among UN agencies and NGOs to use the common data collection tool and GIS platform. In the case of this assessment, UNDP relied on the local volunteers' capacity to conduct exhaustive field survey and used the common data collection tool and platform. Since quick deployment of the massive field survey in crisis situation is challenging for the UNDP, a solution could be to actively engage the local actors and initiatives for the assessment. Alternatively, given that there were many surveys going on in parallel, building in key questionnaires into other assessments could be another solution to extend the survey capacity.

9- MSB & UNDP (2010), Debris Management Guidelines.

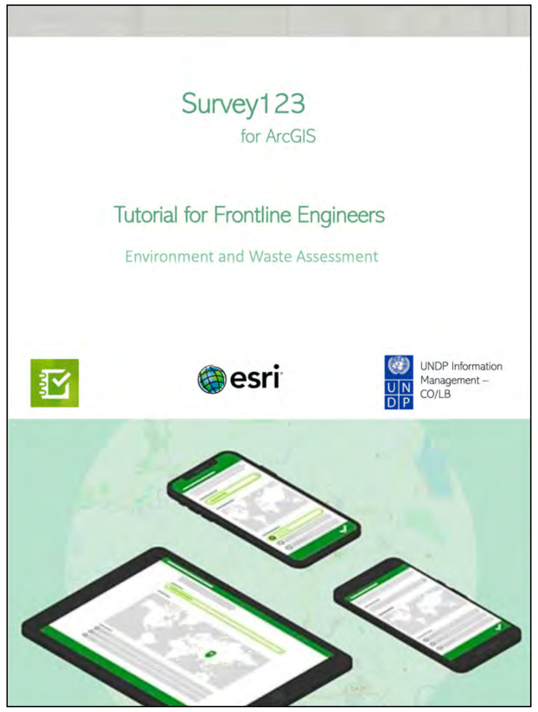
Annex 1. Survey Questionnaires

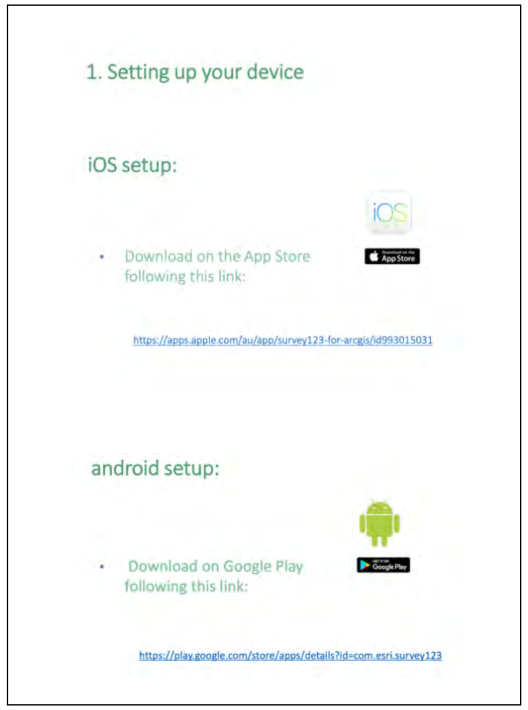
House and Building Damage Assessment for Beirut Blast

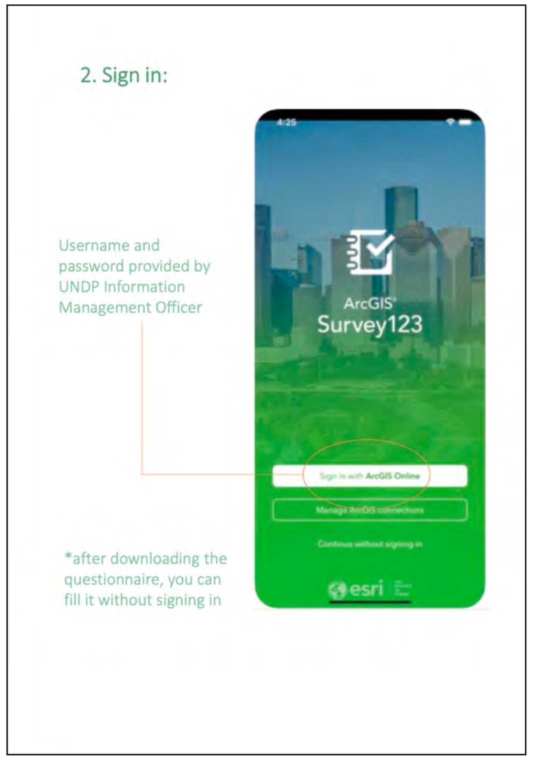
Annex 2. Beirut Port Explosions: Operational Zones Reference Map5

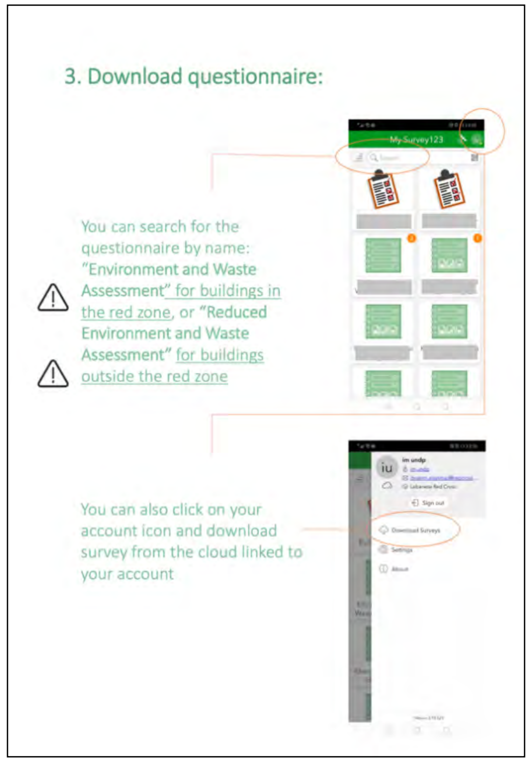


Annex 3. Training Manual for Data Collection Tool (Survey123 for ArcGIS)









3. Download questionnaire:

Once downloaded, the questionnaire will show on your My Survey123 homepage. You can click on it to start collecting data

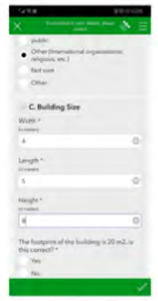
You can refresh the questionnaire in case it has been updated by going to the account icon>download surveys step in the previous page

4. Collect data

From the homepage, click on the questionnaire, then click Collect to make a new entry

You can also view items that are already sent, queued in the Outbox or saved in Drafts

Items marked with an asterix * are required



5. Send data: Outbox or Sent folders

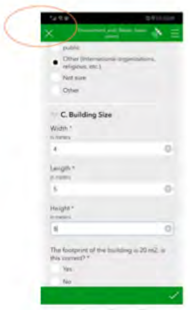
If you filled all required fields and if you are sure of all entered data, press the check mark ✓

Please only use this option if you are sure you don't need to modify the data anymore

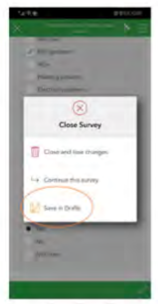
You will have the choice to Send now if you have an internet connection or Save in Outbox if you are not connected.

6. Incomplete data: Drafts folder

If your data sheet is still not ready to be sent (incomplete, data needs review, etc.), you can save your data in the Drafts folder by clicking on the X button



You will have the option here to Save in Drafts and continue the data collection for this unit at a later stage



7. Complete datasheets in Drafts

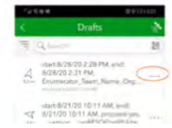
Access the Drafts folder from the questionnaire's main page

You will find all datasheets saved there. Press on the unit itself to complete the datasheet and send it.

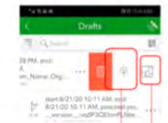
Notice the three buttons next to each unit

8. Helpful functionalities in Drafts

View the location of a unit saved in Drafts by pressing on the three buttons next to the datasheet

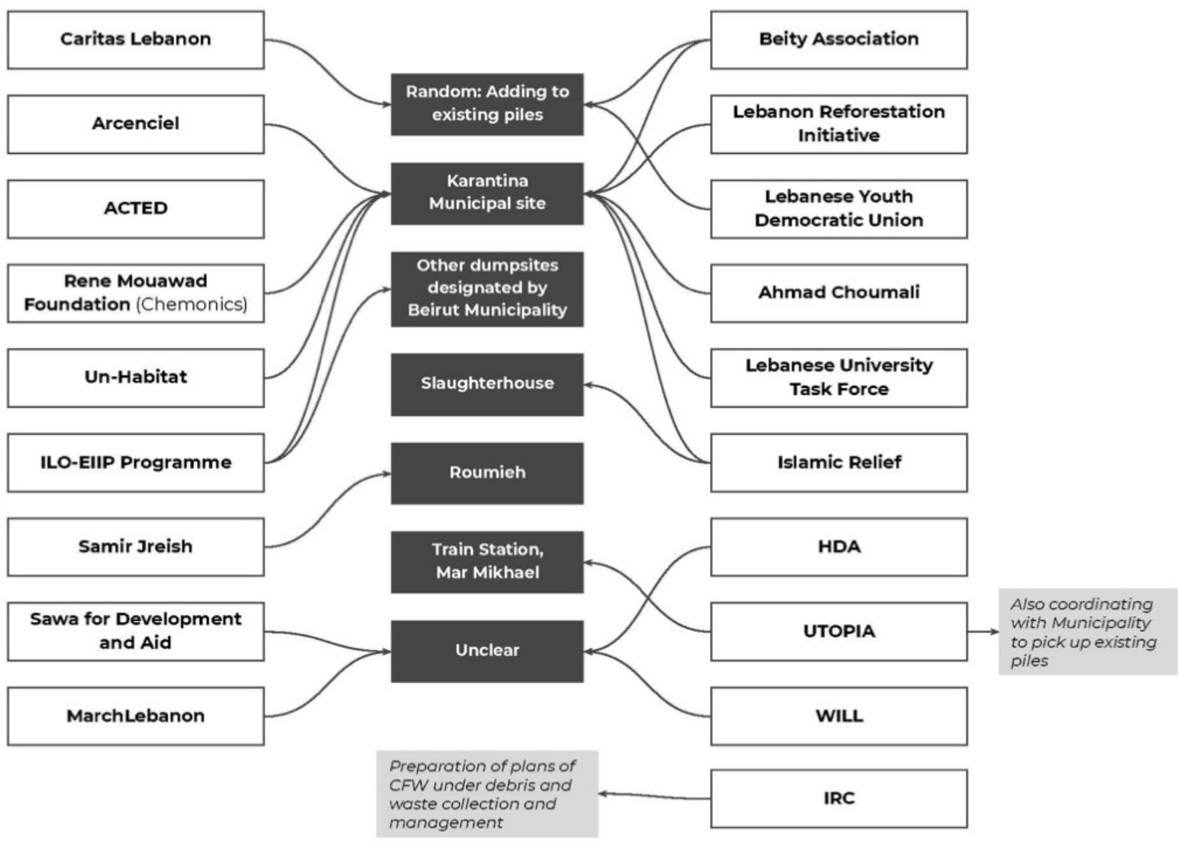


You will find three functionalities: delete from drafts, open in Google maps, or view on the maps of Survey123

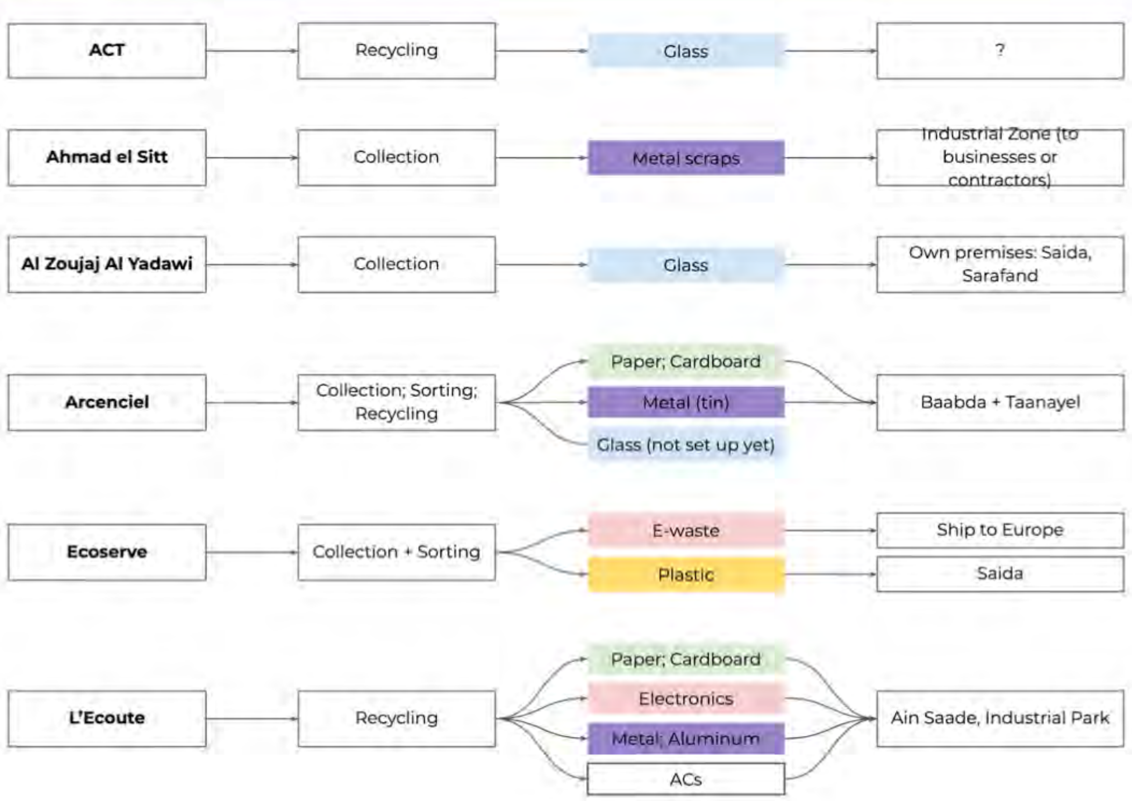


Annex 4. Mapping of Waste Management Initiatives by NGOs

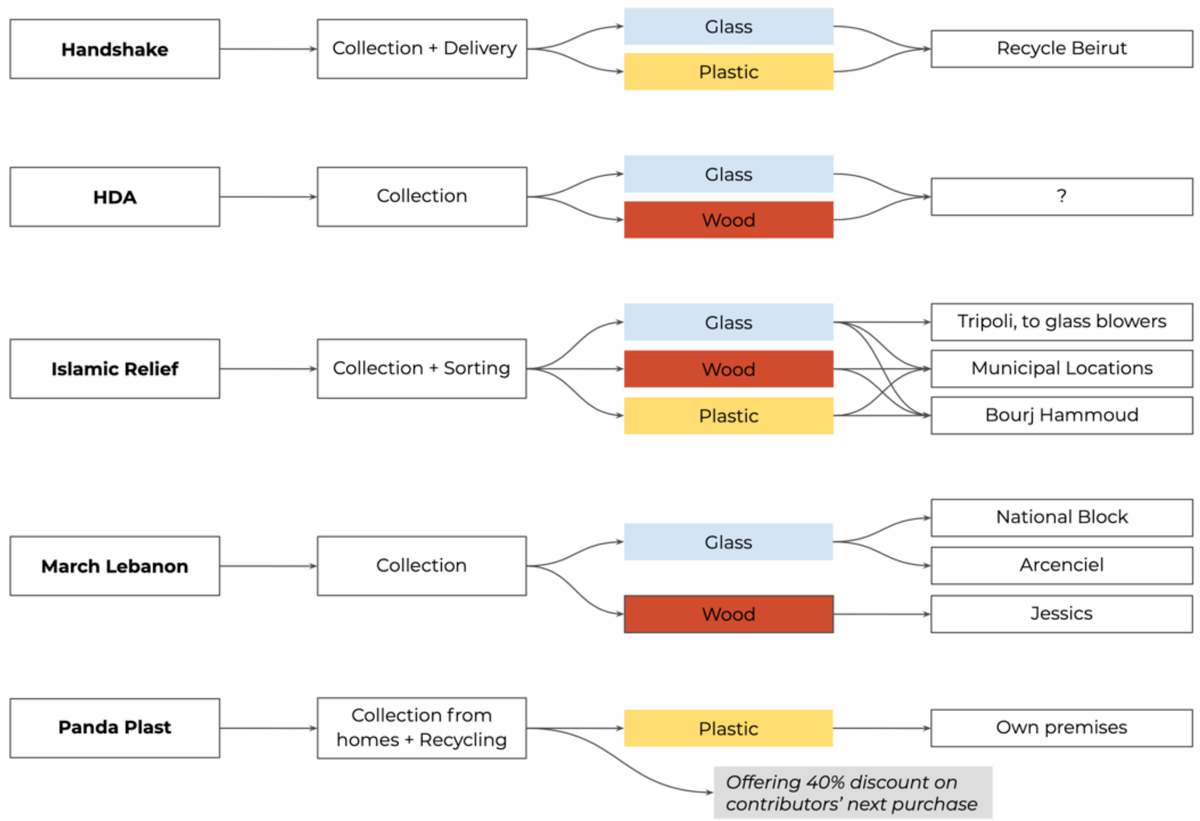
DEBRIS COLLECTING + DUMPING



RECYCLING



RECYCLING (cont)



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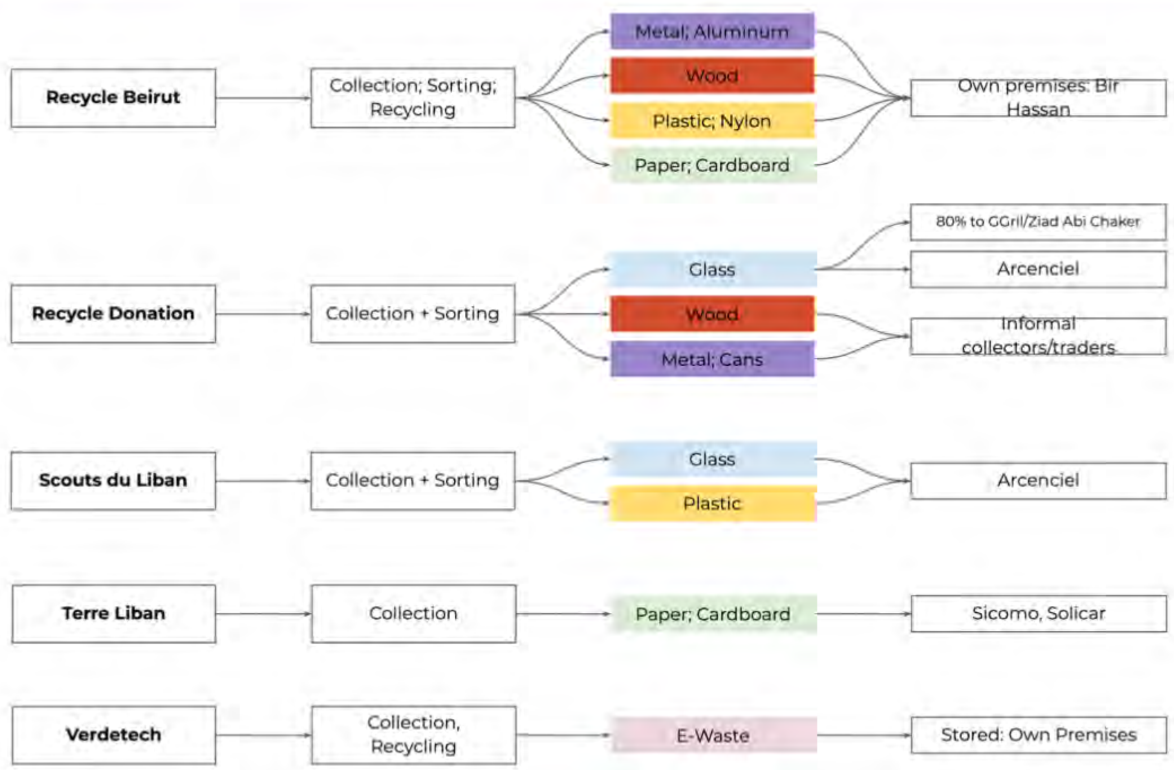

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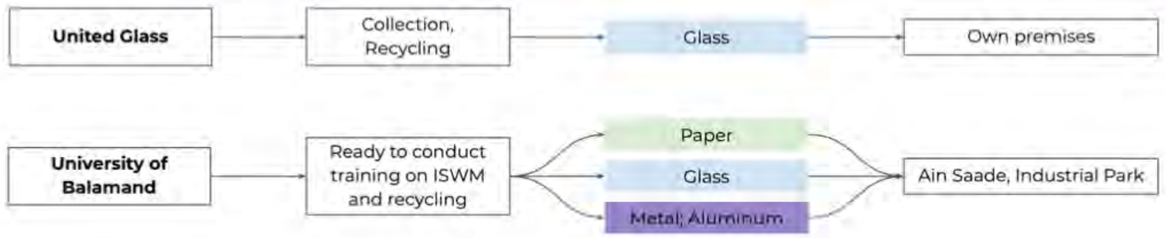
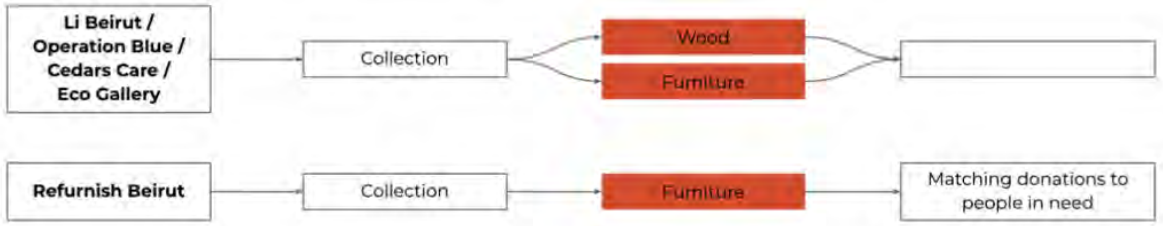


UPCYCLING



Annex 5. Site Survey Photos

UNDP is the leading United Nations organization fighting to end the injustice of poverty, inequality, and climate change. Working with our broad network of experts and partners in 170 countries, we help nations to build integrated, lasting solutions for people and planet.